Zał. Nr 1 do ZW 16/2020

PROGRAM OF STUDIES

FACULTY:	Chemistry
MAIN FIELD OF STUDY:	**CHEMICAL NANO-ENGINEERING**
BRANCH OF SCIENCE:	engineering and technology
DISCIPLINES:	D1 chemical engineering (major discipline)
EDUCATION LEVEL:	second-level studies
FORM OF STUDIES:	full-time studies
PROFILE:	general academic
LANGUAGE OF STUDY:	English

Content:

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

In effect since 2022/2023

*delete as applicable

Zał. Nr 2 do ZW 16/2020

ASSUMED LEARNING OUTCOMES

FACULTY: Chemistry
MAIN FIELD OF STUDY: **Chemical Nano-engineering**
EDUCATION LEVEL: second-level studies
PROFILE: general academic

Location of the main-field-of study:
Branch of science: Engineering and technology
Discipline: Chemical engineering

Explanation of the markings:
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

W - category "knowledge"
U - category "skills"
K - category "social competences"

K (*faculty symbol*) _W1, K (*faculty symbol*) _W2, K (*faculty symbol*) _W3, … - main-field-of study learning outcomes related to the category "knowledge"
K (*faculty symbol*) _U1, K (*faculty symbol*) _U2, K (*faculty symbol*) _U3, … - main-field-of study learning outcomes related to the category "skills"
K (*faculty symbol*) _K1, K (*faculty symbol*) _K2, K (*faculty symbol*) _K3, … - main-field-of study learning outcomes related to the category "social competences"

_inż. – learning outcomes related to the engineer competences

Main field of study learning outcomes	Description of learning outcomes for the main-field-of study **Chemical Nano-engineering** After completion of studies, the graduate:	Reference to PRK characteristics		
		Universal first-degree characteristics (U)	Second degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels of PRK	Characteristics for qualifications on 7 level of PRK, enabling acquiring engineering competences
KNOWLEDGE (W)				
K2Acne_W01	knows and understands the basic and advanced concepts of applied **mathematics** used in chemical nano-engineering. *zna i rozumie podstawowe i zaawansowane pojęcia matematyki stosowanej w nanoinżynierii chemicznej.*	P7U_W	P7S_WG	
K2Acne_W02	has in-depth knowledge **on numerical modeling** of nanometric systems applied in nano-engineering, *zna podstawy modelowania numerycznego nano-systemów stosowanych w nanoinżynierii,*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W03	knows the basics and applications of instrumental methods (for example / including **optoelectronics** microscopy, X-Ray, NMR) for characterization of nanomaterials *zna podstawy i zastosowania optoelektroniki;*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W04	has knowledge of **bio- and nano-sensors** and their applications; knows engineering applications of nanostructures?? (*posiada wiedzę o nano-sensorach i ich zastosowaniach)*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W05	has knowledge **of nanomaterials and biomaterials**; knows how to select methods and materials for synthesis of various nano-objects. (*posiada wiedzę na temat nanomateriałów i biomateriałów zna sposoby doboru metod i materiałów do wytwarzania różnych nanoobiektów)*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W06	Knows similarities and differences between macroscopic chemical engineering and chemical nano-engineering. Knows "top down" and "bottom up" methodologies allowing the transfer of knowledge between domains. *(zna podobieństwa i różnice między inżynierią chemiczną i nanoinżynierią chemiczną. Zna metodologie „top down" i „bottom up" umożliwiające transfer wiedzy między tymi dziedzinami)*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W07	knows ***quantitative structure–property relationship*** *(*QSPR) methodology and its applications in profiling properties needed in nano-engineering.	P7U_W	P7S_WG	P7S_WG_Inż

	zna metodologię ilościowego badania zależności między strukturą a aktywnością (ang. QSAR) i jej zastosowania do doboru właściwości pożądanych w zastosowaniach nanoinżynierii.			
K2Acne_W08	has knowledge of extended **physical chemistry (*thermodynamics, chemical kinetics,* electrochemistry, quantum chemistry and statistical thermodynamics) of condensed matter**, and understands it in nano-scale, knows its applications in the field of nano-engineering. (*posiada wiedzę na temat fizykochemii faz skondensowanych (termodynamika, kinetyka chemiczna, elektrochemia, chemia kwantowa i termodynamika statystyczna), rozumie jej specyfikę w obiektach w skali nanometrów i potrafi zastosować w zakresie nano-inżynierii*)	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W09	has in-depth knowledge of **organic chemistry, including polymers, supramolecular chemistry and nano-machines** *ma pogłębioną wiedzę w zakresie chemii organicznej, w tym chemii polimerów, chemii supramolekularnej a także w zakresie nano-maszyn*	P7U_W	P7S_WG	
K2Acne_W10	has in-depth knowledge of development trends, new achievements and applications in the field of chemical nano-engineering *ma pogłębioną wiedzę o trendach rozwojowych, nowych osiągnięciach i zastosowaniach w zakresie nano-inżynierii chemicznej*	P7U_W	P7S_WG	P7S_WG_Inż
K2Acne_W11	knows principles of intellectual property protection, patent protection and copyrights, also in the context of the diploma thesis being prepared *zna pojęcia i zasady ochrony własności intelektualnej, ochrony patentowej i prawa autorskiego, także w kontekście przygotowywanej pracy dyplomowej.*	P7U_W	P7S_WK	
K2Acne_W12	knows the rules of health and safety in laboratory work *zna zasady bezpieczeństwa i higieny pracy w pracy laboratoryjnej*	P7U_W	P7S_WK	
K2Acne_W13	knows the ethical conditions in the context of scientific activity. *zna etyczne uwarunkowania w kontekście działalności naukowej.*	P7U_W	P7S_WK	
K2Acne_W14	knows the basic concepts of entrepreneurship *zna podstawowe pojęcia dotyczące przedsiębiorczości*	P7U_W	P7S_WK	P7S_WK_Inż
SKILLS (U)				
K2Acne_U01	uses the basic and advanced concepts of applied **mathematics** used in chemical nano-engineering. *korzysta z podstawowych i zaawansowanych pojęć matematyki stosowanej w nanoinżynierii chemicznej.*	P7U_U	P7S_UW	
K2Acne_U02	is able to **determine and characterize structures** and describe the **properties** of various **nanomaterials** using **chemical, instrumental and simulation methods**	P7U_U	P7S_UW	P7S_UW_Inż

	(potrafi określić struktury i opisać właściwości różnych nanomateriałów za pomocą metod chemicznych, instrumentalnych i symulacyjnych)			
K2Acne_U03	can **present and evaluate a material** in the nano- and micro-scale for specific industrial and technological applications; is able to assess and formulate current trends in the field of nanotechnology for industrial needs *(potrafi przedstawić i ocenić materiał w skali nano- i mikro- do konkretnych zastosowań przemysłowo-technologicznych; jest w stanie ocenić i sformułować aktualne trendy w dziedzinie nanotechnologii dla potrzeb przemysłowych)*	P7U_U	P7S_UW	P7S_UW_Inż
K2Acne_U04	is able to **design bonding schemes and interactions** characteristic for nano-metric systems to be used in molecular modeling *(potrafi zaprojektować wiązania i oddziaływania charakterystyczne dla układów nanometrycznych w celu zastosowania w modelowaniu molekularnym)*	P7U_U	P7S_UW	P7S_UW_Inż
K2Acne_U05	can **interpret experimental data** using statistical methods supported by professional software. *(potrafi opracować dane eksperymentalne z wykorzystaniem metod statystycznych, w tym wspomagany specjalistycznym oprogramowaniem komputerowym)*	P7U_U	P7S_UW	P7S_UW_Inż
K2Acne_U06	can **design** a **mathematical model of materials and processes,** and **perform computer simulations**, including use of existing commercial software *(umie zbudować model matematyczny materiału i procesu, i wykonać obliczenia symulacyjne* wspomagane dostępnym komercyjnym oprogramowaniem)	P7U_U	P7S_UW	P7S_UW_Inż
K2Acne_U07	acquires, critically evaluates and creatively processes **information from scientific literature, databases** and other properly selected sources *(pozyskuje, krytycznie ocenia i twórczo przetwarza informacje z literatury naukowej, baz danych oraz innych właściwie dobranych źródeł)*	P7U_U	P7S_UW P7S_UU	
K2Acne_U08	individually or in group, **plans and conducts experiments/research** in accordance with health and safety rules; can manage the team work *(samodzielnie i/lub w grupie planuje oraz przeprowadza eksperymenty i badania naukowe z zachowaniem zasad bezpieczeństwa i higieny pracy; potrafi kierować pracą zespołu)*	P7U_U	P7S_UO P7S_UU	
K2Acne_U09	can **interpret and understands research results**, make a critical analysis of them, indicate measurement errors and formulate conclusions *(potrafi opracować wyniki badań, dokonać ich krytycznej analizy, wskazać błędy pomiarowe i formułować wnioski)*	P7U_U	P7S_UW	
K2Acne_U10	can present the own results of research in the form of **a self-prepared written report**, *(potrafi przedstawić wyniki badań własnych w postaci samodzielnie przygotowanego opracowania pisemnego)*	P7U_U	P7S_UW	
K2Acne_U11	can present the goals and results of scientific work in the form of **an oral presentation** using modern information and communication techniques.	P7U_U	P7S_UW P7S_UK	

	(potrafi przedstawić cele i wyniki pracy naukowej w formie ustnej prezentacji wykorzystując nowoczesne techniki informacyjno-komunikacyjne)			
K2Acne_U12	can explain the **role of nanostructured materials** in novel technologies of energy conversion and storage. *(potrafi wyjaśnić rolę materiałów nanostrukturalnych w nowych technologiach produkcji i magazynowania energii.)*	P7U_U	P7S_UW	P7S_UW_INŻ
K2Acne_U13	is able to describe and explain **structural changes** in processed nanomaterials *(potrafi opisać i wyjaśnić zmiany strukturalne w modyfikowanych nanomateriałach)*	P7U_U	P7S_UW	P7S_UW_INŻ
K2Acne_U14	can design, **synthesize and fabricate nanoscale systems** *(potrafi zaprojektować, syntezować i wytworzyć układy w nanoskali)*	P7U_U	P7S_UW	P7S_UW_INŻ
K2Acne_U15	**knows foreign language** at the level C2, according to the European System of Language Education *(posługuje się językiem obcym na poziomie zaawansowania C2, zgodnie z Europejskim Systemem Opisu Kształcenia Językowego)*	P7U_U	P7S_UK	
K2Acne_U16	understands the need of constant self-development and learning *(rozumie potrzebę stałego samorozwoju i dokształcenia)*	P7U_U	P7S_UU	
SOCIAL COMPETENCES (K)				
K2Acne_K01	is ready to critically evaluate his knowledge and received content *jest gotów do krytycznej oceny posiadanej wiedzy i odbieranych treści*	P7U_K	P7S_KK	
K2Acne_K02	understands the need for entrepreneurial thinking and action *rozumie potrzebę przedsiębiorczego myślenia i działania*	P7U_K	P7S_KO	
K2Acne_K03	is aware of the need to act in the public interest *jest świadom potrzeby działania na rzecz interesu publicznego*	P7U_K	P7S_KO	
K2Acne_K04	recognizes the importance of knowledge in solving cognitive and practical problems; is ready to use the knowledge and experience of experts in the event of difficulties solving a problem *uznaje znaczenie wiedzy w rozwiązywaniu problemów poznawczych i praktycznych; jest gotów do korzystania z wiedzy i doświadczenia ekspertów w razie trudności z rozwiązywaniem problemu*	P7U_K	P7S_KK	
K2Acne_K05	interacts in the group, responsibly, taking various roles in it, including managerial *odpowiedzialnie współdziała w grupie przyjmując w niej różne role, w tym kierownicze*	P7U_K	P7S_KR	
K2Acne_K06	is ready to take initiatives, inspire and organize activities for the socio-economic environment *jest gotów do podejmowania inicjatyw, inspirowania i organizowania działalności na rzecz otoczenia społeczno-gospodarczego.*	P7U_K	P7S_KO	
K2Acne_K07	is ready to respect the principles of professional ethics and the law, including copyrights	P7U_K	P7S_KR	

	jest gotów do przestrzegania zasad etyki zawodowej i poszanowania prawa, w tym praw autorskich			
K2Acne_K08	recognizes the importance and understands the non-technical aspects and effects of scientific and engineering activities, including its impact on the environment, as well as the associated responsibilities *uznaje ważność i rozumie pozatechniczne aspekty i skutki działalności naukowej i inżynierskiej, w tym jej wpływ na środowisko, a także związaną z tym odpowiedzialność*	P7U_K	P7S_KK P7S_KO	
K2Acne_K09	is aware of the social role of a technical university graduate and the need to uphold the ethos of the engineering profession; understands the need to provide the society with information and opinions on the achievements of technology *ma świadomość społecznej roli absolwenta uczelni technicznej i konieczności podtrzymywania etosu zawodu inżyniera; rozumie potrzebę przekazywania społeczeństwu informacji i opinii dotyczących osiągnięć techniki*	P7U_K	P7S_KR	

DESCRIPTION OF THE PROGRAM OF STUDIES

Main field of study: Chemical Nano-engineering	**Profile:** general academic
Level of studies: second-level	**Form of studies:** full-time

1. General description

1.1 Number of semesters: ***4***	*1.2 Total number of ECTS points necessary to complete studies at a given level:* ***120***
1.3 Total number of hours: ***1335***	*1.4 Prerequisites (particularly for second-level studies):* *According to the Consortium Agreement and general admission rules at Wrocław University of Science and Technology*
1.5 Upon completion of studies graduate obtains professional degree of: ***magister inżynier***	1.6 *Graduate profile, employability:* The competences of a graduate of the Chemical Nano-Engineering are: 1. Thorough knowledge of the principles of nano-engineering and nano-chemistry. The graduate possesses an interdisciplinary training in the field of nano-engineering, which includes a profound understanding of the chemistry and characterization of nano-materials and nano-systems. 2. Ability to synthesize nano-objects by chemical ways, to characterize and model them, and apply nano-objects particularly in nano-machines, supramolecular assemblies and in medical nano-devices. Develop a creative experimental approach to prepare, characterize and model nano-objects (nanostructures, nanomaterials or nano-devices) with unknown properties, or resolve problems related to their identification/application/production. 3. Thorough knowledge of theoretical modelling and numerical simulation methods at multi-scale. The graduate possesses expertise in numerical modelling to predict the chemical and physical properties at the nano-scale using disciplinary

	knowledge of fundamental sciences and transdisciplinary knowledge of nano-sciences. 4. Capacity to manage and to use nanotechnologies to create new devices. Capacity to promote and to develop scientific and technological innovation. The graduate is able to construct and realize individually or in a team all steps of a research and development project in the domain of nano-sciences et nanotechnologies, mobilizing various pluridisciplinary parties. 5. Possibility of making a critical analysis of scientific information, summarizing and discussing a critical bibliographic review of the literature within nanoscience/nanotechnology/nano-engineering. 6. Capacity of technical and economic evaluation of a project of innovation and research. The graduate is able to conceive, prepare and use nano-objects in various professional contexts, integrating ethical environmental and societal challenges. 7. Ability to integrate in a professional organization and develop ethics and responsibility – capacity to work effectively in a team project. The highly qualified and creative graduate is trained for the labour market with a big capacity to adapt themselves and to find new solutions for technological development – educate a new generation of engineers who can participate in the creation of new high-technology companies.
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 program of the Chemical Nano-engineering studies is in line with the University's strategy and development plan of the Faculty of Chemistry, which consists in increasing the level of correlation of the University's and the Faculty's activities with the market needs. The proposed field of study will contribute to the internationalization of the University and the improvement of the quality of education through didactic interdisciplinarity. The development of the field of study will contribute to the development of laboratories in the field of competency specializations and advanced technologies, with a recommendation for their accreditation. In the future, the course will increase scientific activity in the field of nanoengineering and chemical nanotechnology, raise the prestige of universities in the country and in the world, as well as increase the applicability and level of commercialization of research results.

2. Detailed description

2.1 Total number of learning outcomes in the program of study: W (knowledge) =14, U (skills) = 16, K (competences) = 9, W + U + K = 39

2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline: (this number must be greater than half the total number of learning outcomes)

D1 (major) chemical engineering 39 (100%)

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

D1 100% ECTS points

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

103 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)

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

The program of the course of studies meets the needs of the labour market of modern industry based on "nano" systems, which includes pharmaceutical biochemistry, photovoltaics, nanorobotics, biotechnology and other rapidly developing industries. The learning outcomes related to the field of study respond to the needs of the industry related to the above-mentioned fields. The field of study, in line with global trends, fills (reduces) the gap between innovative industry and scientific laboratories.

