PART A: COURSE PROGRAMME

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time
7.	ISCED code	0533 (Physics)
8.	Connection between the field of study and university development strategy, including the university mission	The education in Physics at the second-degree level (2-year master's studies) is realized in English in two specializations: Fundamental and applied physics and Nanophysics and mesoscopic materials - modeling and application (Polish-French studies). Education in both specializations is consistent with the 2020-2025 Development Strategy of the University of Silesia in Katowice and Poland's development strategy (Poland 2030). It serves the implementation of the UN Sustainable Development Goals. Due to each specialization's curriculum's specificity, the relationship of the field of study with the Development Strategy, including the University mission, has been described for each specialization separately. Specialization: Fundamental and Applied Physics - Relation to the development strategy and mission of the University. The establishment of the specialization in Fundamental and Applied Physics in 2021 resulted from the need to adapt education to socio-economic demands. The curriculum considers the priorities and operational goals defined in the Strategy for the Development of the University (aimed at transforming the University into a research university of international significance and prestige), including the assumptions of the program "ONE UNIVERSITY - MULTIPLE POSSIBILITIES. Integrated Programme.". Education aims to educate highly specialized specialists to meet the employment market's needs, including expanding the expert faculty by graduates of the University. Education at the Fundamental and Applied Physics specialization is closely connected with scientific research conducted at the August Chełkowski Institute of Physics. This research is related to the most important contemporary challenges to civilization and is part of the University's Priority Research Areas (POB). The range of offered subjects includes education in theoretical physics, atomic and molecular physics, condensed phase physics, nuclear and particle physics, astrophysics and cosmology, and physics applications in various fields. The curriculum also includes subjects to enhance computer skills. The offer is in line with the following Priority Research Areas of the University: Harmonious human development - concern for health protection and quality of life, Modern materials and technologies and their socio-cultural implications, Environmental and climate change with its attendant societal challenges, the study of the fundamental properties of nature. Education within the specialization of Fundamental and Applied Physics is realized by involving students in the research work of functioning research teams and individualizing the education process. The educational process is carried out in an environment that supports the acquisition of knowledge, based on current trends in education (the diploma module is the central axis of education, the ability to choose the path of education following the interests of the student), teaching methods (project and problem-based learning, classes in small groups, online and hybrid forms of education that increase flexibility and the degree of interaction between the teacher and the student) and scientific and research apparatus. The curriculum of Fundamental and Applied Physics strongly reinforces the internationalization of the University. All classes are conducted in English, which improves Polish students' language competencies and enables international students to undertake studies at

		the University or realize a part of the curriculum under academic exchange programs (e.g., ERASMUS +). The program also provides a possibility to serve an internship in foreign academic or scientific institutions or companies with a profile related to the specialization. Specialization: Nanophysics and Mesoscopic Materials - Modelling and Applications The field of study Nanophysics and mesoscopic materials-modelling and application delivered on 2 level of education integrates very well with the four strategic objectives identified in the Education Area in the University of Silesia Development Strategy 2020-2025. These are Modification of the education offer in order to link it more closely with research activities, taking into account the directions of higher education development, Internationalization of education, Individualisation of education and project-problem education, Modern educational methods using new technologies based on interactivity. As a university field of study the ‘Physics’ and specialization “Nanophysics and mesoscopic materials - modelling and applications” delivered here distinguishes by an increased emphasis on basic modules, like nanophysics, quantum physics etc. parallel to maintaining modules that require the student’s own workload like Laboratory training and Internship. Both modules can be carried out with an international collaboration by polish and french research teams based on the International Academic Cooperation Agreement signed between the University of Silesia in Katowice and Le Mans University. So we put emphasis on the participation of students in the scientific projects realized in that two moduli, which are oriented to projects-based learning. Students carry out scientific projects, and the obtained results are often published in journals included in the Journal Citation Reports database, which also fits in with the University's strategy in the field of internationalization of scientific research. Students, as part of their international internships, receive not only the necessary skills in their further academic career, but also acquire the essential predispositions to work in innovative nanotechnology companies. Good internationalization practices are realized by Institute of Physics since the academic year 2007/2008, when the double-diploma studies were started. Since then, monitoring the nanophysic's graduates career, we are convinced that they are mostly continuing their adventure with science, mainly in doctoral studies in several European countries, including co-tutelles financed by the government of the Republic of France. Continuation of the implementation Polish-French studies on specialization Nanophysics and mesoscopic materials-modelling and application will strengthen the existing long-term cooperation and contribute to the strategy of development of both partner Polish and French universities as modern European scientific and didactic centres. The curriculum for physics major is taught by experienced academic teachers conducting world-class research. The current personnel policy of the Institute of Physics is aimed at attracting outstanding scholars who will be involved in the implementation of the educational process at the specialization in Fundamental and Applied Physics. Within the framework of the academic exchange programs operating at the University, it is also planned to involve external experts (e.g., visiting professors) to teach selected classes of the specialization program. It is intended to conclude a collaboration with the leading foreign academic centers to implement a study program. The quality of education is verified and improved on an ongoing basis following the Education Quality Assurance System operating at UŚ. The education process is subject to periodic evaluation by the evaluating institutions (PKA). The educational offer will be modified periodically to ensure a closer connection between the offer and the research activity of the Institute, the University's Strategy, and socio-economic demands.
9.	Number of semesters	4
10.	Degree	magister (Master's Degree)
11.	Specializations	Fundamental and Applied Physics Nanophysics and Mesoscopic Materials - Modelling and Applications