The preparation of graduates to enter the labour market is reflected, inter alia, in the following learning outcomes:

- Has knowledge of development trends and new achievements in the field of chemical nano-engineering. Can assess the usefulness and the possibility of using new achievements in the field of nano-chemical engineering and nanotechnology,
- knows the basic concepts of entrepreneurship,
- Has knowledge of the design, synthesis, production and properties of nanosystems, the use of computer techniques, optimization and characterization of nanometric systems,
- Is able to present and evaluate the material in the nano- and micro-scale for specific industrial and technological applications; is able to assess and formulate current trends in the field of nanotechnology for industrial needs,
- independently and / or in a group is able to plan and conduct experiments and research in accordance with the principles of occupational health and safety; can manage the work of the team.

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 courses / groups of courses marked with the BU[1] code)

84 ECTS

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

Number of ECTS points for obligatory subjects	10
Number of ECTS points for optional subjects	0
Total number of ECTS points	**10**

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 courses/group of courses denoted with code P)

Number of ECTS points for obligatory subjects	46
Number of ECTS points for optional subjects	39
Total number of ECTS points	**85**

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 courses/groups of courses denoted with code O)

6 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:**

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.

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

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. 5 ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	ICC025008w	Economics and Management	30					K2Acne_W14 K2Acne_K02	30	90	3		2,1	T/Z	Z				KO
2	ICC025008c	Economics and Management		30				K2Acne_W14 K2Acne_K02, K2Acne_K06	30	60	2		1,4	T/Z	Z			P	KO
		Total	**30**	**30**					**60**	**150**	**5**		**3,5**						

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

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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]

4.1.1.3 *Sporting classes* block *(... ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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]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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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]

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					
30	**30**				**60**	**150**	**5**		**3,5**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course /group of courses	Way[3] of crediting	Course/group of courses			
			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	ICC025015w	Computational Modelling of Nano-Systems	24					K2Acne_W02, K2Acne_W07	24	90	3	3	2,1	T/Z	Z		DN		PD
2	ICC025015c	Computational Modelling of Nano-Systems		21				K2Acne_U04, K2Acne_U06	21	60	2	2	1,4	T/Z	Z		DN	P	PD
3	ICC025015l	Computational Modelling of Nano-Systems			18			K2Acne_U04, K2Acne_U06, K2Acne_U09, K2Acne_K05	18	60	2	2	1,4	T	Z		DN	P	PD
		Total	**24**	**21**	**18**				**63**	**210**	**7**	**7**	**4,9**						

4.1.2.2 *Physics* block

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course /group of courses	Way[3] of crediting	Course/group of courses			
			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]

4.1.2.3 *Chemistry* block

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course /group of courses	Way[3] of crediting	Course/group of courses			
			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	ICC025013w	Organic chemistry of Nanomaterials	15					K2Acne_W03, K2Acne_W09	15	30	1	1	0,7	T/Z	Z		DN		PD
2	ICC025013c	Organic chemistry of Nanomaterials		9				K2Acne_U14	9	30	1	1	0,7	T/Z	Z		DN	P	PD
3	ICC025013l	Organic chemistry of Nanomaterials			3			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	3	30	1	1	0,7	T	Z		DN	P	PD
		Total	**15**	**9**	**3**				**27**	**90**	**3**	**3**	**2,1**						

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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					
39	**30**	**21**			**90**	**300**	**10**	**10**	**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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 *(min. 64 ECTS):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	ICC025011w	Nano-Electrochemistry	15					K2Acne_W03, K2Acne_W08	15	30	1	1	0,7	T/Z	**E**		DN		K
2	ICC025011c	Nano-Electrochemistry		9				K2Acne_U02	9	30	1	1	0,7	T/Z	Z		DN	P	K
3	ICC025011l	Nano-Electrochemistry			3			K2Acne_W12, K2Acne_U02, K2Acne_U09, K2Acne_K05	3	30	1	1	0,7	T	Z		DN	P	K
4	ICC025012w	Solid State Chemistry and Nanomaterials	36					K2Acne_W03, K2Acne_W05 K2Acne_W08	36	90	3	3	2,1	T/Z	**E**		DN		K
5	ICC025012c	Solid State Chemistry and Nanomaterials		21				K2Acne_W12, K2Acne_U02	21	90	3	3	2,1	T/Z	Z		DN	P	K
6	ICC025012l	Solid State Chemistry and Nanomaterials			6			,K2Acne_U02, K2Acne_U09, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
7	ICC025014w	Basic Quantum Chemistry Modelling	15					K2Acne_W07, K2Acne_W01, K2Acne_W02	15	30	1	1	0,7	T/Z	Z		DN		K
8	ICC025014c	Basic Quantum Chemistry Modelling		9				K2Acne_U01, K2Acne_U06, K2Acne_U04, K2Acne_U06	9	30	1	1	0,7	T/Z	Z		DN	P	K
9	ICC025014l	Basic Quantum Chemistry Modelling			3			K2Acne_U01, K2Acne_U06, K2Acne_U04, K2Acne_U06,	3	30	1	1	0,7	T	Z		DN	P	K
10	ICC025016w	Thermodynamics of Materials-Interactions and Surface Forces	15					K2Acne_W08	15	30	1	1	0,7	T/Z	Z		DN		K
11	ICC025016c	Thermodynamics of Materials-Interactions and Surface Forces		9				K2Acne_U02, K2Acne_U04, K2Acne_U06,	9	30	1	1	0,7	T/Z	Z		DN	P	K
12	ICC025016l	Thermodynamics of Materials-Interactions and Surface Forces			3			K2Acne_U02, K2Acne_U04, K2Acne_U06, K2Acne_U09, K2Acne_K05	3	30	1	1	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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

13	ICC025001w	Crystallography and Structure of solids	30					K2Acne_W03, K2Acne_W08	30	60	2	2	1,4	T/Z	Z		DN		K
14	ICC025001c	Crystallography and Structure of solids		15				K2Acne_U02, K2Acne_U07	15	30	1	1	0,7	T/Z	Z		DN	P	K
15	ICC025002w	Synthesis and Fabrication of Nano-engineering Systems	30					K2Acne_W05, K2Acne_W09	30	60	2	2	1,4	T/Z	**E**		DN		K
16	ICC025002c	Synthesis and Fabrication of Nano-engineering Systems		15				K2Acne_U02, K2Acne_U05, K2Acne_U14	15	30	1	1	0,7	T/Z	Z		DN	P	K
17	ICC025003w	Fabrication of Smart Polymers	30					K2Acne_W05, K2Acne_W08, K2Acne_W09	30	60	2	2	1,4	T/Z	Z				K
18	ICC025003l	Fabrication of Smart Polymers			15			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_U09, K2Acne_K05	15	30	1	1	0,7	T	Z		DN	P	K
19	ICC025004w	Engineering of Nano-machines	15					K2Acne_W06, K2Acne_W08, K2Acne_W09	15	30	1	1	0,7	T/Z	Z		DN		K
20	ICC025004s	Engineering of Nano-machines					15	K2Acne_U03, K2Acne_U07, K2Acne_K01, K2Acne_K08	15	30	1	1	0,7	T/Z	Z		DN	P	K
21	ICC025005w	Bio-photonics	15					K2Acne_W05, K2Acne_W03, K2Acne_W04	15	30	1	1	0,7	T/Z	**E**		DN		K
22	ICC025005s	Bio-photonics					15	K2Acne_U03, K2Acne_U07, K2Acne_K01, K2Acne_K08	15	30	1	1	0,7	T/Z	Z		DN	P	K
23	ICC025006w	Biomaterials-Biomedical Devices	15					K2Acne_W04, K2Acne_W09	15	60	2	2	1,4	T/Z	Z		DN		K
24	ICC025006l	Biomaterials-Biomedical Devices			15			K2Acne_U09, K2Acne_U14, K2Acne_K05	15	30	1	1	0,7	T/Z	Z		DN	P	K
25	ICC025007w	Nanostructures in Industrial and Numerical Applications	30					K2Acne_W01, K2Acne_W02, K2Acne_W07, K2Acne_U01	30	60	2	2	1,4	T/Z	Z		DN		K
26	ICC025007c	Nanostructures in Industrial and Numerical Applications		30				K2Acne_W01, K2Acne_U01, K2Acne_U06	30	60	2	2	1,4	T/Z	Z		DN	P	K
27	ICC025007p	Nanostructures in Industrial and Numerical Applications				30		K2Acne_K08, K2Acne_K05	30	30	1	1	0,7	T/Z	Z		DN	P	K
28	ICC025021w	Nanoscale Synthesis Methods	24					K2Acne_W05, K2Acne_W03, K2Acne_W08	24	60	2	2	1,4	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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

29	ICC025021c	Nanoscale Synthesis Methods		15				K2Acne_U03, K2Acne_U04, K2Acne_U14	15	60	2	2	1,4	T/Z	Z		DN	P	K
30	ICC025021l	Nanoscale Synthesis Methods			6			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
31	ICC025022w	Macromolecular and Supramolecular Chemistry	24					K2Acne_W09	24	60	2	2	1,4	T/Z	Z		DN		K
32	ICC025022c	Macromolecular and Supramolecular Chemistry		15				K2Acne_W12, K2Acne_U06, K2Acne_U14	15	60	2	2	1,4	T/Z	Z		DN	P	K
33	ICC025022l	Macromolecular and Supramolecular Chemistry			6			K2Acne_U06, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
34	ICC025023w	Characterization of Nano-engineering Systems	24					K2Acne_W03	24	60	2	2	1,4	T/Z	**E**		DN		K
35	ICC025023c	Characterization of Nano-engineering Systems		18				K2Acne_U07, K2Acne_U09	18	60	2	2	1,4	T/Z	Z		DN	P	K
36	ICC025023l	Characterization of Nano-engineering Systems			12			K2Acne_W12, K2Acne_U07, K2Acne_U08, K2Acne_U09, K2Acne_K05	12	60	2	2	1,4	T	Z		DN	P	K
37	ICC025024w	Nanoscale Energy Technology,Nano-sensors and Microfluidics	24					K2Acne_W04, K2Acne_W06, K2Acne_W10	24	60	2	2	1,4	T/Z	Z		DN		K
38	ICC025024c	Nanoscale Energy Technology,Nano-sensors and Microfluidics		15				K2Acne_U07	15	60	2	2	1,4	T/Z	Z		DN	P	K
39	ICC025024l	Nanoscale Energy Technology,Nano-sensors and Microfluidics			6			K2Acne_U07, K2Acne_U08, K2Acne_U12, K2Acne_U09, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
40	ICC025009c	Nano-engineering Seminar + Project		18				K2Acne_U07, K2Acne_W10, K2Acne_K03, K2Acne_K09	18	60	2		1,4	T/Z	Z			P	K
41	ICC025009p	Nano-engineering Seminar + Project				30		K2Acne_U07, K2Acne_W10, K2Acne_U03, K2Acne_U07, K2Acne_K08, K2Acne_K01, K2Acne_K03	30	60	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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

								K2Acne_K08, K2Acne_K09, K2Acne_K05											
42	ICC025009s	Nano-engineering Seminar + Project					18	K2Acne_U07, K2Acne_W10, K2Acne_U12, K2Acne_K08, K2Acne_K03, K2Acne_K09, K2Acne_K05	18	60	2		1,4	T/Z	Z			P	K
		Total	**342**	**189**	**75**	**60**	**48**		**714**	**1920**	**64**	**58**	**44,8**		**6**				

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					
342	**189**	**75**	**60**	**48**	**714**	**1920**	**64**	**58**	**44,8**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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. ..... ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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																	

4.2.1.2 *Foreign languages* block *(min. 6 ECTS):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	CHC025001c	Language (English) C2		18				K2Acne_U15	18	60	2		1,4	T/Z	Z	O		P	KO
2	JZL100921c	Language (English) C2		30				K2Acne_U15	30	60	2		1,4	T/Z	Z	O		P	KO
3	CHC025003c	Language (English) C2		18				K2Acne_U15	18	60	2		1,4	T/Z	Z	O		P	KO
		Total		**66**					**66**	**180**	**6**		**4,2**						

4.2.1.3 Sporting classes block *(…ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

4.2.1.4 *Information technologies* **block** *(min. .... ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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					
	66				**66**	**180**	**6**		**4,2**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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 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					

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 elective courses blocks

4.2.3.1 Block. *Graduation profile* *(min. 30 ECTS):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.	ICC025040l	Master Thesis			360			K2Acne_W01, K2Acne_U09, K2Acne_U10, K2Acne_U11, K2Acne_U16 K2Acne_K04, K2Acne_K08, K2Acne_K07	360	900	30	30	21	T	Z		DN	P	K
		Total			**360**				**360**	**900**	**30**	**30**	**21**						

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 Block. *Elective courses* *(min. 5 ECTS):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.		**BLOCK: Option A Chemistry (optional)**	**24**	**15**	**6**				**45**	**150**	**5**	**5**	**3,5**				**DN**		
	ICC025025w	NMR of Nanosystems	24					K2Acne_W03, K2Acne_U13	24	60	2		1,4	T/Z	Z				K
	ICC025025c	NMR of Nanosystems		15				K2Acne_U13	15	60	2		1,4	T/Z	Z			P	K
	ICC025025l	NMR of Nanosystems			6			K2Acne_U09, K2Acne_U13	6	30	1		0,7	T	Z			P	K
	ICC025026w	Structural and Function Properties of Biopolymers	24					K2Acne_W03, K2Acne_W09, K2Acne_U13	24	60	2		1,4	T/Z	Z				K
	ICC025026c	Structural and Function Properties of Biopolymers		15				K2Acne_W12, K2Acne_U13	15	60	2		1,4	T/Z	Z			P	K
	ICC025026l	Structural and Function Properties of Biopolymers			6			K2Acne_U09, K2Acne_U13	6	30	1		0,7	T	Z			P	K
2.		**BLOCK: Option B Modelling (optional))**	**24**	**15**	**6**				**45**	**150**	**5**	**5**	**3,5**				**DN**		
	ICC025027w	Nanoscale Structural Transformations and Kinetics	24					K2Acne_W08	24	60	2		1,4	T/Z	Z				K
	ICC025027c	Nanoscale Structural Transformations and Kinetics		15				K2Acne_U13	15	60	2		1,4	T/Z	Z			P	K
	ICC025027l	Nanoscale Structural Transformations and Kinetics			6			K2Acne_U09, K2Acne_K05	6	30	1		0,7	T	Z			P	K
	ICC025028w	Probability and Statistical Methods for Modelling Engineers	24					K2Acne_W01, K2Acne_U01, K2Acne_U03	24	60	2		1,4	T/Z	Z				K
	ICC025028c	Probability and Statistical Methods for Modelling Engineers		15				K2Acne_W01, K2Acne_U01, K2Acne_U03, K2Acne_U05, K2Acne_U06	15	60	2		1,4	T/Z	Z			P	K
	ICC025028l	Probability and Statistical Methods for Modelling Engineers			6			K2Acne_W01, K2Acne_U01, K2Acne_U03, K2Acne_U05, K2Acne_U06, K2Acne_U09, K2Acne_K05	6	30	1		0,7	T	Z			P	K
		Total	**24**	**15**	**6**				**45**	**150**	**5**	**5**	**3,5**						

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 elective courses 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					
24	**15**	**366**			**405**	**1050**	**35**	**35**	**24,5**

Caution!
T/Z – remote form of course is allowable only for forms: lecture, seminar, exercises; the Dean's approval of remote form of course is required and in total remote form cannot exceed 75% of ECTS points

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 (*if it is foreseen at first level studies)*

Type of diploma dissertation	magister inżynier*	
Number of diploma dissertation semesters	Number of ECTS points	Code
1	**30**	**ICC025030l**
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	**21**	
Number of DN[5] ECTS points	**30**	

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

Type of classes	Ways of verifying assumed learning outcomes
lecture	examination, progress/final test
class	progress/final test
laboratory	pretest, report from laboratory
project	project defence
seminar	participation in discussion, topic presentation, essay
training	report from training
diploma dissertation	prepared diploma dissertation

6. Range of diploma examination

1. Basic measurement methods in the nano scale - idea, scope of applicability, basic apparatus, description of speed.
2. Basic mechanisms of nanosystem synthesis - idea, scope of applicability, basic apparatus, description of speed.
3. Technologies using nanoparticles.
4. Adsorption in nanoporous materials.
5. Quantum and statistical foundations of nano-properties.
6. Modeling of microscopic mechanisms.
7. Modeling of materials for the needs of nanoengineering.
8. Prospects for the use of nanomachines in medicine

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

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

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

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

DZIEKAN
prof. dr hab. Piotr Młynarz
(1)

.....	.....
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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 16/2020
Attachment no. 3 to Program of Studies

PLAN OF STUDIES

FACULTY: Chemistry

MAIN FIELD OF STUDY: **Chemical Nano-engineering**

EDUCATION LEVEL: second-level studies

FORM OF STUDIES: full-time studies

PROFILE: general academic

LANGUAGE OF STUDY: English

In effect since**:** 2022/2023

Plan of studies structure (optionally)

1) in ECTS point layout

(space for scheme of plan)

2) in hourly layout

(space for scheme of plan)

STUDIA II STOPNIA, MAGISTERSKIE (4 sem)

KIERUNEK: **Chemical Nano-Engineering (studia międzynarodowe)**

Semester 1	Semester 2	Semester 3	Semester 4
Marseille 270h/30ECTS/3E	**Wrocław 435h/30ECTS/2E**	**Rome 270h/30ECTS/2E**	**360h/30ECTS**
(Nano-Chemistry)	**(Nano-Engineering)**	**(Nano-Applications)**	
	Crystallography and Structure of Solids 2w+1c (2+1 ECTS)	Nanoscale Synthesis Methods **E** 24w+15c+6l (2+2+1 ECTS)	
	Synthesis and Fabrication of Nano-engineering Systems **E** 2w+1c (2+1 ECTS)	Macromolecular and Supramolecular Chemistry/ 24w+15c+6l (2+2+1 ECTS)	**Master Thesis**
Nano-Electrochemistry **E** 15w+9c+3l (1+1+1 ECTS)	Fabrication of Smart Polymers 2w+1l (2+1 ECTS)	Characterization of Nano-Engineering Systems **E** 24w+18c+12l (2+2+2 ECTS)	
Solid State Chemistry and Nano-materials **E** 36w+21c+6l (3+3+1 ECTS)	Engineering of Nano-machines 1w+1s (1+1 ECTS)	Nanoscale Energy Technology, Nano-sensors and Micro-fluidics 24w+15c+6l (2+2+1 ECTS)	
Organic Chemistry of Nano-materials 15w+9c+3l (1+1+1 ECTS)	Bio-photonics **E** 1w+1s (1+1 ECTS)	NMR of Nanosystems 24w+15c+6l (2+2+1 ECTS) **(Option A: Chemistry)**	
Basic Quantum Chemistry Modeling 15w+9c+3l (1+1+1 ECTS)	Biomaterials-Biomedical Devices 1w+1l (2+1 ECTS)	Structural and Functional Properties of Biopolymers 24w+15c+6l (2+2+1 ECTS) **(Option A: Chemistry)**	
Computational Modeling of Nano-Systems 24w+21c+18l (3+2+2 ECTS)	Nanostructures in Industrial and Numerical Applications 2w+2c+2p (2+2+1 ECTS)	Nanoscale Structural transformations and Kinetics 24w+15w+6l (2+2+1 ECTS) **(Option B: Modeling)**	
Thermodynamics of Materials- Interactions and Surface Forces **E** 15w+9c+ 3l (1+1+1 ECTS)	Economics and Management 2w+2c (3+2 ECTS)	Probability and Statistical Methods for Modelling Engineers 24w+15c+6l (2+2+1 ECTS) **(Option B: Modeling)**	
Nano-engineering Seminar + Project 18 c (2 ECTS)	Nano-engineering Seminar + Project 2p (2 ECTS)	Nano-engineering Seminar + Project 18s (2 ECTS)	
Language 18c (2 ECTS)	Language 2c (2 ECTS)	Language 18c (2 ECTS)	
Semester 1	**Semester 2**	**Semester 3**	**Semester 4**

1. Set of obligatory and optional courses and groups of courses in semestral arrangement

Semester 1 (as a part of EMJMD performed in Aix Marseille Université, Marseille, France)

Obligatory courses / groups of courses **Number of ECTS points 28**

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.	ICC025011w	Nano-Electrochemistry	15					K2Acne_W03, K2Acne_W08	15	30	1	1	0,7	T/Z	**E**		DN		K
2.	ICC025011c	Nano-Electrochemistry		9				K2Acne_U02	9	30	1	1	0,7	T/Z	Z		DN	P	K
3.	ICC025011l	Nano-Electrochemistry			3			K2Acne_W12, K2Acne_U02, K2Acne_U09, K2Acne_K05	3	30	1	1	0,7	T	Z		DN	P	K
4.	ICC025012w	Solid State Chemistry and Nanomaterials	36					K2Acne_W03, K2Acne_W05 K2Acne_W08	36	90	3	3	2,1	T/Z	**E**		DN		K
5.	ICC025012c	Solid State Chemistry and Nanomaterials		21				K2Acne_W12, K2Acne_U02	21	90	3	3	2,1	T/Z	Z		DN	P	K
6.	ICC025012l	Solid State Chemistry and Nanomaterials			6			,K2Acne_U02, K2Acne_U09, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
7.	ICC025013w	Organic chemistry of Nanomaterials	15					K2Acne_W03, K2Acne_W09	15	30	1	1	0,7	T/Z	Z		DN		PD
8.	ICC025013c	Organic chemistry of Nanomaterials		9				K2Acne_U14	9	30	1	1	0,7	T/Z	Z		DN	P	PD
9.	ICC025013l	Organic chemistry of Nanomaterials			3			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	3	30	1	1	0,7	T	Z		DN	P	PD
10.	ICC025014w	Basic Quantum Chemistry Modelling	15					K2Acne_W07, K2Acne_W01, K2Acne_W02	15	30	1	1	0,7	T/Z	Z		DN		K
11.	ICC025014c	Basic Quantum Chemistry Modelling		9				K2Acne_U01, K2Acne_U06, K2Acne_U04, K2Acne_U06	9	30	1	1	0,7	T/Z	Z		DN	P	K
12.	ICC025014l	Basic Quantum Chemistry Modelling			3			K2Acne_U01, K2Acne_U06, K2Acne_U04, K2Acne_U06, K2Acne_U09, K2Acne_K05	3	30	1	1	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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

13.	ICC025015w	Computational Modelling of Nano-Systems	24					K2Acne_W02, K2Acne_W07	24	90	3	3	2,1	T/Z	Z		DN		PD
14.	ICC025015c	Computational Modelling of Nano-Systems		21				K2Acne_U04, K2Acne_U06	21	60	2	2	1,4	T/Z	Z		DN	P	PD
15.	ICC025015l	Computational Modelling of Nano-Systems			18			K2Acne_U04, K2Acne_U06, K2Acne_U09, K2Acne_K05	18	60	2	2	1,4	T	Z		DN	P	PD
16.	ICC025016w	Thermodynamics of Materials-Interactions and Surface Forces	15					K2Acne_W08	15	30	1	1	0,7	T/Z	**E**		DN		K
17.	ICC025016c	Thermodynamics of Materials-Interactions and Surface Forces		9				K2Acne_U02, K2Acne_U04, K2Acne_U06,	9	30	1	1	0,7	T/Z	Z		DN	P	K
18.	ICC025016l	Thermodynamics of Materials-Interactions and Surface Forces			3			K2Acne_U02, K2Acne_U04, K2Acne_U06, K2Acne_U09, K2Acne_K05	3	30	1	1	0,7	T	Z		DN	P	K
19.	ICC025009c	Nano-engineering Seminar + Project		18				K2Acne_U07, K2Acne_W10, K2Acne_K03, K2Acne_K09	18	60	2		1,4	T/Z	Z			P	K
		Total	**120**	**96**	**36**				**252**	**840**	**28**	**26**	**19,6**		**3**				

Optional courses 18 hours in semester, 2ECTS points

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	CHC025001c	Language (English) C2		18				K2Acne_U15	18	60	2		1,4	T/Z	Z	O		P	KO
		Total		**18**					**18**	**60**	**2**		**1,4**						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
120	**114**	**36**			**270**	**900**	**30**	**26**	**19,6**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 courses / groups of courses Number of ECTS points 28

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			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.	ICC025001w	Crystallography and Structure of solids	30					K2Acne_W03, K2Acne_W08	30	60	2	2	1,4	T/Z	Z		DN		K
2.	ICC025001c	Crystallography and Structure of solids		15				K2Acne_U02, K2Acne_U07	15	30	1	1	0,7	T/Z	Z		DN	P	K
3.	ICC025002w	Synthesis and Fabrication of Nano-engineering Systems	30					K2Acne_W05, K2Acne_W09	30	60	2	2	1,4	T/Z	**E**		DN		K
4.	ICC025002c	Synthesis and Fabrication of Nano-engineering Systems		15				K2Acne_U02, K2Acne_U05, K2Acne_U14	15	30	1	1	0,7	T/Z	Z		DN	P	K
5.	ICC025003w	Fabrication of Smart Polymers	30					K2Acne_W05, K2Acne_W08, K2Acne_W09	30	60	2	2	1,4	T/Z	Z		DN		K
6.	ICC025003l	Fabrication of Smart Polymers			15			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_U09, K2Acne_K05	15	30	1	1	0,7	T	Z		DN	P	K
7.	ICC025004w	Engineering of Nano-machines	15					K2Acne_W06, K2Acne_W08, K2Acne_W09	15	30	1	1	0,7	T/Z	Z		DN		K
8.	ICC025004s	Engineering of Nano-machines					15	K2Acne_U03, K2Acne_U07, K2Acne_K01, K2Acne_K08	15	30	1	1	0,7	T/Z	Z		DN	P	K
9.	ICC025005w	Bio-photonics	15					K2Acne_W05, K2Acne_W03, K2Acne_W04	15	30	1	1	0,7	T/Z	**E**		DN		K
10.	ICC025005s	Bio-photonics					15	K2Acne_U03, K2Acne_U07, K2Acne_K01, K2Acne_K08	15	30	1	1	0,7	T/Z	Z		DN	P	K
11.	ICC025006w	Biomaterials-Biomedical Devices	15					K2Acne_W04, K2Acne_W09	15	60	2	2	1,4	T/Z	Z		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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

12.	ICC025006l	Biomaterials-Biomedical Devices			15			K2Acne_U09, K2Acne_U14, K2Acne_K05	15	30	1	1	0,7	T	Z		DN	P	K
13.	ICC025007w	Nanostructures in Industrial and Numerical Applications	30					K2Acne_W01, K2Acne_W02, K2Acne_W07, K2Acne_U01	30	60	2	2	1,4	T/Z	Z		DN		K
14.	ICC025007c	Nanostructures in Industrial and Numerical Applications		30				K2Acne_W01, K2Acne_U01, K2Acne_U06	30	60	2	2	1,4	T/Z	Z		DN	P	K
15.	ICC025007p	Nanostructures in Industrial and Numerical Applications				30		K2Acne_K08, K2Acne_K05	30	30	1	1	0,7	T/Z	Z		DN	P	K
16.	ICC025008w	Economics and Management	30					K2Acne_W14, K2Acne_K02	30	90	3		2,1	T/Z	Z				KO
17.	ICC025008c	Economics and Management		30				K2Acne_W14, K2Acne_K02, K2Acne_K06	30	60	2		1,4	T/Z	Z			P	KO
18.	ICC025009p	Nano-engineering Seminar + Project				30		K2Acne_U07, K2Acne_W10, K2Acne_U03, K2Acne_U07, K2Acne_K08, K2Acne_K01, K2Acne_K03 K2Acne_K08, K2Acne_K09, K2Acne_K05	30	60	2		1,4	T	Z			P	K
		Total	**195**	**90**	**30**	**60**	**30**		**405**	**840**	**28**	**21**	**19,6**		**2**				

Optional courses (minimum 30 hours in semester, 2 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	JZL100921c	Language(English) C2		30				K2Acne_U15	30	60	2		1,4	T/Z	Z	O		P	KO
		Total		**30**					**30**	**60**	**2**		**1,4**						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
195	**120**	**30**	**60**	**30**	**435**	**900**	**30**	**21**	**21**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 (as a part of EMJMD performed in University Tor Vergata, Rome, Italy)

Obligatory courses / groups of courses Number of ECTS points 23

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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.	ICC025021w	Nanoscale Synthesis Methods	24					K2Acne_W05, K2Acne_W03, K2Acne_W08	24	60	2	2	1,4	T/Z	**E**		DN		K
2.	ICC025021c	Nanoscale Synthesis Methods		15				K2Acne_U03, K2Acne_U04, K2Acne_U14	15	60	2	2	1,4	T/Z	Z		DN	P	K
3.	ICC025021l	Nanoscale Synthesis Methods			6			K2Acne_W12, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
4.	ICC025022w	Macromolecular and Supramolecular Chemistry	24					K2Acne_W09	24	60	2	2	1,4	T/Z	Z		DN		K
5.	ICC025022c	Macromolecular and Supramolecular Chemistry		15				K2Acne_W12, K2Acne_U06, K2Acne_U14	15	60	2	2	1,4	T/Z	Z		DN	P	K
6.	ICC025022l	Macromolecular and Supramolecular Chemistry			6			K2Acne_U06, K2Acne_U08, K2Acne_U09, K2Acne_U14, K2Acne_K05	6	30	1	1	0,7	T	Z		DN	P	K
7.	ICC025023w	Characterization of Nano-engineering Systems	24					K2Acne_W03	24	60	2	2	1,4	T/Z	**E**		DN		K
8.	ICC025023c	Characterization of Nano-engineering Systems		18				K2Acne_U07, K2Acne_U09	18	60	2	2	1,4	T/Z	Z		DN	P	K
9.	ICC025023l	Characterization of Nano-engineering Systems			12			K2Acne_W12, K2Acne_U07, K2Acne_U08, K2Acne_U09, K2Acne_K05	12	60	2	2	1,4	T	Z		DN	P	K
10.	ICC025024w	Nanoscale Energy Technology,Nano-sensors and Microfluidics	24					K2Acne_W04, K2Acne_W06, K2Acne_W10	24	60	2	2	1,4	T/Z	Z		DN		K
11.	ICC025024c	Nanoscale Energy Technology,Nano-sensors and Microfluidics		15				K2Acne_U07	15	60	2	2	1,4	T/Z	Z		DN	P	K
12.	ICC025024l	Nanoscale Energy Technology,Nano-sensors and Microfluidics			6			K2Acne_U07, K2Acne_U08, K2Acne_U12, K2Acne_U09, K2Acne_K05	6	30	1	1	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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

13.	ICC025009s	Nano-engineering Seminar + Project					18	K2Acne_W10, K2Acne_U07, K2Acne_U12, K2Acne_K08, K2Acne_K03, K2Acne_K09, K2Acne_K05	18	60	2		1,4	T/Z	Z			P	K
		Total	**96**	**63**	**30**		**18**		**207**	**690**	**23**	**21**	**16,1**		**2**				

Optional courses (minimum 45 hours in semester, 5 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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		**Block: Option A Chemistry(optional)**	**24**	**15**	**6**				**45**	**150**	**5**	5	**3,5**				**DN**		
a	ICC025025w	NMR of Nanosystems	24					K2Acne_W03, K2Acne_U13	24	60	2	2		T/Z	Z				K
b	ICC025025c	NMR of Nanosystems		15				K2Acne_U13	15	60	2	2		T/Z	Z			P	K
c	ICC025025l	NMR of Nanosystems			6			K2Acne_U09, K2Acne_U13	6	30	1	1		T	Z			P	K
d	ICC025026w	Structural and Function Properties of Biopolymers	24					K2Acne_W03, K2Acne_W09, K2Acne_U13	24	60	2	2		T/Z	Z				K
e	ICC025026c	Structural and Function Properties of Biopolymers		15				K2Acne_W12, K2Acne_U13	15	60	2	2		T/Z	Z			P	K
f	ICC025026l	Structural and Function Properties of Biopolymers			6			K2Acne_U09, K2Acne_U13	6	30	1	1		T	Z			P	K
2		**Block: Option B Modelling(optional)**	**24**	**15**	**6**				**45**	**150**	**5**	5	**3,5**				**DN**		
a	ICC025027w	Nanoscale Structural Transformations and Kinetics	24					K2Acne_W08	24	60	2	2		T/Z	Z				K
b	ICC025027c	Nanoscale Structural Transformations and Kinetics		15				K2Acne_U13	15	60	2	2		T/Z	Z			P	K
c	ICC025027l	Nanoscale Structural Transformations and Kinetics			6			K2Acne_U09, K2Acne_K05	6	30	1	1		T	Z			P	K
d	ICC025028w	Probability and Statistical Methods for Modelling Engineers	24					K2Acne_W01, K2Acne_U01, K2Acne_U03	24	60	2	2		T/Z	Z				K
e	ICC025028c	Probability and Statistical Methods for Modelling Engineers		15				K2Acne_W01, K2Acne_U01, K2Acne_U03, K2Acne_U05, K2Acne_U06	15	60	2	2		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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

f	ICC025028l	Probability and Statistical Methods for Modelling Engineers			6			K2Acne_W01, K2Acne_U01, K2Acne_U03, K2Acne_U05, K2Acne_U06, K2Acne_U09, K2Acne_K05	6	30	1	1		T	Z		DN	P	K
		Total	**24**	**15**	**6**				**45**	**150**	**5**	**5**	**3,5**						

Optional courses (minimum 18 hours in semester, 2 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	CHC025003c	Language (English) C2		18				K2Acne_U15	18	60	2		1,4	T/Z	Z	O		P	KO
		Total		**18**					**18**	**60**	**2**		**1,4**						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
120	**96**	**36**		**18**	**270**	**900**	**30**	**26**	**21**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 4

Obligatory courses / groups of courses Number of ECTS points ……..