12.	The semester from which the specializations starts	1
13.	Percentage share of scientific or artistic disciplines in education (along with the indication of the leading discipline)	• *[leading discipline]* physical sciences (natural sciences): 100%
14.	Percentage of the ECTS credits for each of the scientific or artistic disciplines to which the learning outcomes are related to the total number of ECTS credits (along with the indication of the leading discipline)	Fundamental and Applied Physics: • *[leading discipline]* physical sciences (natural sciences): 100% Nanophysics and Mesoscopic Materials - Modelling and Applications: • *[leading discipline]* physical sciences (natural sciences): 100%
15.	Number of ECTS credits required to achieve the qualification equivalent to the level of study	Fundamental and Applied Physics: 120, Nanophysics and Mesoscopic Materials - Modelling and Applications: 120
16.	Percentage of the ECTS credits for optional modules in relation to the total number of ECTS credits	Fundamental and Applied Physics: 68%, Nanophysics and Mesoscopic Materials - Modelling and Applications: 39%
17.	Total number of ECTS credits that a student must obtain in the modules taught	Fundamental and Applied Physics: 120, Nanophysics and Mesoscopic Materials - Modelling and Applications: 90
18.	Number of ECTS credits that a student must obtain in modules assigned to disciplines within the humanities or social sciences (not less than 5 ECTS) - in the case of fields of study assigned to disciplines within the fields other than, respectively, humanities or social sciences	Fundamental and Applied Physics: 5, Nanophysics and Mesoscopic Materials - Modelling and Applications: 5
19.	Graduation requirements for a particular specialization	<u>Fundamental and Applied Physics</u> The condition for graduation is: • passing all the modules in the program for this specialization and passing the required examinations, • writing and defending the master's thesis • obtaining the required ECTS scores. <u>Nanophysics and Mesoscopic Materials - Modelling and Applications</u> Requirements for graduation with the specialization "Nanophysics and mesoscopic materials - modeling and application (Polish-French studies)" The condition of graduation is: • passing all modules specified in the Physics study plan for the specialization "Nanophysics and mesoscopic materials" and passing all required exams, • obtaining the number of ECTS points required by the study plan.

		• writing an MA thesis in English and defending the thesis before an examination board, which also includes an academic teacher from the French side.
20.	Organization of the process of obtaining a degree	Specialization: Fundamental and Applied Physics. §1 The present Rules and Regulations of studies are a detailed version of § 33, 34, 35, 36, 37, 38 of the legally binding Rules and Regulations of studies at the University of Silesia being an annexe to Resolution No. 368 of the Senate of the University of Silesia in Katowice of 30th April 2019. §2 1. The student makes a declaration regarding the supervisor's selection no later than two weeks after the monographic lecture conducted at the beginning of the first semester. 2. The supervisor determines the diploma thesis subject with the student following the conditions defined under §34 (5) of the Rules and Regulations of studies. Simultaneously, they select modules that correspond to the topic chosen within a group of diploma modules according to the curriculum. 3. The RTP form related to the registration of the diploma thesis (Annexe No. 1 to Order No. 16 of the Rector of the University of Silesia in Katowice of 28th January 2015) signed by the supervisor and the student without undue delay is delivered to the Dean's office related to the particular programme. §3 The student prepares and submits the diploma thesis following the Web Service of the Archives of Diploma Theses (apd.us.edu.pl). §4 1. After submitting by the Master's student the diploma thesis approved by the supervisor, the supervisor and the reviewer prepare the review no later than three days before the Master's examination deadline. 2. Reviews include a proposal of the grade related to the thesis. 3. Reviews are available to the Master's student beforehand so they can get acquainted with them. §5 The conditions for graduation are: – getting credits from all the subject modules defined by the curriculum and successfully passing the required examinations, – writing and defending the Master's thesis before the examination board, getting the number of ECTS credits as required by the curriculum. Conditions for admission for the defence of the diploma thesis and the diploma examination: 1. Achieving the required learning outcomes, including getting credits and passing examinations from all modules and the required number of ECTS credits provided for in the curriculum throughout the entire course of education for Physics. 2. Submission of the student record book with all the required entries and credits to the last semester's successful passing. 3. Submission of an appropriate number of copies of the diploma thesis and the required documents following the current requirements for submitting diploma theses at the Faculty of Science and Technology. 4. Positive grades from two reviews (i.e. from the supervisor and the reviewer). §6 1. The student takes the diploma examination before the examination board appointed by the Dean of the Faculty of Science and Technology. The board comprises a chairperson and two members (supervisor and reviewer of the thesis), at least one who should have a post-doctoral degree. 2. The diploma examination comprises two parts: (a) defending the diploma thesis, (b) answering questions by the Master's student. 3. The thesis defence begins with the multimedia presentation of the Master's student's thesis subject and answering to the questions from the examination board on the topic presented.

		4. In the second part of the examination, the Master's student answers three drawn questions. The questions cover the topics from the modules defined by the 2nd-cycle studies curriculum in Physics. 5. At the end of the examination: a. The examination board establishes component grades related to the answers to the particular examination questions. b. The examination board determines the diploma thesis grade and the final grade be placed on the diploma following the regulations defined under § 38 of the Rules and Regulations of studies. 6. The grades are announced to the Master's student immediately after establishing them by the examination board. Specialization: Nanophysics and Mesoscopic Materials - Modelling and Applications Requirements for graduation with the specialization "Nanophysics and mesoscopic materials - modeling and application (Polish-French studies)" The condition of graduation is: • passing all modules specified in the Physics study plan for the specialization "Nanophysics and mesoscopic materials" and passing all required exams, • obtaining the number of ECTS points required by the study plan. • writing an MA thesis in English and defending the thesis before an examination board, which also includes an academic teacher from the French side The diploma obtaining is related to passing a diploma examination, consisting of two parts. The first part is associated with the thesis presented by the student. It consists in the presentation of achievements resulting from the diploma thesis development and in showing the subject-matter knowledge related to the dealt topic. The second part is a knowledge exam, associated with the studied speciality. The final mark of the diploma examination is determined by the Examination Commission in accordance with requirements included in the regulations of studies at the University of Silesia and Le Mans University in the case of students who decide to apply for a double diploma. The MA exam is taken at the Examination Commission appointed by the Deputy Dean appropriate for the field of studies. The Examination Commission consists of the chairman and minimum two members (thesis supervisor and/or tutor, thesis reviewers) and additionally an academic teacher from Le Mans University. If it is not possible to organize the MA exam in the ordinary procedure involving the committee member from France, the mode is possible online.
21.	Internships (hours and conditions) in the case of practical programmes and in general university programme - if such requires internship	<u>Fundamental and Applied Physics</u> The program of studies combines education with practical activity. For this purpose, students will have internships in scientific institutes, Polish or foreign, modern industry or R&D laboratories. The training topics can be theoretical physics, experimental physics, physics applications, computer modeling of physical processes, or related branches. Total hours of the internship: 160. Completion by the end of the 4th semester.