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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																	

Optional courses (minimum 360 hours in semester, 30 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Total number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			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	ICC025040l	Master Thesis			360			K2Acne_W01, K2Acne_U09, K2Acne_U10, K2Acne_U11, K2Acne_U16 K2Acne_K04, K2Acne_K08, K2Acne_K07	360	900	30	30	21	T	Z		DN	P	K
		Total			**360**				**360**	**900**	**30**	**30**	**21**						

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					
		360			**360**	**900**	**30**	**30**	**21**

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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

Course / group of courses code	Names of courses / groups of courses ending with examination	Semester
ICC025011w	Nano-Electrochemistry	1
ICC025012w	Solid State Chemistry and Nanomaterials	
ICC025016w	Thermodynamics of Materials-Interactions and Surface Forces	
ICC025002w	Synthesis and Fabrication of Nano-engineering Systems	2
ICC025005w	Bio-photonics	
ICC025021w	Nanoscale Synthesis Methods	3
ICC025023w	Characterization of Nano-engineering Systems	
-	-	4

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

Semester	Allowable deficit of ECTS points after semester
1	-
2	-
3	-
4	-

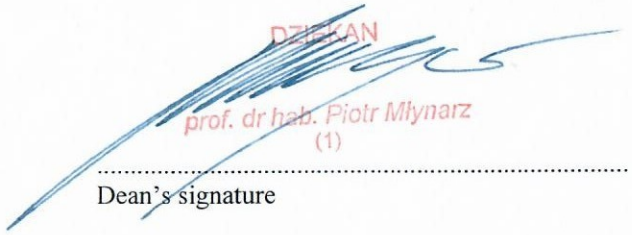
Caution!
T/Z – remote form of course is allowable only for forms: lecture, seminar, exercises; the Dean's approval of remote form of course is required and in total remote form cannot exceed 75% of ECTS points.

[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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – 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 course / group of courses – enter P. For the group of courses – 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 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish Podstawy Modelowania Kwantowo-Chemicznego
Name of subject in English Basic quantum chemistry modelling
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	9	3		
Number of hours of total student workload (CNPS)	30	30	30		
Form of crediting	Examination	Examination / crediting with grade*	/crediting with grade	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1	1	1		
including number of ECTS points for practical classes (P)		1	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7	0.7	0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Basic quantum chemistry modelling

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SUBJECT OBJECTIVES

C1 The main goal of this course is to learn how to run a quantum chemical calculation and analyze its output. In order to achieve this, students will learn a) the underlying concepts of the different families of quantum chemical methods, b) how to prepare the input of - and run a quantum chemical calculation c) how to extract and analyze the useful information from the output of the calculation

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 The students should understand the differences between the major classes of modeling methods: classical (molecular mechanics, MM), quantum (ab initio and semi-empirical wave-function methods, density based methods), mixed classical-quantum methods.

relating to skills:
PEU_U01 students will be able to select the appropriate methods in order to prepare, run and analyze a quantum chemistry calculation on a given system
relating to social competences:
PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	The concept of potential energy surfaces (PES) : stationnary points, gradient vector, Hessian matrix, minimum energy path 2.What is needed in an input of a quantum chemical calculation ? zmatrix, spin multiplicity, basis set, electronic state, geometry optimization, frequency calculations, specific molecular properties 3.What is the method of choice to model my system ? Short review of quantum chemistry methods, their pros and cons	15
	Total hours	15

Classes + Laboratory		**Number of hours**
Cl1 + Lab 1	Use of commercial quantum chemical softwares and graphical interfaces. The students will gain hands-on experience with performing quantum chemical calculations, and analyzing the results : a. Butterfly inversion in AX3 compounds b. Ring strain in small molecules c. Steric hindrance	12
	Total hours	12

TEACHING TOOLS USED
N1. Lecture N2. Computer Lab hours

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 Written exam	PEU_W01	
F2 Hands-on report	PEU_U01	
P=0.6*F1+0.4*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Essentials of computational chemistry, Theories and Models, C.J. Cramer, Wiley.
Introduction to computational chemistry, F. Jensen, Wiley. Computational chemistry : introduction to the theory and applications of molecular and quantum mechanics, E.G.Lewars, Springer

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

D. Hagebaum-Reignier (http://ism2.univ-amu.fr/fr/annuaire/ctom/hagebaum-reignierdenis) S. Humbel (http://ism2.univ-amu.fr/fr/annuaire/ctom/humbelstephane)

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Biomateriały i Urządzenia Biomedyczne
Name of subject in English Biomaterials and Biomedical Devices
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	60		30		
Form of crediting	Examination / crediting with grade*		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)	1,4		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Basic knowledge of chemical engineering

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SUBJECT OBJECTIVES

C1 - Getting acquainted with the types of drug carriers and the basic mechanisms of drug release.
C2 - Familiarization with the structure and principle of operation of nanosensors used in medicine.
C3 - Getting acquainted with the method of producing drug carriers and the method of determining the release rate of drugs.

SUBJECT EDUCATIONAL EFFECTS

In terms of knowledge:
The person who successfully completed the course:
PEU_W01 - the student will be able to classify the structural aspects of biomaterials.
PEU_W02 - the student will be able to name and describe the elements of designing biomaterials for the human body.

In terms of skills:
The person who successfully completed the course:
PEU_U01 - The student will be able to determine the biological properties of materials.
PEU_U01 - The student will be able to build a simple blood glucose meter

In terms of social competences:
The person who successfully completed the course:
PEU_K01 - Can work in a group of several people, both in conducting experiments and computer processing of the results

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Introduction to the course. The idea of drug dosing in long-term local therapy. (Bio)biocompatible polymers. Diffusive transport of drugs from homo- and heterogenous drug carriers. Description of the release rate controlled by diffusion and dissolution Hydrogels applied externally and internally. Enzymatic release of drugs. Bioluminescent sensors Biosensors based on DNA. Credits in writing.	15
	Total hours	15

Laboratory		**Number of hours**
Lab1	Biological Performance of Materials	7
Lab 2	Micro/Nanofluidics for Bioengineering & Lab-on-a-Chip – construction of glucometer	8
	Total hours	15

TEACHING TOOLS USED
N1. Lecture with multimedia presentation N2. Laboratory N3. Description of experimental results using computer graphics programs N4. Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P(lecture)	PEU_W01 - PEU_W02	Final test (max. 10 points)
P2 (laboratory)	PEU_U01 – PEU_U02 PEK_K01	Attendance at the classroom (4.5 points) Reports (5.5 points)

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: Biomedical Engineering - W.M. Saltzman Applied Biophysics for drug discovery - D.Huddler, E.R.Zartler Advanced Biomaterials and Biodevices - A.Tivari, A.N.Nordin **SECONDARY LITERATURE:** Biosensors Nanotechnology - A.Tivari, A.P.F.Turner
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. dr hab. inż. Anna Trusek, anna.trusek@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Biofotonika
Name of subject in English Biophotonics
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	30				30
Form of crediting	Examination				crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1				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				0,7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of physics.
2. Fundamentals of chemistry
3. Fundamentals of biology on the high school level

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SUBJECT OBJECTIVES

C1 To provide students with additional knowledge in the field of light-matter interactions
C2 Familiarize students with knowledge about modern use of light in biology and medicine
C3 To provide students with an additional knowledge about materials used in light-related therapies
C4 Familiarizing students with modern biophotonics

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:
PEK_W01 student has a structured, theoretically founded general knowledge covering key issues in the field of light-matter interaction
PEK_W02 student knows new methods of bioimaging
PEK_W03 student knows modern methods of lasers applications in biology and medicine
PEK_W04 student knows the basic methods of application of biosensors

PEK_W06 student knows and understands selected applications of plasmonic nanoparticles
PEK_W07 student knows and understands the perspectives and risks associated with the use of light
PEK_W08 student knows the modern methods of photodynamic therapies
PEK_W09 student has knowledge about photonic biocrystals
PEK_W10 student knows new ways of photoproductions by 3-D technique

related to skills:
PEK_U01 – student can name and define biophotonics. He knows the latest literature on biophotonics. Searching for information on biophotonics from available sources.
PEK_U02 – student knows how to use lasers in biology and medicine
PEK_U03- student is able to name and define advanced equipment used in biophotonics
PEK_U04- student has language skills in the field of biophtonics
PEK_U05- student can name and define biosensors
PEK_U06- student has language skills in the field of biophotonics
PEK_U07- student is able to make a critical analysis of the prospects for the use of biomaterials
PEK_U08- student can name and define new biomaterials
PEK_U09- student knows the latest literature on biomaterials
PEK_U10 - student knows the various applications of DNA
PEK_U11 – student can give an example of biosensor
PEK_U12 - student knows bio-derivatives for photonics and material engineering
PEK_U13- student can define photonic biocrystals
PEK_U14 - student knows the 3-D printing technique with light

related to social competences:
PEK_K01student 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.
PEK_K02 student is able to work in a group, performing various roles including group leader.
PEK_K03 student is aware of the social role of the engineer.
PEK_K04 student is ready to critically evaluate his/her knowledge and received content.

PROGRAMME CONTENT		
Lecture		Number of hours
Lec 1	Fundamentals of light-matter interactions Principles of lasers, current laser technology. Bioimaging – principles, techniques and applications. Principles of biosensors. Plasmonic nanoparticles for cancer detection and treatment. Light activated therapies, photodynamic therapy. Photonic biocrystals. Biocompatible materials for photonics - 3-D printing of new biomaterials.	15
	Total hours	15

Seminar	**Number of hours**

Semin 1	Plasmonic nanoparticles for cancer detection and treatment Biomaterials for photonics Nonlinear bioimaging Photonics crystals in nature Photodynamic therapy Biosensors in practice Advances in 3-D printing for medicine Bioimaging in therapies	15
	Total hours	15

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 seminars	PEU_W01-W10	test
P2 lecture	PEU_U01-U14 PEU_K01-K04	presentations assessment

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Paras N. Prasad, Nanophotonics, Wiley-Interscience, 2004

[2]Challa Kumar, Nanomaterials for Medical Diagnosis and Therapy, Wiley, 2007
[3] Yoon Yeo, Nanoparticulate drug delivery systems : strategies, technologies, and applications, Wiley, 2013
[4] Paras N. Prasad, Introduction to biophotonics, Wiley-Interscience; 2003
[5] Ruikang K. Wang, Valery V Tuchin ,Advanced Biophotonics: Tissue Optical Sectioning, CRC Publishing, 2013

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

Dr hab. inż. Katarzyna Matczyszyn, katarzyna.matczyszyn@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in Polish Komputerowe modelowanie nanosystemów
Name of subject in English Computational modeling of nanosystems
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	21	18		
Number of hours of total student workload (CNPS)	90	60	60		
Form of crediting	Examination / c	crediting with grade*	crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	3	2	2		
including number of ECTS points for practical classes (P)		2	2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.1	1.4	1.4		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. general Physics, basic molecular chemistry

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SUBJECT OBJECTIVES

C1The main goal of this course is to study the molecular dynamics and Monte Carlo methodology for atomistic numerical modeling. Introduction to the quantum ab initio methods.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01students will understand molecular dynamics and Monte Carlo methodology for atomistic numerical modeling.
relating to skills:
PEU_U01 students will be able to start design, start and analyse molecular modeling projects
relating to social competences:

PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Engineering computation applied to nanotechnology: Monte Carlo and molecular dynamics methods. Principles of molecular simulations.	24
	Total hours	24

Classes + Laboratory		**Number of hours**
cl1 + Lab 1	1.Use open-source and commercial software. The students will gain hands-on experience with development of molecular dynamics and Monte Carlo codes, performing simulations, and analyzing simulation results. 2. The students will also learn to apply molecular simulation techniques for solving nanoengineering problems 3. Problem statements, selecting algorithms, writing computer programs, and analyzing output using Matlab (Scilab, Python).	39
	Total hours	39

TEACHING TOOLS USED
N1. Lecture N2. Computer Lab hours

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 Written exam	PEU_W01	
F2Project report	PEU_U01	
P=0.5*F1+0.5*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Understanding molecular simulations, D. Frenkel. B. Smith. Molecular Modelling, A.Leach

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
B. Kuchta (http://madirel.univ-amu.fr/pages_web_KUCHTA_BOGDAN/infos

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Ekonomia i zarządzanie
Name of subject in English Economics and management
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	90	60			
Form of crediting	crediting with grade*	crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	3	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)	2,1	1,4			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

None

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SUBJECT OBJECTIVES

C1 . Acquiring the knowledge of basic notions, methods and tools in economics
C2 . Acquiring the knowledge of basic notions, methods and tools in management

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

After the course, the student:
PEU_W01 – knows basic definitions in economics;
PEU_W02 – knows basic definitions in management;

related to skills:

After the course, the student:

PEU_U01 – is able to interpret financial information about organization;
PEU_U02 – is able to make basic management decisions in organization on the basis of financial information;
PEU_U03 – is able to define, plan and control the realization of projects;
PEU_U04 – is able to make managerial decisions on the basis of mathematical models.

related to social competences:
After the course, the student:
PEU_K01 – is able to discuss the current position and development possibilities of an organization;
PEU_K02 – is able to present the arguments for selected managerial decisions.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Financial information – balance sheet Financial information – revenues, expenditures, profit, cash flow Managerial accounting – variable and fixed cost Managerial accounting – breakeven point Managerial accounting – direct and indirect cost Managerial accounting – activity based costing Investment decisions – NPV, IRR, PI Mathematical models in managerial decisions Project definition Project planning Project control Budgeting	30
	Total hours	30

Classes		**Number of hours**
Cl 1	Financial information – balance sheet Financial information – revenues, expenditures, profit, cash flow Managerial accounting – variable and fixed cost Managerial accounting – break even point Managerial accounting – direct and indirect cost Managerial accounting – activity based costing Investment decisions – NPV, IRR, PI Mathematical models in managerial decisions Project definition Project planning Project control Budgeting Risk management	30
	Total hours	30

TEACHING TOOLS USED
N1. Diaporama presentations N2. Computational examples (EXCEL) N3. Open discussion of managerial 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
F	PEU_K01, PEU_K02	Continuous evaluation of participation in the discussions
P	PEU_W01, PEU_W02, PEU_U01, PEU_U02, PEU_U03, PEU_U04, PEU_U01	Test at the end of the semester: minimum 50% of points

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

1. J.K. SHIM, J.G. SIEGEL, THEORY AND PROBLEMS OF FINANCIAL ACCOUNTING, THE MCGRAW-HILL COMPANIES, INC., 1999
2. J.K. SHIM, J.G. SIEGEL, MANAGERIAL ACCOUNTING, THE MCGRAW-HILL COMPANIES, INC., 2012
3. PROJECT MANAGEMENT, VIBRANT PUBLISHERS, 2017

SECONDARY LITERATURE:

1. C.F. GRAY, PROJECT MANAGEMENT, 6E, THE MCGRAW-HILL COMPANIES, INC., 1999
2. D.H. MARSHALL, A SURVEY OF ACCOUNTING, IRWIN INC. 1983
3. H.P.WILLIAMS, MODEL BUILDING IN MATHEMATICAL PROGRAMMING, JOHN

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

Dorota KUCHTA e-mail: dorota.kuchta@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Inżynieria nanomaszyn
Name of subject in English Engineering of Nanomachines
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	30				30
Form of crediting	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 classes (P)					1
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7				0.7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. *Elemental mathematics: Analysis I and II, algebra*
2. *Elemental physics: Physics I and II*
3. *Elemental chemistry: General chemistry, organic chemistry*

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SUBJECT OBJECTIVES

C1 Application of thermodynamics and organic chemistry to nanoengineering.
C2 Understanding structure and dynamics of molecules elements of molecular motors.
C3 Gives ability to select Artificial Molecular Machines for particular application.

SUBJECT EDUCATIONAL EFFECTS

Relating to knowledge:

A person who passed the subject
PEU_W01 – knows fundamentals of structure and thermodynamics of molecules
PEU_W02 – knows fundamentals of the description of artificial molecular machines
PEU_W03– knows fundamentals of the functioning molecular machines

Relating to skills:
A person who passed the subject
PEU_U01 – can solve elementary structural and thermodynamics problems related to Artificial Molecular Machines
PEU_U02– can select MM according to the required application.
PEU_U03– can find a design for particular molecular level job
Relating to social competences:
A person who passed the subject
PEU_K01 – possesses ability of combining information from disparate fields of science (mathematics, physics, chemistry, mechanics) to arrive at coherent conclusions

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Elements of molecular structures related to Molecular Machines (MM) Laws of thermodynamics. Entropy, free energy and free enthalpy. Potential energy surfaces, External potential and MM interactions Thermal fluctuations. Ratchet and Brownian machines. Rotaxanes. Molecular shuttles. Molecular switches. The power sources for artificial molecular-level machines. Applications of MM	15
	Total hours	15

Seminar		**Number of hours**
Sem1	Mechanically interlocked molecules. Mechanical bonds versus covalent bond Molecular pump From molecular shuttle to switches Unidirectional transport Motors and car race Nano-molecular machines powered by light Nano-molecular machines powered by chemistry Surface nanomachines	30
	Total hours	30

TEACHING TOOLS USED
N1. *Lecture: multimedia presentation* N2. *Seminar: a set of problems, presented to the students for individual elaboration and discussed during the seminar*

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during	Learning outcomes code	Way of evaluating learning outcomes achievement

semester), P – concluding (at semester end)		
F1	*PEU_U01, PEU_U02, PEU_U03*	Presentation
F2	*PEU_W01, PEU_W02, PEU_W03*	Exam
P	**P= 0.5(F1+F2)** Condition of passing: P=50% or more	

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: 1. Peter Atkins, Julio De Paula, "Atkins' Physical Chemistry", Eighth edition, Oxford University Press, Oxford 2006 2. Collection of scientific journal papers **SECONDARY LITERATURE:** 1. NIST WebBook - Chemistry
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Szczepan Roszak, Szczepan.roszak@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Synteza „inteligentnych" polimerów
Name of subject in English Fabrication of "smart" polymers
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	60		30		
Form of crediting			/ 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		0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of organic and inorganic chemistry from 1st level of studies.
2. Basic laboratory skills and ability for teamwork

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SUBJECT OBJECTIVES

C1 To provide students with a general knowledge of polymerization reactions as well as relation between materials structure and their physicochemical properties.
C2 To familiarize students with main classes of smart polymers and their potential in various aspects of modern life and industry.
C3 Widening the knowledge about the latest achievements in smart polymers field.
C4 To acquaint students with some practical aspects of polymerization (selected methods, polymerization mixture composition, reaction parameters, preparation procedures) important for fabrication of polymers with designed purposes.

SUBJECT EDUCATIONAL EFFECTS

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

Student, who has completed the course:

PEU_W01 has gained knowledge of structure and techniques of various polymers synthesis for special applications

PEU_W02 knows relations between polymers structure, properties and applications of those materials and can design polymerization process for fabrication of final products

PEU_W03 is familiar with main groups of smart polymers and their application in various fields

relating to skills:

PEU_U01 is able to select and apply basic methods of polymer synthesis to obtain materials having designed properties

PEU_U02 can evaluate the basic parameters of synthesis influencing polymer structure and morphology

PEU_U03 is able to prepare a final report describing performed block of experiments and obtained results summarized by detailed analysis of properties in relation to polymer structure and synthesis method

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Polymers – definition, basic knowledge of polymers, types of polymerizations Irregularities in polymerization reactions, random character of polymerizations Special types of polymerizations (ROMP, ATRP etc.), polymers topology, controlling polymerization kinetics, controlling polymers' composition and physical properties. Part I Special types of polymerizations (ROMP, ATRP etc.), polymers topology, controlling polymerization kinetics, controlling polymers' composition and physical properties. Part II Physical means of controlling the properties of polymers and "plastics" Thermosensitive polymers and their applications Temperature swing sorption, grafted polymers. Organizing the polymer architecture around template - Molecularly Imprinted Polymers (MIP) Application of MIPs to separation science and catalysis Polymeric carriers for biomolecules Properties of such polymers and requirements towards carrier-enzyme system Synthetic polymers for solid phase syntheses, polymeric scavengers Ion-exchangers and their applications (ion-exchange, catalysis) Polymeric fibres, membranes for separation processes (also hybrid materials) Polymers for ion-exchange chromatography, separation of aminoacids	30
	Total number of hours	30

	Laboratory	**Number of hours**
Lab 1	Synthesis of stimuli-responsive hydrogels.	30

	Internal phase emulsion polymerization (HIPE) as a method used for formation of polymeric materials with unique porous structures. Basic characterization of obtained materials.	
	Total hours	30

TEACHING TOOLS USED

N1. Lectures with multimedia presentations
N2. Performing experiments with different laboratory equipment and instruments
N3. Preparation of report including analysis and interpretation of obtained results

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_U01-U03	2 graded summary reports
F2	PEU_U01-U02	Final colloquium
P1 (lecture)	PEU_W01-W03	Written test (minimum examination pass mark is 53 %)
P 2 (laboratory) Grade = (F1 + F2)/2		

PRIMARY AND SECONDARY 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] L.H. Sperling, "Introduction to Physical Polymer Science", 4th ed., Hoboken, NJ, John Wiley & Sons, 2006.
[4] F. Billmayer, "Textbook of Polymer Science", 3rd ed., New York [etc.], John Wiley & Sons, 1984.
[5] K. Dorfner (Ed.), "Ion exchangers", Walter de Gruyter, New York, 1991 (or later reprints).
[6] M. Komiyama, T. Takeuchi, T. Mukawa, H. Asanuma, „Molecular Imprinting: From Fundamentals to Applications", Weinheim, Wiley-VCH 2003.

SECONDARY LITERATURE:

[1] R.M. Ottenbrite, K. Park, T. Okano (Eds.), "Biomedical Applications of Hydrogels Handbook", Springer Science & Business Media New York, 2010.
[2] R. Barbucci (Ed.), "Hydrogels. Biological Properties and Applications", Springer-Verlag Italia, Milan 2009.
[3] N.R. Cameron, D.C. Sherrington, "High internal phase emulsions (HIPEs) — Structure, properties and use in polymer preparation", in: Biopolymers Liquid Crystalline Polymers Phase Emulsion, Advances in Polymer Science, vol 126, Springer, Berlin, Heidelberg 1996.

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

Prof. dr hab. inż. Andrzej Trochimczuk, andrzej.trochimczuk@pwr.edu.pl (lecture)
Dr inż. Anna Jakubiak-Marcinkowska, anna.jakubiak@pwr.edu.pl (laboratory)

Zał. nr 5 do ZW 16/2020

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in Polish Nano-Electrochemia
Name of subject in English Nano-Electrochemistry
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	9	3		
Number of hours of total student workload (CNPS)	30	30	30		
Form of crediting	Examination /	crediting with grade	crediting with grade	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1	1	1		
including number of ECTS points for practical classes (P)		1	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7	0.7	0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. general chemistry.

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SUBJECT OBJECTIVES

The main goal of this lecture is to acquire the basics of electrochemistry and electrochemical methods. The interest of electrochemistry in the field of nanoengineering will be demonstrated trough examples in nanosynthesis and characterization.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01student should be able to explain theoretically the behaviour of simple electrochemical interface using the main model in thermodynamics and kinetics.

relating to skills:

PEU_U01students will be able to understand the main principles of electrochemistry and apply them to nanomaterials (synthesis and characterization)

PEU_U02 They will also acquire the basic knowledge about the experimental implementation of the main electrochemical techniques that can be used as characterization tool in general or more specifically in nanomaterials.
relating to social competences:
PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	.Electrochemistry basics: thermodynamics and kinetics applied to electrochemistry 2. Experimental approach of electrochemistry: steady state and transient methods (voltametry, chronopotentiometry, chronoamperometry, pulse methods...), impedance spectroscopy. 3. Application to the synthesis and characterization of nanomaterials (nanoparticles, nanostructured surfaces...)	15
	Total hours	15

Laboratory		**Number of hours**
Cl1 + Lab 1	Experimental approach of electrochemistry: steady state and transient methods (voltametry, chronopotentiometry, chronoamperometry, pulse methods...), impedance spectroscopy.	12
	Total hours	12

TEACHING TOOLS USED
N1. Lecture N2.Lab hours

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 Exam (100%)	PEU_W01, PEU_U01, PEU_U02	
F2		
F3		
P=F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Recommended or required readings BARD / ALLEN : Electrochemical Methods: Fundamentals and Applications Pierre FABRY : Electrochemistry: The Basics, With Examples.

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

C. . Lebouin, F. Vacandio

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Nanostruktury w przemysłowych i numerycznych zastosowaniach
Name of subject in English Nanostructures in Industrial and Numerical Applications
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30		30	
Number of hours of total student workload (CNPS)	60	60		30	
Form of crediting	crediting with grade*	crediting with grade*		crediting with grade*	
For group of courses mark (X) final course					
Number of ECTS points	2	2		1	
including number of ECTS points for practical classes (P)		2		1	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4		0,7	

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

C1 Gaining basic knowledge of computational quantum chemistry
C2 Gaining knowledge how to select the proper computational technique for application in nano-engineering
C3 Application of computational quantum chemistry methods to model properties of light-driven molecular motors.

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SUBJECT OBJECTIVES

C1 Gaining basic knowledge of computational quantum chemistry
C2 Gaining knowledge how to select the proper computational technique for application in nano-engineering
C3 Application of computational quantum chemistry methods to model properties of light-driven molecular motors

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEK_W01 Student has knowledge regarding the variety of quantum-chemistry methods
PEK_W02 Student can choose the right computational approach to specific properties of nano-systems
PEK_W03 Student knows the basic principles of operation of light-driven molecular machines

related to skills:

PEK_U01 Student can work in the high-performance computing center environment
PEK_U02 Student can run efficiently quantum-chemistry programs
PEK_U03 Student can analyze the results of quantum-chemistry calculations
PEK_U04 Student can pinpoint the operation mechanism of light-driven molecular machines using computational quantum chemistry methods

related to social competences:

PEK_K01student understands the need to inform the public about the need to achieve the goals of development of nanoengineering
PEK_K02 student is able to work in a group, performing various roles including group leader
PEK_K03 student is aware of the social role of the engineer
PEK_K04 student is ready to critically evaluate his/her knowledge and received content

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Applications of computational quantum chemistry in modeling of nanostructures – an overview	
	The basics of molecular quantum mechanics	
	Hartree-Fock self-consistent-field method	
	Density functional theory. Kohn-Sham method.	
	Time-dependent density functional theory: formalism and applications.	
	Gaussian basis sets for molecular calculations	
	Methods to account for environmental effects	
	Electron correlation: Møller-Plesset perturbation theory	
	Electron correlation: Coupled-cluster theory	
	Electron correlation: Multiconfigurational self-consistent-field method	
	Applications: Modeling of excited states	
	Applications: Light-driven molecular motors (part 1)	
	Applications: Light-driven molecular motors (part 2)	
	Applications: Light-driven molecular motors (part 3)	
	Total hours	30

Classes		Number of hours
Cl	Introduction to high-performance computer center environment	
C2	Quantum chemistry computer tools: an introduction.	
C3	Building structures, geometry optimization, vibrational analysis	
C4	Building structures, geometry optimization, vibrational analysis (cont.)	
C5	Hartree-Fock self-consistent-field method	
C6	Density functional theory and its time-dependent extension	
C7	Methods to account for environmental effects	
C8	Møller-Plesset perturbation theory and coupled-cluster theory	
C9	Project 1: Modeling of spectra of molecules in solution (individual assignments)	
C10	Project 1: Modeling of spectra of molecules in solution (individual assignments)	
C11	Multiconfigurational self-consistent field method	
C12	Project 2: Light-driven molecular motors (individual assignments)	
C13	Project 2: Light-driven molecular motors (individual assignments)	
C14	Project 2: Light-driven molecular motors (individual assignments)	
C15	Project 2: Light-driven molecular motors (individual assignments)	
	Total hours	30

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

Project		Number of hours
Proj 1	Introductory classes	
Proj 2	Individual assignments	
Proj 3	Application of multiscale modeling in nanotechnology	
Proj 4	Fundamentals of molecular dynamic simulations	
Proj 5	Thermostats and barostats	
Proj 6	Force-fields	
Proj 7	Modeling in transport using molecular dynamics	
Proj 8	Predicting properties using molecular dynamics	
Proj 9	Combining molecular dynamics with other modeling techniques	

Proj 10	Individual assignments (assessment part 1)	
Proj 11	Project 1: presentations	
Proj 12	Molecular machines and molecular dynamics (part 1)	
Proj 13	Individual assignments (assessment part 2)	
Proj 14	Molecular machines and molecular dynamics (part 2)	
Proj 15	Project 2: presentations	
	Total hours	30

TEACHING TOOLS USED
N1. Lecture with multimedia presentation N2. Hands-on sessions using computers N3. Preparation of 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
P (lecture)	PEK_W01 - PEK_W03	Written evaluation
F1-F15 (class)	PEK_U01 - PEK_U04	Evaluation of individual reports
F1-F15 (Project)	PEK_U03 – PEK_U04 PEK_K01 – PEK_K04	Evaluation of the student's project presentation

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: N. Levine, „Quantum Chemistry", 7th Edition, Pearson Education, 2014. **SECONDARY LITERATURE:** Roos, R. Lindh, P. A. Malmqvist, V. Veryazov, P. O. Widmark, „Multiconfigurational Quantum Chemistry", 1st Edition, Wiley, 2016. Koch, M. C. Holthausen, „A Chemist's Guide to Density Functional Theory", 2nd Edition, Wiley, 2000.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Dr. Robert Zaleśny E-mail: robert.zalesny@pwr.edu.pl

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish Chemia organiczna materiałów
Name of subject in English Organic chemistry of materials**.**
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	9	3		
Number of hours of total student workload (CNPS)	30	30	30		
Form of crediting	Examination /	Examination / crediting with grade*	crediting with grade	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1	1	1		
including number of ECTS points for practical classes (P)		1	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7	0.7	0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. general organic chemistry, aromatic chemistry chemistry

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SUBJECT OBJECTIVES

C1 The main goal of this course is to study the important reactions that are useful for the generation of π-conjugated materials and the functionalization of nanomaterials. Introduction to palladium-catalyzed coupling reactions and chemistry of nanocarbons.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01The students should understand the chemical and physical principles that underlie the synthesis, structure and properties of organic molecules.

relating to skills:

PEU_U01 students will be able to design synthetic schemes toward functional molecular architectures

relating to social competences:

PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	- General concepts (upgrade): - bonding/antibonding molecular orbitals in organic molecules - pi-conjugation and aromaticity - resonance/inductive effect of substituents - nucleophiles/electrophiles - main classes of organic reactions - Aromatic chemistry: - electrophilic aromatic substitution: mechanism, reactions, regiochemistry - nucleophilic substitution - Coordination chemistry: - coordination complexes: type of ligands, d-block metals, number of valence electrons - structures: octahedral, tetrahedral, and square planar geometries - bonding in coordination complexes: crystal-field model and ligand-field theory Cross-coupling reactions: - catalysis: definition, catalytic cycle - palladium-catalyzed cross-coupling reactions: general concepts, palladium coordination complexes - a case study: the Sonogashira reaction Optical properties of pi-conjugated organic materials: - Electronic absorption, fluorescence - Applications in organic electronics	15
	Total hours	15

Classes + Laboratory		**Number of hours**
Cl1 + Lab 1	Covalent and non-covalent functionalization of carbon nanotubes and graphene.	12
	Total hours	12

TEACHING TOOLS USED
N1. Lecture N2. Practical exercises

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 Written exam (60%)	PEU_W01	
F2 Project presentations (40%)	PEU_U01	
P=0.6*F1+0.4*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Review papers in Chemical Reviews and the relevant papers in journals of organic chemistry
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
F. Fages (http://www.cinam.univ-mrs.fr)

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Nanoinżynieria Seminarium + Projekt
Name of subject in English Nano-engineering Seminar + Project
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)		18			
Number of hours of total student workload (CNPS)		60			
Form of crediting	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points		2			
including number of ECTS points for practical classes (P)		2			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)		1.4			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Bases of physics and chemistry.
2. Introductory notions in material science.
3. Basic information on programming and computer simulations.
4. Basic knowledge about potential applications of nanotechnologies.

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SUBJECT OBJECTIVES

C1 . Analysis of current trends in nanotechnology and nanoengineering.
C2 . Update on the newest discoveries in nanotechnology and nanoengineering.

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:
After the course, the student:

PEU_W01 – knows the current trends and discoveries in nanotechnology and nanoengineering;
PEU_W02 – understand what are the real perspectives of nanotechnologies development;

related to skills:

After the course, the student:
PEU_U01 – is able to search for information in international scientific journals;
PEU_U02 – is able to analyze the information from a scientific paper;
PEU_U03 – is able to prepare a synthetic, comprehensive slides of scientific quality;
PEU_U04 – is able to give the presentation and give quality answers to the questions in the discussion following presentation.

related to social competences:

After the course, the student:
PEU_K01 – is able to discuss the current trends in nanotechnologies;
PEU_K02 – is able to present the arguments for the large scale applications of nanotechnologies;
PEU_k03 – is able to take part and argue in discussions about the environmental and health consequences of nanotechnologies development.