		Nanophysics and Mesoscopic Materials - Modelling and Applications As part of the internship in the fourth semester, students must complete the Internship module, which is a laboratory internship as part of the study plan and can be carried out in Poland or abroad (France). For Polish students who decide to obtain a Polish-French diploma, the Internship module must be completed at the University of Le Mans (France) on the basis of a double diploma agreement. The module is implemented at the University of Silesia by French students and by those Polish students who do not decide to obtain a double diploma. Part of the module may be implemented in industrial research laboratories. The internship is carried out on a continuous basis for a period of 4 months.
22.	Total number of ECTS credits that a student must obtain in internships	Fundamental and Applied Physics: 18, Nanophysics and Mesoscopic Materials - Modelling and Applications: 30
23.	Number of ECTS credits - higher than 50% of the total number of credits - that a student must obtain: • in general university programmes within a module connected with research carried out in the scientific or artistic disciplines to develop his/her knowledge and research skills; • in practical programmes within a module to develop practical skills	Fundamental and Applied Physics: 115, Nanophysics and Mesoscopic Materials - Modelling and Applications: 109
24.	General description of the programme	Physics is one of the most crucial research area in modern science. Discoveries of new phenomena, deepening of knowledge about the structure of matter and related interactions and understanding the consequences of natural laws and scientific theories lead to changes in the world around us. Physics brings together advanced experiments, computations, and theoretical considerations to describe what is unknown. Experiments are carried out on highly sophisticated facilities/equipment, often as part of international collaborations. Developments in physics result in new technologies that are extensively used in a wide range of industries, including the health and environmental sectors. The computational aspects use machine learning and other advanced techniques in data science. Theoretical physics aims to predict physical systems' behavior and interpret the experimental results in terms of mathematical models of the physical world's structure and evolution. The Physics Master's degree program is closely related to the A. Chełkowski Institute of Physics' scientific activities. Students will participate in the Institute's activities, including regular seminars, colloquia, and workshops involving physicists worldwide. Students will also be involved in a research-level project as part of their dissertation. The study program and scientific research will be carried out at the Chorzow campus of the Silesian University and partly within the framework of activities based on cooperation between the Institute of Physics and many prestigious institutions worldwide. This program provides exposure to frontier physics activities and develops general transferable skills related to data analysis, research, and communication. The program leads to careers in research, teaching, and industry and develops very valued computing skills.
25.	General description of the specialization	Fundamental and Applied Physics The Master program in Physics at Fundamental and Applied Physics specialization offers a broad selection of courses, covering all the main topics of modern physics. The aim is to prepare graduates for various forms of a career in research institutes, R&D institutes and modern high-tech industry, as well as to continue their education at the PhD level.

		The study program includes a small number of basic compulsory subjects and a large group of diploma modules, chosen by a student with the advice of a supervisor. The offer of courses to be selected within the diploma modules is approved annually by the Teaching Council for Physics. The program's backbone is a set of two blocks: Diploma courses I and Diploma courses II, complemented with master thesis laboratories and seminars, as well as a specialized lecture. Each of the Diploma course blocks is a collection of modules to choose from, including 120 hours of lectures and 120 hours of complementary classes such as conversations. The choice of thesis modules is motivated by the subject of the master's thesis. Depending on the interests, a student can select modules from narrow specialization or covering a relatively wide range of topics. Proposed courses are closely related to scientific activities conducted at the Institute of Physics in theoretical physics, atomic and molecular physics, condensed phase physics, nuclear physics, elementary particle physics, astrophysics and cosmology. They also address issues at the borderline of these branches of physics and physics applications in various fields. The Fundamental and Applied Physics specialization offer can be enlarged and adjusted yearly by lectures and classes proposed by foreign partners. Nanophysics and Mesoscopic Materials - Modelling and Applications Full-time second-cycle studies in Physics, specialization: Nanophysics and mesoscopic materials - modeling and application, conducted since the academic year 2007/2008 together with the University of Le Mans (France), lasts 4 semesters. They enjoy considerable popularity among both French and Polish students. Polish-French studies are implemented on the basis of the Agreement on International Academic Cooperation on the basis of a jointly agreed study program between partner universities completed with a double diploma: Master of Physics and Nanomaterials - University of Le Mans and Master of Physics, specialization: nanophysics and mesoscopic materials - modeling and application - University of Silesia in Katowice. The teaching process involves the staff of two partner universities, which conducts world-class scientific research on the synthesis and characterization of physical properties of low-dimensional systems, including nanoparticles and magnetic nanocomposites, thin layers, carbon based nanomaterials and other nano-sized objects. Master's students are intensively involved in conducted experimental work and numerical simulations of low-dimensional objects, and the results of their work are often published in international cooperation between Institute of Physics of the University of Silesia and Le Mans University. The prerequisite for obtaining a double diploma is the completion of the Internship module at the partner university in the 4th semester (210 hours). For completing the internship the student receives 30 ECTS points. During the in France, the student conducts research as part of his/her master's thesis on a selected topic under the guidance of the scientific supervisor from France (University of Le Mans) and Poland (University of Silesia). Additionally, in the 2nd semester students have the opportunity to pass the module Laboratory training at the University of Le Mans. During the course, students learn the research techniques of nano- and mesoscopic materials available in both partner units. Master's thesis is prepared by students in English. Similarly, the defense and the MA examination carried out in the same language by the joint Polish-French commission. Internships are carried out by the students thanks to financial support, e.g. French Embassy in Poland and European funds (Erasmus + program). Graduates of the specialization Nanophysics and mesoscopic materials - modeling and application are educated extensively about physical processes occurring in nano- or mezoscopic objects, have professional knowledge of solid state physics, modern materials with industrial applications. They have the opportunity to continue scientific research at doctoral studies, including continuing cooperation with a Le Mans University as co-tutelle studies. Thanks to the dual study program, graduates not only acquire the necessary skills in their