PROGRAMME CONTENT		
Seminar		**Number of hours**
Cl1	Introduction to nanoengineering: nanoscale fabrication, top-down and bottom-up approaches: nanolithography and self-assembly. Synthesis techniques, processes, microstructural control, and unique physical properties of materials in nanodimensions Nanoscale detection methods. Molecular electronics. Nanotechnology in integrative systems. Nanotechnology in magnetic systems Quantum mechanics in nanoelectronics, Wave mechanics, the Schroedinger equation, free and confined electrons, band theory of solids Biomimetic systems: nanomotors, lipid vesicles. Nanobiotechnology. Nanofluidics. Mechanical behavior of nanostructures. Nanoactuators. Specific role of molecular interactions and signal pathways at nanoscale. Chemical principles involved in synthesis, assembly, and performance of nanostructured materials and devices. Classical and statistical thermodynamics of small systems: chemical and physical interactions, transport of matter, diffusion. Characterization tools of nanomaterials and nanostructures. 0D, 1D, and 2D nanosolids: nanotubes, nanowires, nanodots. Nanoparticles and nanocomposites. Nanoscale optoelectronics. Nanowires, quantum dots, thin films, electrical transport, electron emission properties, optical properties. Optical tweezers., Carbon-based nanomaterials. Supramolecular chemistry. Liquid crystals. Colloid and polymer chemistry. Surface modification and functionalization. Catalysis. Biomolecules: structure/function relation. Principles of biochemistry tailored to nanotechnologies. Nanomedicine . Broad implications of nanotechnology. Problems in miniaturization: scaling laws, nanoscale physics.	

	Total hours	18

TEACHING TOOLS USED
N1. Diaporama presentations. N2. Review of recent articles published in relevant ‘nano’ oriented scientific journals. N3. Invited presentations of scientists and industrial staff working in the domains of nanotechnology. N4. Analysis of the potential master thesis subjects. .

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_U02, PEU_U03, PEU_U04, PEU_K01, PEU_K02, PEU_K03	30’ presentation on a chosen aspect/application of nanotechnology or nanoengineering will be graded.

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Scientific journals from the field of nanosciences.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Bogdan KUCHTA e-mail: bogdan.kuchta@univ-amu.fr

Zał. nr 5 do ZW 16/2020

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in Polish Chemia Ciała Stałego i Nanomateriały
Name of subject in English Solid-State Chemistry and Nanomaterials
Main field of study (if applicable): …….
Specialization (if applicable): Chemical Nano Engineering
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	36	21	6		
Number of hours of total student workload (CNPS)	90	90	30		
Form of crediting	Examination	Examination / crediting with grade*	crediting with grade	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	3	3	1		
including number of ECTS points for practical classes (P)		3	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.1	2.1	0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. general (inorganic) chemistry,
2. basic physical-chemistry,
3. basic thermodynamics.

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SUBJECT OBJECTIVES

C1 The objectives of this course is threefold: to describe and characterize the crystalline structure of bulk materials and to know the main techniques used for their elaboration, to overview the different conventional and emergent chemical methods applied to elaborate nanomaterials using bottom-up (and top-down) approaches and finally to comprehend the relations between structure and properties

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 Describe and study the crystalline structure of materials

relating to skills
PEU_U01 - Select and optimize a protocol to elaborate inorganic solid nanomaterials according to given specifications
PEU_U02 Comprehend the relations between structure and properties
relating to social competences:
PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	1/ After a brief introduction on symmetry elements and operations, the structure of important classes of solids is developed: Metals simple close packed structures, Basic simple structures such as salts (CsCl, NaCl, CaF2), oxides (Na2O) and sulphides (ZnS) and more complex structures: carbon-based structures (graphite and diamond) and oxides (rutile, perovskite, layered perovskite, spinel). 2/ The second chapter focussed on X-Ray diffraction techniques. First the basics of X-Ray diffraction is presented then the acquired knowledge is applied on the study of crystalline structures using X-Ray diffraction patterns obtained on powders. 3/ The last chapter deals with the description of elaboration techniques that are conventionally used to prepare powders at micrometer scale.	18
Lec 2	1/ Brief introduction on the unique properties of nanomaterials and their applications in the multiple domains of nanotechnology (environment, energy, medical, optics, lab-on-chip…). 2/ Chemistry involved in the synthesis of inorganic (metal oxides, metals, quantum-dots) nanostructured materials. Understand the various steps that lead to nanomaterials from molecular and/or supramolecular precursors. Condensation in solution, solid-state reactions, sol-gel chemistry, colloidal chemistry, surface functionalisation. 3/ Understand the Thermodynamic and kinetic controls over nucleation, growth, ripening, and self-assembly at the nanoscale. 4/ Describe the elaboration of model nanostructured materials including nanoparticles, nano-wires, nano-coatings, nanoporous materials, hierarchical nanomaterials, nanocomposites, and their properties and applications. 5/ Describe the potential combinations of these materials with “topdown” processes such as lithography, nano-imprint, micro-contact printing, selective etching to elaborate complex nanopatterns.	18
	Total hours	36

PROGRAMME CONTENT		
Classes		**Number of hours**
Cl1	1/ After a brief introduction on symmetry elements and operations, the structure of important classes of solids is developed: Metals simple close packed structures, Basic simple structures such as salts (CsCl, NaCl, CaF2), oxides (Na2O) and sulphides (ZnS) and more complex structures: carbon-	11

	based structures (graphite and diamond) and oxides (rutile, perovskite, layered perovskite, spinel). 2/ The second chapter focussed on X-Ray diffraction techniques. First the basics of X-Ray diffraction is presented then the acquired knowledge is applied on the study of crystalline structures using X-Ray diffraction patterns obtained on powders. 3/ The last chapter deals with the description of elaboration techniques that are conventionally used to prepare powders at micrometer scale.	
Cl 2	1/ Brief introduction on the unique properties of nanomaterials and their applications in the multiple domains of nanotechnology (environment, energy, medical, optics, lab-on-chip…). 2/ Chemistry involved in the synthesis of inorganic (metal oxides, metals, quantum-dots) nanostructured materials. Understand the various steps that lead to nanomaterials from molecular and/or supramolecular precursors. Condensation in solution, solid-state reactions, sol-gel chemistry, colloidal chemistry, surface functionalisation. 3/ Understand the Thermodynamic and kinetic controls over nucleation, growth, ripening, and self-assembly at the nanoscale. 4/ Describe the elaboration of model nanostructured materials including nanoparticles, nano-wires, nano-coatings, nanoporous materials, hierarchical nanomaterials, nanocomposites, and their properties and applications. 5/ Describe the potential combinations of these materials with "topdown" processes such as lithography, nano-imprint, micro-contact printing, selective etching to elaborate complex nanopatterns.	10
	Total hours	21

Laboratory		**Number of hours**
Lab 1	In order to comprehend the relations between structure and properties, a laboratory work will deal with the synthesis of materials both at micro- and nanometer scales, their characterization and the study of their properties. It will be associated with the reading of the more significant papers linked to the subject.	9
	Total hours	9

TEACHING TOOLS USED
N1. Lecture N2. Computer Lab hours

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 Written exam	PEU_W01	
F2 Lab work	PEU_U01, PEU_U02	
P = 0.8*F1+0.2*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] SOLID STATE CHEMISTRY, An introduction, Lesley Smart and Elaine Moore BASIC SOLID STATE CHEMISTRY, Anthony R. West [2] NANOCHEMISTRY, Geoffrey A Ozin and André C Arsenault CONTROLLED GROWTH OF NANOMATERIALS, Lide Zhang, Xiaosheng Fang, Changhui Ye.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
David Grosso, Prof. Aix-Marseille University (http://davidgrosso.wixsite.com/scientist-site) and Virginie Hornebecq, Associate Prof. (AixMarseille University)

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Krystalografia i struktura ciał stałych
Name of subject in English Crystallography and structure of solids
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	60	30			
Form of crediting	crediting with grade*	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)	1,4	0,7			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General knowledge of mathematics, physics and chemistry.

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SUBJECT OBJECTIVES

C1 Knowledge of the structure, symmetry and diffraction of macro-, micro- and nanocrystals.
C2 Knowledge of directions of development of crystallography.
C3 Understanding data in crystallographic papers.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

A person who has completed the course:
PEK_W01 has knowledge of the structure and symmetry of crystals.
PEK_W02 understands the international symbols and graphical representation of space groups and the international symbols of crystal classes.
PEK_W03 knows the relationships between a diffraction pattern and crystal structure.
PEK_W04 has knowledge of directions of development of crystallography.

relating to skills:
A person who has completed the course:
PEK_U01 is able to study scientific literature on crystal structures and to evaluate crystal data.
related to social competences:
A person who has completed the course:
PEK_K01 is able to take part in discussions on crystallographic structural studies.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	The historical and current definitions of crystals and crystallography. The internal structure of crystals. A crystal lattice, row lines, lattice planes, Miller symbols, a unit cell and cell types. The mosaic structure of real crystals, dislocations. The internal symmetry of crystals. Symmetry elements and operations. Relationships between the internal and external symmetry of crystals. Crystal systems vs symmetry. Crystal systems and cell parameters. The conventional choice of unit cells. The Bravais unit cells. Space groups: international symbols and graphical representations. An asymmetric unit cell. Relationships between the symbol of a space group and the symbol of a point group (crystal class). The types of point groups. Examples of crystal structures. Crystallographic databases. X-rays: properties and sources. Synchrotron radiation: sources of the first, second, third and fourth generations and properties. Synchrotron crystallographic studies. The directions and intensities of diffracted beams. Factors influencing the directions and intensities. The phase problem. Diffraction pattern vs internal structure and symmetry of crystals. Neutronography and electronography vs roentgenography. Crystallographic information files (cif). Nanocrystals. The quantitative and qualitative definition. The internal structure of nanocrystals vs macrocrystals. Defects. External appearance. Diffraction in nanocrystals vs diffraction in microcrystalline materials. The broadening and shifting of peaks in powder diffraction patterns. Apparent lattice parameters: determination and influencing factors. Properties. Synchrotron crystallographic studies of nanocrystals. Quasi crystals: 1D, 2D and 3D-dimensional. Internal and external structure. Diffraction. Properties. Crystallographic data in scientific papers.	30
	Total hours	30

Classes		**Number of hours**
Cl 1	The preliminary classes. Lattice points, row lines, lattice planes. Symmetry elements: an inversion center, a mirror plane, rotation axes, rotoinversion axes.	15

	Screw axes and glide planes. Bravais lattices. Partial test I Systematic absences. Crystal classes: symbols and graphical representation Physical properties of crystals. Partial test II Total hours	
	Total hours	15

TEACHING TOOLS USED
N1. A multimedia presentation N2. Crystallographic models N3. A blackboard.

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(lectures)	PEK_W01, PEK_W02	Partial test I
F2(lectures)	PEK_W03, PEK_W04	Partial test II
F3(classes)	PEK_W01, PEK_W02	Partial test I
F4(classes)	PEK_W03, PEK_U01	Partial test II
P1=(F1+F2)/2 P2=(F3+F4)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] P. Luger, Modern X-Ray Analysis on Single Crystals, de Gruyter, Berlin, 2014.
[2] R. J. D. Tilley, Crystals and Crystal Structures, John Wiley & Sons Ltd, Chichester, 2006.

SECONDARY LITERATURE:

C. Giacovazzo, H. L. Monaco, G. Artioli, D. Viterbo, G. Ferraris, G. Gilli, G. Zanotti, M. Catti, Fundamentals of crystallography, C. Giacovazzo Ed., Oxford, 2011.
[2] International Tables for Crystallography, Volume A, Springer, 2005; Willey 2016.

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

Ilona Turowska-Tyrk, professor (ilona.turowska-tyrk@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Synteza i wytwarzanie systemów nano-inżynieryjnych
Name of subject in English Synthesis and Fabrication of Nano-engineering Systems
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, , full-time
Kind of subject: obligatory
Subject code …….
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)	60	30			
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)	1.4	0.7			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of organic and inorganic chemistry
2. Basic knowledge of spectroscopic methods

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SUBJECT OBJECTIVES

C1. To provide students with the issues of organic chemistry in nano-engineering systems including bioorganic chemistry
C2. To provide students with the issues of nano-engineering mimetic systems
C3. To provide students with the molecular receptors issues
C4. To provide students with the structure, properties and use of particular groups of compounds used in nano-engineering systems
C6. To acquaint students with scientific literature and literature examples

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 – student knows what nano-engineering is and knows the scope of its applicability
PEU_W02 – student knows the properties of particular groups of compounds used in nano-engineering
PEU_W03 – student knows the methods of nanosystems synthesis

PEU_W04 – student knows the types of interactions between molecules and knows what compounds form individual interactions

related to skills:

PEU_U01 - student can find a suitable group of compounds that can be used in nano-engineering systems

PEU_U02 - student can construct complex questions in factographic databases and find and analyze professional literature

PEU_U03 - student can analyze the types of interactions responsible for the interaction of molecules

PEU_U04 - student can distinguish and describe the properties of particular groups of compounds applicable in nano-engineering systems

PEU_U05 - student is able to design a potential receptor or mimetic of a biologically active compound based on the acquired knowledge in nano-engineering systems

related to social competences:

PEU_K01 student is able to work in a group, performing various roles including group leader

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

PROGRAMME CONTENT		
Lecture		Number of hours
Lec 1	Presentation of the general characteristics of the subject	2
Lec 2	Organic chemistry reactions	2
Lec 3	Click chemistry and nano-scaffolds	2
Lec 4	Synthesis, structure, properties and application of rotaxanes and catenanes in nano-engineering systems	2
Lec 5	Synthesis, properties and application of dendrimers in nano-engineering systems	2
Lec 6	Peptide and protein mimetics in nano-engineering systems	2
Lec 7	Cyclodextrins in nano-engineering systems	2
Lec 8	Synthesis, structure, properties and application of cyclophanes in nano-engineering systems	2
Lec 9	Designing, properties and application of calixarenes	2
Lec 10	Mimetics of DNA and RNA nucleic acids in nano-engineering systems	2
Lec 11	Enzyme mimetics - Molecular imprinting polymers	2
Lec 12	Micellar catalysis, liposomes, fatty acid mimetics	2
Lec 13	Construction, properties and application of porphyrins	2
Lec 14	Carbohydrates and their derivatives in nano-engineering systems	2
Lec 15	Receptors for compounds with diol moieties	2
	Total hours	30

Classes		Number of hours
Cl	General characteristics of the subject nano-engineering systems Organic chemistry reactions Click chemistry and nano-scaffolds Synthesis, structure, properties and application of rotaxanes and catenanes in nano-engineering systems Synthesis, properties and application of dendrimers in nano-engineering systems Peptide and protein mimetics in nano-engineering systems Cyclodextrins in nano-engineering systems Synthesis, structure, properties and application of cyclophanes in nano-engineering systems Designing, properties and application of calixarenes Mimetics of DNA and RNA nucleic acids in nano-engineering systems Enzyme mimetics - Molecular imprinting polymers Micellar catalysis, liposomes, fatty acid mimetics Construction, properties and application of porphyrins Carbohydrates and their derivatives in nano-engineering systems	15
	Total hours	15

TEACHING TOOLS USED
Lecture N1 information lecture N2 problem lecture N3 multimedia presentation Classes N8 multimedia 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
P1 (lecture)	PEU_W01-W04	Written test
P2 (classes)	PEU_U01-U05 PEU_K01-K02	Score for multimedia presentation

PRIMARY AND SECONDARY LITERATURE
[1] SOURCE LITERATURE - SCIENTIFIC PUBLICATIONS
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Piotr Młynarz, piotr.mlynarz@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Termodynamika Materiałów, Siły Międzymolekularne i Powierzchniowe.

Name of subject in English Thermodynamics of Materials, Intermolecular and Surface Forces

Main field of study (if applicable): Chemical Nano-Engineering

Specialization (if applicable): ……..

Profile: academic

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

Kind of subject: obligatory

Subject code …….

Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	9	3		
Number of hours of total student workload (CNPS)	30	30	30		
Form of crediting	Examination /	crediting with grade	crediting with grade	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1	1	1		
including number of ECTS points for practical classes (P)		1	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7	0.7	0.7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. basic chemical thermodynamics

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SUBJECT OBJECTIVES

C1 Knowledge of basic aspect of thermodynamics. Quantitative understanding of the different intermolecular forces between atoms/ions and molecules at the nanoscale level.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 The students should be able to apply equilibrium thermodynamics, including elementary phase diagrams, understand bonds in solids and use defect engineering for the tuning of properties of solids.

relating to skills:

PEU_U01Students will be able to understand bonds in solids and use defect engineering for the tuning of properties
relating to social competences:
PEU_K01

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	1. Fundamental laws of chemical and materials thermodynamics (principles, state functions, chemical potential, reference states, activity…) 2. Basic theory of bonds and modeling of interactions: quantitative understanding of the different intermolecular forces between atoms/ions and molecules and how these interactions can explain materials properties and interesting phenomena at the nanoscale (quantum size effects, wetting, self-assembly…) 3. Crystal defects: point defects, dislocations, surfaces and interfaces, defect engineering	15
	Total hours	15

Classes + Laboratory		**Number of hours**
Cl 1 + Lab 1	1. Fundamental laws of chemical and materials thermodynamics (principles, state functions, chemical potential, reference states, activity…) 2. Basic theory of bonds and modeling of interactions: quantitative understanding of the different intermolecular forces between atoms/ions and molecules and how these interactions can explain materials properties and interesting phenomena at the nanoscale (quantum size effects, wetting, self-assembly…) 3. Crystal defects: point defects, dislocations, surfaces and interfaces, defect engineering	12
	Total hours	12

TEACHING TOOLS USED

N1. lecture
N2. theoretical questions and exercises

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 Written examination	PEU_W01	
F2 Written examination	PEU_U01	
F3		
P=0.75xF1+0.25xF2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

Basic Solid State Chemistry, A. R. West, Wiley Physical Chemistry of Ionic Materials, J. Maier, Wiley

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

Philippe Knauth (http://madirel.univ-amu.fr/pages_web_KNAUTH_PHILIPPE/annuaire)

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish CHARAKTERYSTYKA SYSTEMÓW NANOINŻYNIERYJNYCH

Name of subject in English CHARACTERIZATION OF NANO-ENGINEERING SYSTEMS

Main field of study (if applicable): Chemical Nano-Engineering

Specialization (if applicable): ……..