		further academic career, but are also well prepared to work in innovative nanotechnology companies, which is highly demanded at the labour market.

PART B: LEARNING OUTCOMES

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Code of the learning outcome of the programme	**Learning outcomes** The graduate:	Codes of the second-order PRK characteristics to which the learning outcome of the programme is related
KNOWLEDGE		
KF_W01	properly understands the civilisational importance of physics and its applications as well as its historical development and the role in the progress of science	2018_P7S_WG
KF_W02	has an in-depth knowledge of selected branches of theoretical and experimental physics	2018_P7S_WG
KF_W03	has an extended knowledge of quantum mechanics and statistical physics	2018_P7S_WG
KF_W04	has an in-depth knowledge of condensed phase physics	2018_P7S_WG
KF_W05	knows and understands the description of physical phenomena within selected theoretical models; can independently reproduce basic physical laws	2018_P7S_WG
KF_W06	knows mathematical formalism useful in constructing and analysing physical models of medium complexity; understands the consequences of using approximate methods	2018_P7S_WG
KF_W07	knows the basics of computational and IT techniques supporting the work of a physicist and understands their limitations	2018_P7S_WG
KF_W08	knows the construction and functioning of scientific apparatus	2018_P7S_WG
KF_W09	knows the basic principles of occupational health and safety to the extent that allows independent work at the research or measurement position	2018_P7S_WG
KF_W10	has an in-depth knowledge of selected scientific methods and is familiar with the issues characteristic of the discipline of science not related to the programme	2018_P7S_WK
W_OOD	has in-depth knowledge of selected scientific methods and knows problems characteristic of a particular field of science unrelated to the leading discipline of the study programme.	2018_P7S_WG, 2018_P7S_WK
SKILLS		
KF_U01	is able to clearly present the results of scientific discoveries and theories in the field of physics in speech and writing	2018_P7S_UW
KF_U02	can use a mathematical apparatus to solve physical problems of medium complexity	2018_P7S_UW
KF_U03	can explain the physical processes occurring in the surrounding world based on the knowledge gained	2018_P7S_UW
KF_U04	can explain the functioning of the research apparatus based on the knowledge gained	2018_P7S_UW
KF_U05	can plan and perform various types of physical measurements and experiments	2018_P7S_UW
KF_U06	is able to choose the right measurement method for a specific problem and the expected effect	2018_P7S_UW
KF_U07	is able to critically analyse and interpret the results of measurements, observations and theoretical calculations	2018_P7S_UW
KF_U08	can discuss measurement errors, identify their sources and assess the consequences	2018_P7S_UW

KF_U09	can use mathematical formalism to build and analyse physical models	2018_P7S_UW
KF_U10	can describe micro and macroscopic properties of the matter based on the knowledge gained and the research conducted	2018_P7S_UW
KF_U11	is able to prepare the elaboration of the study results, including explanation of the aim of the study, adopted methodology, description, analysis and discussion of the results obtained and their significance compared to similar studies	2018_P7S_UW
KF_U12	is able to obtain information from literature, databases and other sources; is familiar with basic scientific journals in physics; is able to integrate and interpret the obtained information, draw conclusions and formulate and justify opinions	2018_P7S_UW
KF_U13	has a sufficient command of English (B2+) to use the specialist literature and to present research results	2018_P7S_UW
KF_U14	is able to apply the obtained knowledge in physics to the discussion of problems in related scientific fields and disciplines	2018_P7S_UW
KF_U15	has an in-depth ability to prepare various written studies in Polish and English on specific physics-related issues or issues from different scientific disciplines	2018_P7S_UK
KF_U16	has an in-depth ability to prepare and present an oral presentation on physics or interdisciplinary issues in Polish and English, using modern multimedia techniques	2018_P7S_UK
KF_U17	is able to determine the directions of further learning and implement the process of self-education e.g. to improve professional competence	2018_P7S_UU
KF_U18	has an in-depth ability to pose and analyse problems based on the content acquired from the discipline of science not related to the programme	2018_P7S_UW
KF_U19	communicates in a foreign language using advanced language communication competences and has the ability to comprehensively read complex scientific texts and an in-depth ability to prepare various written works (including research) and oral presentations on specific issues in a given programme in a foreign language	2018_P7S_UK
U_OOD	has advanced skills to set scientific questions and analyse problems or to solve problems practically on the basis of the course content, experience and skills gained in a particular field of science unrelated to the leading discipline of the study programme.	2018_P7S_UW
SOCIAL COMPETENCES		
KF_K01	understands the need for further education and can inspire and organise the learning process of others	2018_P7S_KK
KF_K02	is able to precisely formulate questions to deepen their own understanding of a given topic or to find the missing elements of reasoning	2018_P7S_KK
KF_K03	is able to work in a group adopting different roles; is able to identify priorities for conducting the task specified by themselves or others	2018_P7S_KO, 2018_P7S_UO
KF_K04	understands the need for regular reading of scientific and popular science journals to broaden and deepen the knowledge of physics	2018_P7S_KK
KF_K05	understands and appreciates the importance of intellectual honesty in their own and others' actions; acts ethically	2018_P7S_KR
KF_K06	is aware of the responsibility for research initiatives; understands social aspects of applying the knowledge acquired	2018_P7S_KO
KF_K07	is able to listen to a different opinion and professionally discuss the issue in question	2018_P7S_KO
KF_K08	can think and act in an entrepreneurial way	2018_P7S_KO
KF_K09	understands the need for an interdisciplinary approach to solving problems, integrating knowledge from different disciplines and practising self-education to deepen the acquired knowledge	2018_P7S_KK
KS_OOD	understands the need for multidisciplinary approach to problem solving, integrating knowledge or using skills from various disciplines, and practicing self-study for deepening the acquired knowledge.	2018_P7S_KK