Profile: academic

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

Kind of subject: obligatory

Subject code …….

Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	18	12		
Number of hours of total student workload (CNPS)	60	60	60		
Form of crediting	Examination	crediting with grade*	crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	2	2	2		
including number of ECTS points for practical classes (P)		2	2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	1,4		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of Physics, Chemistry and Material Science.
2. It is required to be able to read scientific texts in English. To understand graphs and scientific figures. To know how to select and correlate topics.

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SUBJECT OBJECTIVES

C1 The course aims to provide students with the fundamental notions of physical and chemical characterizations of nanomaterials and nanostructures. Different analysis techniques are highlighted such as optical microscopèy, electronic and contact microscopies, optical and infrared spectroscopies, XPS, Auger, SIMS, etc. A general overview of the radiation-matter interaction is also given. Students will also acquire practical skills thanks to some laboratories that will be carried out during the course.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 At the end of the course it is required to be able to illustrate the relevant points of the program in a concise and analytical manner with appropriate language.

relating to skills:

PEU_U01 It is necessary to know how to analyze a problem / question and to know how to organize an adequate response justifying it. It is necessary to know how to reorganize and develop the experiments performed in the laboratory.

relating to social competences:

PEU_K01 They are required to be able to describe the topics covered during the course in a professional manner and with adequate language. They are required to be able to extract the important concepts and to illustrate them in a synthetic and punctual way by providing examples.

PROGRAMME CONTENT

	Lecture+Classes+Laboratory	**Number of hours**
Lec 1	1. Relativistic dynamics; Atomic structure and transitions. 2. Radiation properties; Radiation – matter interaction. 3. X-ray photoemission spectroscopy (XPS), Auger electron spectroscopy (AES), Ultraviolet photoemission spectroscopy (UPS), electron energy loss spectroscopy (EELS): Principles and instrumentation. 4. Secondary ion mass spectrometry (SIMS): Principles and instrumentation. 5. Depth profiling and chemical imaging by using XPS, AES and SIMS techniques. 6. Practical applications of surface analysis techniques: examples and experimental tests in the laboratory. 7. Morphological characterization: Optical Microscopy, Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). The instrumentations and the basic working principles of the different techniques will be illustrated. 8. Optical spectroscopy of nanostructures. The main optical techniques such as absorption, reflection and photoluminescence will be explained. The influence of the small dimensions of the nanostructures on the optical properties will be discussed. 9. Some practical applications will be carried on and some laboratory instrumentations will be shown.	54
	Total hours	54

TEACHING TOOLS USED

N1. Frontal lessons with slides and with a continuous interaction with students. Laboratory lessons with direct participation of the students in the practical scientific experiences.

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 – oral exam (100%)		The final examination consists in some oral questions regarding the entire program. Questions are often also on the laboratory experiences carried out during the lectures.
P = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] J.F. Watts and J. Wolstenholme, An Introduction to Surface Analysis, Wiley, 2003; Y.-W. Chung, Practical Guide to Surface Science and Spectroscopy, Academic Press, 2001; Fundamentals of light microscopy and electronic imaging D. B. Murphy John Wiley and Sons (2001); Physical Principles of Electron Microscopy R.F. Egerton Springer (2005); Nanostructures and Nanomaterials: Synthesis, Properties and Applications G. Cao and Y. Wang World Scientific Publishing (2011). Slides of the lessons.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Paolo Prosposito

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish METODY SYNTEZY W NANOSKALI
Name of subject in English NANOSCALE SYNTHESIS METHODS
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
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	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic inorganic and organic chemistry.

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SUBJECT OBJECTIVES

C1 Knowledge to design the material properties starting from atomic and molecular structures. The main goal of this course is to to provide a comprehensive picture of the synthesis of inorganic and organic nanoparticles.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Ability to design the properties of materials starting from the atomic and molecular structures;

PEU_W02 Knowledge of advanced materials (polymeric, metallic, ceramic, composite and nanostructured) in terms of microstructure;

PEU_W03 Knowledge and understanding of the most modern methods of organic and inorganic synthesis applied to nano-science;

PEU_W04 Knowledge and understanding of the chemical and physical characteristics of the main materials.relating to skills:

PEU_U01 Structure property correlations for materials. Ability to select the most appropriate material for a specific application. Ability to predict the degradation of a material in relation to the environment to which it is exposed. Choice of the most suitable materials for the realization of a product in relation to its characteristics and the required application.

PEU_U02 The ability to obtain and describe data resulting from experiments and analysis, in order to arrive at the formulation of an interpretative judgment on the results acquired;
The ability to collect and process technical and safety information, taking into account the chemical and physical properties of the material, including any specific risk.

relating to social competences:

PEU_K01 The international environment in which the Master will take place will result in an increase in communication skills. Teaching includes oral exams (in English) and will train students to effectively support scientific discussions by improving their skills.

PROGRAMME CONTENT		
Lecture+Classes+Laboratory		**Number of hours**
Lec1 Cl1 La1	1. Nanoscale synthesis and bottom-up techniques 2. Advanced synthetic tools for the covalent assembly of building blocks in the preparation of molecular systems relevant in nanochemistry 3. Carbon-based nanomaterials 4. Sol-gel and colloidal chemistry 5. Applications of sol-gel chemistry 6. Nanoporous materials 7. Healt, safty and environmental issues	45
	Total hours	45

TEACHING TOOLS USED

N1. Different teaching approaches will be used during the course. Teacher-centered approach will be applied in teaching fundamental skills across the chemical areas. Student learning will be measured through oral tests.

N2. The student-centred approach will be applied during the classroom exercises. Here students will play an active and participatory role in their learning process. Student learning will be measured through both formal (final exam) and informal (class discussions) assessment forms.

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 – oral exam (100%)		Training will be completed by projects and specific seminars. The assessment will take place through oral tests and laboratory reports. For the oral test the competent use of a scientific language, the ability to synthesize, the clarity of exposition. Votes above 28 will be awarded to students whose tests meet all the aspects listed above. To achieve a score higher than 28, students must demonstrate that they have acquired an excellent knowledge of all the topics covered during the course.
P = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Materials for engineers, W.F. Hosford, Cambridge 2008; Nanomaterials: An Introduction to Synthesis, Properties and Applications, D. Vollath, Wiley 2nd Edition, 2013.

Nanoscience and Nanomaterials: Synthesis, Manufacturing and Industry Impacts; Wei-Hong Zhong, Bin Li, Russell G. Maguire, Vivian T. Dang, Jo Anne Shatkin, Gwen M. Gross, Michael C. Richey DEStech Publications, Inc.

Nanomaterials and Nanocomposites. Synthesis, Properties, Characterization Techniques, and Applications; R. Kumar Goyal, Taylor and Francis, 2017.

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

Prof. Maria Luisa Di Vona

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish CHEMIA MAKRO- I SUPRAMOLEKULARNA
Name of subject in English MACROMOLECULAR AND SUPRAMOLECULAR CHEMISTRY
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
Form of crediting	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	2	2	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Requested prerequisites are Physical Chemistry (Thermo and Kinetics), Organic Chemistry, Elements of Spectroscopy.

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SUBJECT OBJECTIVES

C1 The aim of the course is to provide the general background on polymer and colloidal and “soft” materials needed for the understanding of phenomena and processes that students will encounter during their further studies or their future working actiivty. At the end of the course concepts such as the molecular weight distributions, step and chain polymerizations and the technology aspects, polymer solutions, gels and self assembly, experimental approaches to study polymer and self assembled materials, elastomers and mechanical behaviour of polymers, will be the knowledge background of the student in order to orient himself in future research topics and work issues.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 At the end of the course the student should know how to analyze the scientific literature at university level and the information contained in a laboratory report in the field of polymer and self assembly chemistry.

PEU_P02 Understanding basic concepts of Polymer Chemistry and self Assembly processes. Ability to apply the knowledge worked out during the couse to the behaviour of polymeric materials.

relating to skills:

PEU_U01 At the end of the course the student should be able to understand and discuss in an organized way the logical steps in a problem solving activity in topics covered during the course, on the basis of the received concepts and information. Operative and conceptual aspects of the work and of the research will be managed in a critical and organized way.

PEU_U02One of the aims of the course is to raise a critical and independent approach in the reading of a scientific journal of the field or about a laboratory report, being able to work out connections and original logical steps

PEU_U03 Ability to perform and understand experiments concernng polymer and self assembling materials and to treat data according to simple theoretical models.

relating to social competences:

PEU_K01 To master concepts worked out in thecourse is at the base of the ability to share such contents also in front of a not-specialized audience without loosing the logic and scientific rigor.

PEU_K02 At the end of the class, the student is able to handle the studied contents in order to understand actively future issues and therefore to progress toward more specialized knowledge.

PROGRAMME CONTENT

	Lecture+Classes+Laboratory	**Number of hours**
Lec1 Cl1 La1	Basic concepts of Polymer Chemistry and self Assembly processes. Laboratories to apply the knowledge worked out during the course to the behaviour of polymeric materials. Experiments concerning polymer and self assembling materials.	24
	Total hours	24

TEACHING TOOLS USED

N1. Lectures to the student audience concerning concepts and examples (3 CFU).

N2. Laboratory experiment concerning issues linked to the information provided in the theoretical modulus (2 CFU).

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 - written examination (100%)		• Final written examination: 10 questions/problems on the topics of the course.
F2		
F3		
P = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] P. J. Flory, Introduction to Polymer Chemistry Cornell University Press. [2] R.J. Young and P.A. Lovell Introduction to polymers CRC Editors. [3] Ian W. Hamley Introduction to Soft Matter Wiley.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Gaio Paradossi

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish TECHNOLOGIA ENERGII W MIKROSKALI, NANOSENSORY I MIRKOFLUIDYKA

Name of subject in English NANOSCALE ENERGY TECHNOLOGY, NANO-SENSORS AND MICRO-FLUIDICS

Main field of study (if applicable): Chemical Nano-Engineering

Specialization (if applicable): ……..

Profile: academic

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

Kind of subject: obligatory

Subject code …….

Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
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	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. It is necessary that the student is familiar with the differential and the integral analysis, with the basic aspects of mechanics and thermodynamics, with the main concepts of quantum mechanics.

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SUBJECT OBJECTIVES

C1 The course provides an introduction to recent application of nanotechnologies to energy and sensors. The selected examples will mainly focus on nanotechnology for solar energy (photovoltaics) and the employment of nanofluidic systems for single molecule sensing and nanoporous membrane for energy harvesting from salinity gradients (blue-energy).

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 For what concern the energy module, at the end of the course, the student will know the main features of a photovoltaic systems and the most modern technology for new generation photovoltaics. Concerning the nanofluidics module, the student will be able to understand the main phenomena related to the transport of mass and ions in electrolyte solutions.

relating to skills:

PEU_U01 The student will be able to recognize the range of validity of the various models proposed for the description of fluids at nanoscale. The student will be able to design and characterize a new generation solar cells. She/He will also be able to apply the knowledge and understanding developed during the course to study and understand recent literature.

PEU_U02 The transversal preparation provided by the course implies: 1) the student's capability to integrate knowledge and manage complexity, 2) the student ability to deal with new and emerging areas in nanotechnology application to energy and sensing and 3) an understanding of the models suited for a given context and their limitations.

relating to social competences:

PEU_K01 The student will be able to communicate the contents of the course to specialists in a clear and unambiguous way. It will also be able to communicate the main features of the models used and their limits to specialists in other related disciplines (example: other engineers, physicists, chemists).

PEU_K02 The structure of the course contents, characterized by various topics apparently separated but connected by a multi-scale and multi-physics vision, will contribute to developing a systemic learning capacity that will allow the student to approach in a self-directed or autonomous way to other frontier problems on nanotechnology application to energy and sensing. Furthermore, the student will be able to read and understand recent scientific literature.

PROGRAMME CONTENT

	Lecture+Classes+Laboratory	**Number of hours**
Lec1 Cl1 La1	Ion transport in nanopores Ion motion in an electrolytic solution. Conductivity and conductance. Quasi-1D model. Access resistance. Application for nanopore sensing: blockade current. Micro and nanofluidics Equation of motion. Conservation of mass and momentum. Boundary conditions. Poiseuille flow. Slip boundary condition. Electrohydrodynamics. Transport equation for ions. Electic double layer. Debye length. Blue energy: from salinity gradient to electric energy. Diffusion Lagrangian and Eulerian description. Langevin equation. Fluctuation-dissipation relation. Molecular dynamics simulations Equation of motion for classical molecular dynamics. Force fields. Lennard-Jones potential. Simulation of biomolecules. Equilibration. Computational laboratory: system set-up and simulation using VMD and NAMD softwares. NanoEnergy General introduction on global energy demand focused on solar energy; Introduction on photovoltaics: the photovoltaic effect, p-n junction, main photovoltaic electrical parameters; solar cell characterization techniques; New generation photovoltaics: organic and hybrid devices; Organic solar cells; Hybrid solar cells Dye Sensitized solar Cells (DSCs) and modules; Perovskite Solar Cells (PSCs) and modules; Nanomaterials and bi-dimensional (2D) materials: properties and	45

	characterization techniques; Perovskite Photovoltaics and 2D materials: power conversion efficiency (PCE), stability and scalability on module dimensions.	
	Total hours	45

TEACHING TOOLS USED
N1. The course follows a traditional teaching model based on lectures and exercises. The introductory lessons will mainly be carried out on the blackboard, deriving the equations in a traditional and rigorous way. The rest of the course will also use presentations. The material will be published on-line typically before classes. As part of the study of Molecular Dynamics simulations, two lessons will be held in the computer lab where the students will set-up and equilibrate a system.

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 micro and nanofluidic module test		Micro and nanofluidics module: The exam is constituted by a written exam and by a discussion on a topic of independent study selected by the student. The aim of the written exam is to assess the student's ability to integrate the various topics covered in different parts of the program and, where possible, to make quantitative estimates on specific cases. The student must demonstrate that she/he has understood the links between the various aspects covered in class and that she/he is able to motivate the choice of the models used (and to critically comment on their limits) according to the features of the problem under consideration. Concerning the discussion of a topic selected by the students, during the course, the teacher will provide a list of possible topics. The student will select a single topic that will be discussed during the exam. The discussion will allow us to evaluate the ability to learn independently and the communication skills developed by the student.
F2 solar energy module test		Solar module: The examination consists in an oral discussion devoted to verify the capability in designing new generation photovoltaic devices with the help of modern nanotechnologies and nanomaterials. Moreover, during the examination students will ask to report about the most recent literature regarding the treated topics.
F3		
P = 0.5*F1+0.5*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] M. San Miguel, and R. Toral. "Stochastic effects in physical systems" Instabilities and Non-equilibrium Structure VI, Springer, (2000).

[2] Varongchayakul, N., Song, J., Meller, A., & Grinstaff, M. W. (2018). Single-molecule protein sensing in a nanopore: a tutorial. Chemical Society Reviews, 47(23), 8512-8524

[3] Sonali Das, Deepak Pandey, Jayan Thomas, and Tania Roy "The Role of Graphene and Other 2D Materials in Solar Photovoltaics", Adv. Mater. 2019, 31, 1802722.

[4] Philip Schulz, "Interface Design for Metal Halide Perovskite Solar Cells", ACS Energy Lett. 2018, 3, 1287−1293.

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

Prof. Mauro Chinappi. Prof. Antonio Agresti

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish STRUKTURALNE I FUNKCJONALNE WŁAŚCIWOŚCI BIOPOLIMERÓW
Name of subject in English STRUCTURAL AND FUNCTIONAL PROPERTIES OF BIOPOLYMERS
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
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	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical analysis, Physics and Chemistry.

SUBJECT OBJECTIVES

C1 Ability to include the main structural and functional properties of biopolymer.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Understanding of the chemical and physical principles that underlie structural motifs in biopolymers, as well as important techniques for their study.

relating to skills:

PEU_U01 Ability to apply the different knowledge learned during the lessons, as well as ability to discriminate between the best strategy to follow for a study project.

PEU_U02 Ability to be independent in a scientific project by acquiring information from other related sectors.…

relating to social competences:

PEU_K01 Ability in the relationship with sectors of genetics, biochemistry and molecular biology to apply for suitable experiments.

PEU_K02 Ability to autonomously extend one's own knowledge by using the suitable literature and to know how to move in sectors related to one's own.