PART C: COURSE STRUCTURE

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time
7.	Academic year for which the revised course structure applies	—

Specialization: Fundamental and Applied Physics

A									year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4			
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	Computer Programming	EN	E	60	15	45	6	15	45	6									
2	Introductory Master Thesis Seminar	EN	Z	15		15	1		15	1									
3	Research Project Laboratory	EN	Z	60	5	55	7	5	55	7									
4	Selected Topics in Quantum Physics	EN	E	60	30	30	6	30	30	6									
5	Statistical Physics	EN	E	40	20	20	5	20	20	5									
6	Master Thesis Laboratory 1	EN	Z	60		60	8					60	8						
7	Master Thesis Seminar 1	EN	Z	15		15	2					15	2						
8	Set of Diploma Courses I	EN	Z	240	120	120	20				120	120	20						
9	Computer Simulations	EN	Z	45		45	3								45	3			
10	Master Thesis Laboratory 2	EN	Z	60		60	5								60	5			
11	Master Thesis Seminar 2	EN	Z	15		15	2								15	2			
12	Set of Diploma Courses II	EN	Z	240	120	120	20							120	120	20			
13	Master Thesis Laboratory 3	EN	Z	60		60	6											60	6
14	Master Thesis Seminar 3	EN	Z	15		15	3											15	3
15	Specialized Lecture (e-learning)	EN	Z	30	30		3										30		3
			TOTAL A:	1015	340	675	97	70	165	25	120	195	30	120	240	30	30	75	12

Internships and field work								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	Internships in Research Teams or Industry	EN	Z	160		160	18											160	18
			TOTAL Internships and field work:	160	0	160	18	0	0	0	0	0	0	0	0	0	0	160	18

Other requirements								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	General Academic Module in Humanities	–	Z	45		45	3		45	3									

Other requirements

								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
2	General Academic Module in Social Sciences	–	Z	30		30	2		30	2									
			TOTAL Other requirements:	75	0	75	5	0	75	5	0	0	0	0	0	0	0	0	0
			TOTAL:	1250	340	910	120	310		30	315		30	360		30	265		30
TOTAL								1250											

Studia kończą się nadaniem tytułu zawodowego magistra na kierunku Physics w specjalności Fundamental and Applied Physics.

Legend

Each semester consists of 15 weeks
E/C - examination/course work
E - ECTS
L - lecture, O - all forms of teaching excluding lecture (practical classes, laboratory classes, discussion classes, seminar, proseminar, language classes, field practice, workshop, internship, tutoring)

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
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4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time
7.	Academic year for which the revised course structure applies	—

Specialization: Nanophysics and Mesoscopic Materials - Modelling and Applications

A								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	Mathematical Methods in Physics	EN	E	60	30	30	5	30	30	5									
2	Numerical Methods	EN	E	40	10	30	4	10	30	4									
3	Quantum Physics	EN	E	50	30	20	5	30	20	5									
4	Solid State Physics	EN	E	50	25	25	5	25	25	5									
5	Statistical Physics	EN	E	40	20	20	4	20	20	4									
6	Classical Optics	EN	E	50	20	30	5				20	30	5						
7	Computer Simulations	EN	Z	30		30	3					30	3						
8	Interaction of Radiation with Matter	EN	E	20	10	10	3				10	10	3						
9	Laboratory Training	EN	Z	100		100	8					100	8						
10	Physics of Magnetic Materials	EN	E	30	10	20	3				10	20	3						
11	Physics of Semiconducting Materials	EN	E	40	10	30	4				10	30	4						
12	Spectroscopic Methods	EN	E	40	20	20	4				20	20	4						
13	Advanced Solid State Physics	EN	E	20	20		3							20		3			
14	Master's Laboratory	EN	Z	100		100	4								100	4			
15	Microsensors	EN	E	50	20	30	5							20	30	5			
16	Nanophysics	EN	E	60	60		5							60		5			
17	Non-linear Optics	EN	E	20	20		3							20		3			
18	Numerical Modeling of Solids	EN	E	40	10	30	4							10	30	4			
19	Physics of Mesoscopic Materials	EN	E	60	40	20	6							40	20	6			
			TOTAL A:	900	355	545	83	115	125	23	70	240	30	170	180	30	0	0	0

Internships and field work								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	Internship	EN	Z	210		210	30											210	30
			TOTAL Internships and field work:	210	0	210	30	0	0	0	0	0	0	0	0	0	0	210	30

Other requirements

								year 1						year 2					
				form of teaching				semester 1			semester 2			semester 3			semester 4		
No.	Module	Lang.	E/C	Total	L	O	Total ECTS	L	O	E	L	O	E	L	O	E	L	O	E
1	Advanced English Language Course	EN	E	30		30	2		30	2									
2	General Academic Module in Humanities	–	Z	45		45	3		45	3									
3	General Academic Module in Social Sciences	–	Z	30		30	2		30	2									
	TOTAL Other requirements:			**105**	**0**	**105**	**7**	**0**	**105**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL:			**1215**	**355**	**860**	**120**	**345**		**30**	**310**		**30**	**350**		**30**	**210**		**30**
	TOTAL							**1215**											

Studia kończą się nadaniem tytułu zawodowego magistra na kierunku Physics w specjalności Nanophysics and Mesoscopic Materials - Modelling and Applications.