PROGRAMME CONTENT		
Lecture+Classes+Laboratory		**Number of hours**
Lec1 Cl1 La1	Structural features and conformational equilibria of polypeptides, proteins, polysaccharides and nucleic acids. Biopolymer-ligand interactions: equilibrium and kinetics aspects. Biopolymers for polymer synthesis. Self assembled systems of biopolymers: hydrogels and microgels. Synthetic polymers with applications in biological environments. Computed aided visualization of biological macromolecules	45
	Total hours	45

TEACHING TOOLS USED

N1. Lectures and some lessons carried out with PC.

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 oral examination		The final examination follows the course outline. General questions will then be asked about the theory and then the practical knowledge acquired will be verified. The final evaluation is expressed with a vote, maximum 30/30. The evaluation takes into account the overall preparation of the candidate, his critical ability, and the level of learning achieved.
P = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:
[1] Materials provided by teacher
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Marco Sette

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish NMR NANO-UKŁADÓW
Name of subject in English NMR OF NANO-SYSTEMS
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
Form of crediting	Examination	crediting with grade*	crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	2	2	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical analysis, Physics and Chemistry.

\

SUBJECT OBJECTIVES

C1 Ability to understand the relevant scientific literature and to extract information from spectra of Nuclear Magnetic Resonance.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Understanding of the necessary NMR experiments of utility in the field of nanosystems and of the basic theory behind each of them.

relating to skills:

PEU_U01 Ability to apply the different methodologies used during the lesson, as well as the ability to discriminate between the best strategy to follow.

PEU_U02 Ability to be independent in a scientific project by acquiring information deriving from other related sectors.

relating to social competences:
PEU_K01 Ability to relate to other sectors to establish appropriate experiments
PEU_K02 Ability to extend their own knowledge for the use of other experiments and to know how to move in sectors related to their own.

PROGRAMME CONTENT		
Lecture+Classes+Laboratory		**Number of hours**
Lec1 Cl1 La1	NMR basic theory: the resonance phenomenon, chemical shift, scalar and dipolar coupling, molecular interactions. One- and two-dimensional experiments in solution and in solid phase. Diffusion experiments. Examples from literature.	45
	Total hours	45

TEACHING TOOLS USED

N1. Lectures and lessons carried out with NMR instrumentation. Lectures introduce the topics that will then be used in practice.

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 oral examination		The final examination follows the course outline. General questions will then be asked about the theory and then the practical knowledge acquired will be verified. The final evaluation is expressed with a vote, maximum 30/30. The evaluation takes into account the overall preparation of the candidate, his critical ability, and the level of learning achieved.
P = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Edwin Becker
High Resolution NMR. Theory and Chemical Applications
Elsevier. 3rd Edition

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

Prof. Marco Sette

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish TRANSFORMACJE STRUKTURALNE W NANOSKALI I ICH KINETYKA

Name of subject in English NANOSCALE STRUCTURAL TRANSFORMATIONS AND KINETICS

Main field of study (if applicable): Chemical Nano-Engineering

Specialization (if applicable): ……..

Profile: academic

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

Kind of subject: obligatory

Subject code …….

Group of courses NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
Form of crediting	crediting with grade*	crediting with grade*	crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	2	2	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. There are no formal prerequisites, however it is appropriate that students have good knowledge of Chemistry.

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SUBJECT OBJECTIVES

C1 The course aims to provide the basic knowledge about the diffusion based phase transformation occurring in the solid state with particular attention to thermodynamics and kinetics. The chemical distribution on nano- and micro-scale and the microstructure of materials will be presented.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 The students should understand how the microstructure of metallic materials can be modified through heat treatments which induce the formation of different phases.

relating to skills:

PEU_U01 The content of the course is useful for determining the fundamental process parameters (temperature, time, atmosphere) of heat treatments to induce the suitable microstructural transformations in metal alloys and achieve the desired mechanical properties for a given engineering application.

PEU_U02 The students will be able to understand how to perform the right heat treatments on metal alloys to get the desired mechanical properties.

relating to social competences:

PEU_K01 Description of the microstructure of metallic materials in terms of type and fraction of different phases, and their effect on the mechanical properties.

PEU_K02 Understanding the relations between microstructural features and mechanical properties of the main families of metal alloys for engineering applications.

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	1. Binary and ternary phase diagrams 2. Classification of diffusion based solid state phase transformations. 3. Transformations occurring through nucleation and growth mechanisms. 4. Transformations occurring through spinodal reaction. 5. Identification of unknown compounds by means of X-ray diffraction. The use of the X-ray database. Lab exercices.	45
	Total hours	45

TEACHING TOOLS USED

N1. The course is held by lectures including theory and exercises.

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 oral examination		The exam of Nanoscale Structural transformations and Kinetics consists of an oral examination.
P = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] D.R. Askeland, The Science and Engineering of Materials, Stanley Thornes Publishers Ltd [2] Porter & Easterling, Phase Transformations
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Roberto Montanari

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish PRAWDOPODOBIEŃSTWO I METODY STATYSTYCZNE DLA MODELOWANIA W INŻYNIERII

Name of subject in English PROBABILITY AND STATISTICAL METHODS FOR MODELLING ENGINEERS

Main field of study (if applicable): Chemical Nano-Engineering

Specialization (if applicable): ……..

Profile: academic

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

Kind of subject: obligatory

Subject code …….

Group of courses NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	24	15	6		
Number of hours of total student workload (CNPS)	60	60	30		
Form of crediting	crediting with grade*	crediting with grade*	crediting with grade*		
For group of courses mark (X) final course					
Number of ECTS points	2	2	1		
including number of ECTS points for practical classes (P)		2	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,4	1,4	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. There are no mandatory prerequisites for this course. However, a basic knowledge of Mathematical Methods for Engineering (calculus, algebra, trigonometry, etc.) is assumed

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SUBJECT OBJECTIVES

C1 After a careful study during the course the students should be able to:

1. Identify the role of statistics in engineering problems.
2. Discuss the methods used by engineers to collect data.
3. Explain the differences between mechanistic and empirical models.
4. Understand and describe sample spaces and events of random experiments with graphs, tables, lists or tree diagrams.
5. Interpret and use the probability of the results to calculate the probabilities of the events. Calculate the probability of joint events and interpret / calculate the conditional probabilities of events.
6. Apply the Bayes theorem.
7. Understand the meanings of a random variable.

8. Select an appropriate discrete / continuous probability distribution. Determine probability, mean, and variance for the presented discrete / continuous probability distributions.
9. Calculate and interpret mean, variance, standard deviation, median and sample interval.
10. Build and interpret normal probability diagrams.
11. Know the general concepts of estimating the parameters of a population or a probability distribution.
12. Explain the properties of point estimators (bias, variance, mean square error).
13. Construct point estimators with moments method and maximum likelihood method.
14. Calculate and explain the precision of the estimation of a parameter.
15. Understand the central limit theorem.
16. Explain the role of normal distribution as a sampling distribution.
17. Build confidence intervals, forecast intervals, tolerance intervals.
18. Structure engineering decision problems as hypothesis tests.
19. Check the hypotheses on the average of a normal distribution using a Z-test or t-test procedure.
20. Test the hypotheses on variance or standard deviation of a normal distribution. Check the hypotheses on a population.
21. Use the P value approach to make decisions in hypothesis tests.
22. Select a sample size for tests on averages, variances and proportions.
23. Explain and use the relationship between confidence intervals and hypothesis testing.
24. Use the chi-square test to test hypotheses about the distribution.
25. Use simple linear regression to build empirical models of technical and scientific data.
26. Understand the use of the least squares method to estimate parameters in a linear regression model.
27. Analyze the residuals to determine if the regression model fits the data or to see if there are violations of the initial hypotheses.
28. Test the statistical hypotheses and construct confidence intervals on the parameters of the regression model.
29. Use the regression model for the prediction of a future observation and construct an appropriate prediction interval on future observation.
30. Use simple transformations to obtain a linear regression model.
31. Apply the correlation model.
32. Finally, discuss how probabilities and probability models are used in engineering and science in general.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Students acquire understanding and knowledge of: 1) fundamental statistical techniques (summary statistics, normal distribution, interval estimation, regression analysis, modelling) and how they relate to the baseline discipline; 2) software statistical techniques; 3) process monitoring by control charts; 4) process optimization by response surface methodology; 5) determining important factors by hypothesis testing; 6) process modelling by, e.g., regression analysis; 7) design of experiments and laboratory recommendation.
The teaching approach provides the foundation for this understanding, in such a way that at the end of the course students have assimilated a complete knowledge of the basic themes.

relating to skills:

PEU_U01 The goals of the course are to help the students to: i) model and simulate basic engineering problems, ii) collect, analyze and present numerical data in general and simulation results in particular, iii) interpret simulation results by means of statistical methods, iv) use statistical principles and concepts, v) develop software for reporting and for graphical presentation, vi) be familiar with basic probability theory and perform estimation, hypothesis testing, simple correlation-/regression analysis, vii) identify, formulate, and solve engineering problems. Such applications of statistics are widespread in all branches of engineering.

PEU_U02 The training provided for students of the course is hallmarked by the acquisition of a flexible mentality that helps them to extend the knowledge learned to new concepts, enabling them to introduce elements of innovation. These activities encourage students to develop: critical thinking and problem solving; critical analysis; independence of judgement. At the end of the course, students are therefore able to pose, refine and evaluate scientific questions, this being a fundamental objective both educational and cognitive.

relating to social competences:

PEU_K01 Students develop the ability to present clearly what they have learned during the course and, in the same way, the additional knowledge gained from practical exercises, classroom exercises and textbooks. They are expected to present their knowledge effectively. These skills, which concern both oral and written presentations, are based on the ability to analyze and integrate the knowledge areas acquired during the course. Students are also encouraged to develop a positive attitude towards teamwork.
The evaluation of the achievement of written and oral communication skills is verified during classroom exercises, practical exercises, tutoring and through written and oral exams at the end of the course.

PEU_K02 Students, through the introduction of a range of fundamental statistical techniques, learn how to: analyse data, apply statistics in engineering contexts, use appropriate statistical sofware. Furthermore they acquire: numeracy skills, effective Information retrieval and research skills, computer literacy. On these bases they will be able to connect and relate knowledge across various scales, concepts, and representations “in” and “across” domains.

PROGRAMME CONTENT

	Lecture+Classes+Laboratory	Number of hours
Lec1 Cl1 La1	– The role of Statistics in Engineering: Mechanistic and Empirical Models, Probability and Probability Models. – Probability: Discrete Random Variables and Probability Distributions; Continuous Random Variables and Probability Distributions. – Point Estimation of Parameters. – Random Sampling and data Description, Statistical Intervals for a Single Sample. – Tests of Hypotheses for a Single Sample. – Simple Linear Regression and Correlation: Empirical Models. – Multiple Linear Regression Model. – The Analysis of Variance (ANOVA): Residual Analysis and Model Checking; The Random Model. – Design of Experiments with Several factors. – Statistical Quality Control.	45
	Total hours	45

TEACHING TOOLS USED

N1. The course is delivered through the following Learning Activities.
1. Attendance of lectures where course material is presented through discussions, worked examples, and demonstrations.
2. Attendance of exercises and practicals where students perform and discuss exercises as part of their formative assessment. These practices help students in consolidating the course material and provide a source of feedback on understanding.
3. Private study to review the course material presented in lectures, read the textbooks, and practice solving conceptual and numerical problems from textbooks, and other sources.
4. Completion of online quizzes and problems that are designed to give students further practice in the application of course material, as well as feedback on their understanding. These also form part of their formative assessment.
5. Application of basic and more advanced statistical methods. Use of the statistical package R, developed through a sequence of computer practicals.

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 written and / or practical examination		The written / practical test is structured to: i) emphasize concepts and techniques acquired during the course; ii) request an explanation of the candidate's reasoning; iii) allow sufficient time for most well-prepared students to complete each application; iv) use innovative types of questions that probe the depth of understanding.
F2 oral examination		The oral exam is based on the students' self-correction of the written / practical test and on in-depth questions related to topics not covered in the written / practical test.
F3		
P = 0.5*F1+0.5*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

– Applied Statistics and Probability for Engineers, D.C. Montgomery, G.C. Runger, Jhon Wiley & Sons 2003
– A Beginner's Guide to R , A.F. Zuur, E.N. Ieno, E.H.W.G. Meesters, Springer 2009
– Introductory Statistics with R, P. Dalgaard, Springer 2008
– The R Book, M.J. Crawley, Wiley 2007
– Statistical Methods for Engineers, G. Vining, Thomson Brooks/Cole 2011
– Probability and Statistics, J.L. Devore, Thomson Brooks/Cole 2000
– Data analysis with Matlab, James Braselton, 2014
– Mathematical and Computational Modeling: With Applications in Natural and Social Sciences, Engineering, and the Arts, First Edition. Roderick Melnik. 2015 John Wiley & Sons, Inc.
– Mathematical Modeling with Excel, B. Albright, Jones & Bartlett Learning, 2009.
– Computational Statistics Handbook with MATLAB, W.L. Martinez, A.R. Martinez, Chapman and Hall Book/CRC Press 2015.
– Linear Models with R, J.J.Faraway, Chapman and HallBook/CRC Press 2014.

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

Prof. Maria Richetta

Zał. nr 5 do ZW 16/2020

FACULTY CHEMISTRY

SUBJECT CARD

Name of subject in Polish NANO-INŻYNIERIA, SEMINARIUM I PROJEKT 3
Name of subject in English NANO-ENGINEERING SEMINAR + PROJECT 3
Main field of study (if applicable): Chemical Nano-Engineering
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					18
Number of hours of total student workload (CNPS)					60
Form of crediting					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. Basic inorganic and organic chemistry.

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SUBJECT OBJECTIVES

C1 The course "Nano-engineering Seminar + Project" is conceived as a forum of exchange for new ideas emerging from the literature and lectures.
The goal is to teach students to work on project, to present its outcome correctly and to be able to defend it. In addition a revision session, where students can express their potential problems and discuss them with other students, under the professor/tutor guidance is planned.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 To integrate knowledge and handle complexity, and formulate judgments in situations characterized by incomplete or limited information,
To reflect on social and ethical responsibilities linked to the application of their knowledge and judgments;

To acquire the learning skills which allow them to continue to study in a manner that may be largely self-directed or autonomous.

relating to skills:

PEU_U01 To apply their knowledge and understanding, in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study;
To communicate their conclusions, the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.

PEU_U02 The ability to obtain and describe results from literature data, in order to arrive at the formulation of an interpretative judgment on the results acquired;
The ability to collect and process technical and safety information, taking into account the properties of the subject including any specific risk.

relating to social competences:

PEU_K01 Direct interaction between researchers and students coming from different countries, with different cultural background will improve the communication skills and increase tolerance.
Their understanding of the foreign cultures and history will allow them for easier contact with people having different cultural background.
The necessity to cooperate with students and professors from different countries and cultures will increase their tolerance and politeness towards strangers.

PEU_K02 Assure an interdisciplinary training in the field of nano-engineering, which includes a profound understanding of the chemistry and the methods of synthesis and characterization of nano-materials and nano-systems.
Capacity to promote and to develop scientific and technological innovation.
Possibility of making a critical analysis of scientific information.
Capacity of technical and economic evaluation of a project of innovation and research.
Capacity to work effectively in a team project.

PROGRAMME CONTENT

	Seminar	**Number of hours**
sem 1	Introduction to nanoengineering; nanoscale fabrication: nanolithography and self-assembly; Nanoscale and molecular electronics; nanotechnology in magnetic systems; nanotechnology in integrative systems; Nanoscale optoelectronics; nanobiotechnology: biomimetic systems, nanomotors, nanofluidics, and nanomedicine. Synthesis techniques, processes, microstructural control, and unique physical properties of materials in nanodimensions. Nanowires, quantum dots, thin films, electrical transport, electron emission properties, optical behavior, mechanical behavior, and technical applications of nanomaterials. Chemical interactions, classical and statistical thermodynamics of small systems, diffusion. Carbon-based nanomaterials, supramolecular chemistry, liquid crystals, colloid and polymer chemistry, lipid vesicles, surface modification, surface functionalization, catalysis. Nanoscale detection methods. Understanding nanotechnology, broad implications, miniaturization: scaling laws; nanoscale physics.	18
	Total hours	18

TEACHING TOOLS USED

N1. Different teaching approaches will be used during the course. Teacher-centered approach will be applied in teaching fundamental skills across the chemical areas. Student learning will be measured through oral tests.
The student-centered approach will be applied during the classroom exercises. Here students will play an active and participatory role in their learning process. Student learning will be measured through both formal (final exam) and informal (class discussions) assessment forms.

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		written examination
F2		For the oral test the competent use of a scientific language, the ability to synthesize, the clarity of exposition.
P = 0.5*F1+0.5*F2		

PRIMARY AND SECONDARY LITERATURE
Literature articles delivered in class
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. Maria Luisa Di Vona