Legend
Each semester consists of 15 weeks
E/C - examination/course work
E - ECTS
L - lecture, O - all forms of teaching excluding lecture (practical classes, laboratory classes, discussion classes, seminar, proseminar, language classes, field practice, workshop, internship, tutoring)

PART D: MODULES DESCRIPTION

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Advanced English Language Course

Module code: W4-2F-13-114

1. Number of the ECTS credits: 2

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_114_1	Understands the importance of oral communication and texts of varying complexity, including understanding of discussions, on general and specialist topics in the field of the subject	KF_U03 KF_U15 KF_U19	5 5 5
2F_114_2	Formulates clear and transparent oral and written statements, using the rules of the organization of statements and an appropriate register	KF_U13 KF_U15 KF_U19	5 5 5
2F_114_3	Communicates with the use of various channels and communication techniques in the field of various fields of science and scientific disciplines relevant to a given field of study	KF_K07 KF_U13 KF_U14 KF_U19	5 5 3 5
2F_114_4	It searches for, selects, analyzes, evaluates and classifies information using various sources and methods	KF_U09	5
2F_114_5	Understands the need for further education, performs self-assessment, is able to supplement and improve the acquired knowledge and skills; is able to work in a team, communicate with the environment in the workplace and outside it	KF_K01 KF_K02 KF_K03 KF_K06 KF_K08 KF_U17	2 2 2 2 2 2

3. Module description	
Description	The module focuses on training in a specialized language in the field of the subject. The module aims to develop communicative language competencies in linguistic activities (reading, listening, speaking, writing, and interaction). The module develops the ability to learn independently, acquire knowledge, work in a team, and communicate effectively with the environment.
Prerequisites	Recommended knowledge of a foreign language acquired at the current stages of education

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_114_w_1	credit	Periodic written and (or) oral tests of language competences acquired during classes and as part of own work, taking into account active participation in classes, on a scale of 2-5	2F_114_1, 2F_114_2, 2F_114_3, 2F_114_4, 2F_114_5
2F_114_w_2	exam	comprehensive written and (or) oral testing of language competences acquired during classes and as part of own work, including active participation in classes, on a scale of 2-5	2F_114_1, 2F_114_2, 2F_114_3, 2F_114_4, 2F_114_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_114_fs_1	practical classes	Exercises using the communicative teaching method, with elements of discussion, with written or oral feedback, with the participation of the student's own work. Exercises are conducted using the activating method (including e.g. project, webquest, case study) as well as distance learning methods and techniques and the use of ICT	30	Work with a textbook, dictionary, exercises, supplementary literature, internet sources. Assimilation and consolidation of language competences acquired during the classes. Preparation of oral and written forms (for example, draft, presentation, dialogue, essay, letter). Work on the e-learning platform.	30	2F_114_w_1, 2F_114_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Advanced Solid State Physics

Module code: W4-2F-17-27

1. Number of the ECTS credits: 3

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_27_1	has in-depth knowledge of selected areas of solid state physics	KF_W02 KF_W10	1 2
2F_27_2	has extended knowledge of the application of quantum mechanics and statistical physics to the description of solids	KF_W03	1
2F_27_3	has in-depth knowledge of the condensed phase theory	KF_W04	3
2F_27_4	knows and understands the physical processes included in the basic models used in the theory of solids	KF_W05	2
2F_27_5	knows the formalism of the second quantization and understands the mean-field approximation	KF_W06	1

3. Module description	
Description	During the lecture the student will learn: - Fock's space, creation and annihilation operators - spin operators - Bloch and Wannier representations and transformations between them - non-interacting electron gas in a tight binding model and dispersion relations for selected lattices - the mean field approximation - physics included in basic models: Hubbard (basic and the extended version), Heisenberg, Ising - Fermi-Dirac and Bose-Einstein distributions derived from commutation relations of creation and annihilation operators - approximate solutions of selected microscopic models
Prerequisites	2F_12, 2_F_13

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_27_w_1	written exam	After the end of the semester. Verification of the skills of a detailed analysis of selected issues discussed in the lecture.	2F_27_5
2F_27_w_2	oral exam	After the end of the semester. Verification of a broader understanding of the microscopic description of solids	2F_27_1, 2F_27_2, 2F_27_3, 2F_27_4

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_27_fs_1	lecture	detailed discussion by the lecturer of the issues listed in the table "module description" using the table and / or multimedia presentations	20	supplementary reading, working with the textbook, trying to find answers to simple problem questions asked during the lecture	30	2F_27_w_1, 2F_27_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Classical Optics

Module code: W4-2F-13-16

1. Number of the ECTS credits: 5

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_16_1	The student has in-depth knowledge of optics, knows the laws, formulas, basic concepts and terminology.	KF_W03	5
2F_16_2	The student has an extended knowledge of the experimental methods used in optics.	KF_W04	4
2F_16_3	The student understands the basic physical phenomena related to the propagation and interaction of electromagnetic waves with matter, knows the methods of describing these phenomena and the possibilities of their use in imaging and in the study of optical parameters of matter	KF_W05	3
2F_16_4	The student knows the structure of optical instruments and measurement limitations resulting from light interference and diffraction.	KF_W08	2
2F_16_5	The student is able to understand in speech and in writing the correct reasoning in the field of classical optics, among others can explain and describe the formation of images obtained with lenses and their simple systems, explain the phenomena of wave interference and diffraction.	KF_U01	5
2F_16_6	The student knows how to apply a mathematical apparatus to solve problems in physics in the field of optics.	KF_U02	4
2F_16_7	On the basis of the acquired knowledge, the student can explain the operation of optical instruments and measure selected quantities characterizing the optical properties of materials and optical systems.	KF_U04	3
2F_16_8	On the basis of the acquired knowledge, the student can describe the optical phenomena observed in the environment.	KF_U10	3

3. Module description

Description	The student during the course will listen to a lecture covering the following issues of classical optics 1. History of optics 2. Nature of light and models of its description a) law of reflection and refraction, light rays b) Fermat's principle c) waves and Huygens principle

	3. Maxwell's equations and wave equation electromagnetic. 4. Wave polarization a) description of linear, elliptical and circular polarization b) light polarization methods 5. Refractive index and dispersion. 6. Reflection of polarized light on the media boundary, total internal reflection. 7. Electromagnetic interference a) Young's experiment b) Superposition and coherence of waves c) interference for two coherent light sources d) interferometers 8. Wave diffraction a) diffraction on a single straight slot b) diffraction gratings c) diffraction at the hole and Airy disk ego, Rayleigh criterion 9. Light propagation in anisotropic media - optical birefringence 10. Geometric optics a) thin lenses and lens equation b) lens systems c) lens defects d) optical instruments e) optical fibers 11. Lasers as coherent light sources - operating principles and design The lecture includes presentations in PowerPoint (their content in the form of pdf files will be forwarded to students). Conversational classes include calculating exercises and discussing issues supplementing the content of the lecture. Students develop and present selected issues - the content of the presentation and how it will be conducted will be assessed. During the laboratory, students conduct experiments using optical instruments and elements. They learn about the construction and operation of instruments, including simple instruments such as a magnifier, telescope and microscope, as well as refractometers, interferometers and spectrometers, and a laser. The exam in the subject is obligatory
Prerequisites	The student should have basic knowledge of physics obtained during lectures in general physics at the first level of education - mechanics, electricity and magnetism, atomic physics.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_16_w_1	colloquium	As part of the seminar, two tests will be conducted (in the middle and at the end of the semester, deadline given two weeks in advance), consisting in solving accounting problems from previously discussed issues; grading scale: 2-5.	2F_16_1, 2F_16_3, 2F_16_4, 2F_16_5, 2F_16_6, 2F_16_8
2F_16_w_2	activity in class	The student's activity during the laboratory classes and the seminar (proposed solutions to problems, participation in discussions, quality of the experiments and demonstrations of	

		experiments) are assessed on a scale of 2-5 (as the average of partial grades).	2F_16_1, 2F_16_2, 2F_16_3, 2F_16_4, 2F_16_5, 2F_16_6, 2F_16_7, 2F_16_8
2F_16_w_3	written exam (or oral exam)	The condition for taking the exam is obtaining a credit for the seminar classes. Scope of the material: all issues discussed during the lectures, during laboratory classes and during the seminar, and the interpretation of formulas with simple calculations; grading scale 2-5.	2F_16_1, 2F_16_2, 2F_16_3, 2F_16_4, 2F_16_5, 2F_16_6, 2F_16_7, 2F_16_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_16_fs_1	lecture	The lecture discusses issues related to the properties of electromagnetic waves in terms of classical optics, enriched with modern applications of optics in the study of matter. It is conducted with the use of audiovisual aids (lectures in PowerPoint) and illustrated with demonstrations of experiences.	20	work with textbooks and lecture materials, supplementary readings,	20	2F_16_w_2, 2F_16_w_3
2F_16_fs_2	discussion classes	Conservatory classes consist in students solving tasks and problems related to the subject of the lecture - students individually present solutions that are discussed in detail in the group. Individuals presenting selected issues supplementing the problems given in the lecture; the presented materials are supplemented by the teacher and the students.	20	independent solving of tasks and physical problems based on textbooks, preparation of a discussion of selected issues and physical experiments	20	2F_16_w_1, 2F_16_w_2, 2F_16_w_3
2F_16_fs_3	laboratory classes	During the laboratory, students perform simple experiments with the use of optical elements and instruments and learn about the construction and operation of instruments and measuring devices operating on the basis of the laws of optics.	10	independent development of the issues necessary to conduct experiments - work with textbooks and lecture materials and based on the knowledge gained during discussion classes	10	2F_16_w_1, 2F_16_w_2, 2F_16_w_3

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Computer Programming

Module code: W4-2F-21-BP.03

1. Number of the ECTS credits: 6

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_BP.03_1	Knows the basics of computational and IT techniques supporting the work of a physicist and understands their limitations	KF_U18 KF_W07	3 5
2F_BP.03_2	Knows mathematical formalism useful in constructing and analysing physical models of medium complexity; understands the consequences of using approximate methods	KF_W06	3
2F_BP.03_3	Can use a mathematical apparatus to solve physical problems of medium complexity	KF_U02	3
2F_BP.03_4	Is able to professionally discuss the issue in question	KF_K07	4

3. Module description	
Description	The course's primary goal is to prepare students to solve with the usage of computer physics problems. The course should prepare students to use selected programming languages on the semi-advanced level, and apply numerical methods and techniques in the scientific work. The course will consist of introductory lectures and laboratory classes. The lecturer will introduce programming techniques and numerical methods. During laboratory classes, student will solve physics problems related to the scope of the master thesis.
Prerequisites	Basic level programming skills.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.03_w_1	Activity in class	Solving problems posed during classes, participation in the discussion on the optimization of the proposed solutions.	2F_BP.03_1, 2F_BP.03_2, 2F_BP.03_3, 2F_BP.03_4
2F_BP.03_w_2	Credit	Credit-based on a prepared and solved individual projects.	2F_BP.03_1, 2F_BP.03_2, 2F_BP.03_3, 2F_BP.03_4

2F_BP.03_w_3	Colloquium	Written test verifying the knowledge and skills in solving tasks and problems from the discussed topics.	2F_BP.03_1, 2F_BP.03_2, 2F_BP.03_3
2F_BP.03_w_4	Exam	Oral or written exam verifying knowledge based on the content of lectures, laboratory classes and indicated in the syllabus literature. Students must pass the laboratory classes in order to take the exam.	2F_BP.03_1, 2F_BP.03_2, 2F_BP.03_3, 2F_BP.03_4

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.03_fs_1	lecture	Presentations introducing programming techniques, numerical methods, analysis techniques, and code optimization techniques	15	Reading the lecture notes, studying recommended literature	30	2F_BP.03_w_4
2F_BP.03_fs_2	laboratory classes	Writing a code (under supervision of instructor) with the use of learn programming techniques	45	Individual solving of problems, preparing individual projects	90	2F_BP.03_w_1, 2F_BP.03_w_2, 2F_BP.03_w_3

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Computer Simulations

Module code: W4-2F-12-17

1. Number of the ECTS credits: 3

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_17_1	Has a basic knowledge of molecular dynamics simulation	KF_W07	5
2F_17_2	He knows the structure, principle of operation and the scope of application of molecular dynamics simulation programs.	KF_W07	4
2F_17_3	Can identify the advantages and limitations of the molecular dynamics simulation method.	KF_W04	4
2F_17_4	Can write implementations of selected procedures and functions used in simulation of molecular dynamics	KF_U02	4
2F_17_5	Is able to independently prepare the study results.	KF_U11	4

3. Module description	
Description	Laboratory classes conducted in the form of workshops during which students will learn about the following issues: - Inter-atomic interactions. - Initial configuration, elimination of total momentum of the system, reduced units, control parameters in the stage of equilibration of the system - Periodic boundary conditions, convention of the nearest images, spherical truncation. – Newton equations of motion for atomic systems, methods of solving differential equations, forces and shifted potential. - Simple thermodynamic averages (energy, temperature, pressure). - Structural properties (binary distribution function, static structure factor), long-range corrections of potential energy and pressure. - Time correlation functions, correlation times and transport coefficients. - Molecular dynamics for various statistical groups. Students receive a description (in electronic form) of issues related to the content of the classes, which are discussed during the classes. The acquired knowledge is used to develop a computer program to simulate the molecular dynamics of the atomic system.
Prerequisites	Elementary knowledge of classical and statistical mechanics, knowledge of programming languages (eg Fortran, C / C ++)

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_17_w_1	Running atomic simulation programs	The basis for passing the laboratory classes is the knowledge of the molecular dynamics simulation method and launching a simulation program for the system of atoms	2F_17_1, 2F_17_2, 2F_17_3, 2F_17_4, 2F_17_5
2F_17_w_2	activity in class	An additional factor in the final evaluation of the laboratory classes is being active and independent in the process of developing computer programs.	2F_17_4, 2F_17_5

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_17_fs_1	laboratory classes	Classes conducted in the form of workshops: theoretical discussion of molecular dynamics simulation with practical application to the system of atoms.	30	supplementary reading, work with the textbook	30	2F_17_w_1, 2F_17_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Computer Simulations

Module code: W4-2F-21-BP.13

1. Number of the ECTS credits: 3

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.13_1	Knows the basics of computational and IT techniques supporting the work of a physicist and understands their limitations	KF_W07	5
2F_BP.13_2	Knows mathematical formalism useful in constructing and analysing physical models of medium complexity; understands the consequences of using approximate methods	KF_W06	3
2F_BP.13_3	Can use a mathematical apparatus to solve physical problems of medium complexity	KF_U02	3
2F_BP.13_4	Is able to professionally discuss the issue in question	KF_K07	4

3. Module description

Description	The e-learning course introduces methods of computer simulations and their applications in solving physical problems. The specific methodology of simulations will match the interest of students and their master physics topics, for example: •Dynamics of molecular systems simulated with the implementation of interactions between molecules; •Nuclear or particle physics simulations based on particle interaction models and tools for building virtual detection systems; •Simulations of the fluid dynamics, low and high energy processes, and other problems related to theoretical physics.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.13_w_1	Activity in e-learning	Solving problems posed during e-learning, participation in the discussion on the optimization of the proposed solutions.	2F_BP.13_1, 2F_BP.13_2, 2F_BP.13_3, 2F_BP.13_4
2F_BP.13_w_2	Colloquium or test, individual projects	Verification of a student progress during e-learning course.	2F_BP.13_1, 2F_BP.13_2, 2F_BP.13_3

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_BP.13_fs_1	laboratory classes	Writing a code based on the prepared e-learning course with usage of selected programming techniques	45	Individual solving of the homework problems, preparing individual projects	45	2F_BP.13_w_1, 2F_BP.13_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: General Academic Module in Humanities

Module code: HMO2

1. Number of the ECTS credits: 3

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
HMO2_1	The student knows selected issues concerning subject specific of humanities, understands their nature, place and importance in the system of science and their connection with the fields of science and scientific disciplines for the studying programme, allowing for the integration of perspectives characteristic of scientific disciplines.	U_OOD W_OOD	4 4
HMO2_2	The student can choose, interpret and make assessment of the knowledge from selected disciplines in humanities, integrate and apply the knowledge in a scientific activity and professional practice in a way which allows original and creative problem solving that experiences as a participant of a cultural life	U_OOD W_OOD	4 4
HMO2_3	The student can creatively take, analyze and involve in current socio-cultural discourses using the knowledge of modern humanities and acquired communication skills, argumentation taking into account various scientific approaches and types of scientific reflection	U_OOD W_OOD	4 4
HMO2_4	The student as a participant of a cultural life in its various forms, indicates a need for a continuous learning and improvement of the dispositions that allow to valuing humanistic reflection and its integrating with the issues and experiences resulting from the selection of his/her own path of scientific and professional activity and individual cultural activity	KS_OOD U_OOD W_OOD	3 3 3

3. Module description	
Description	General Academic Module in Humanities module allows the student to get acquainted with selected areas of humanities and allows a practical analysis of the assumptions presented in various humanistic theories. The student has the opportunity to compare various methodological and interpretative approaches, gain knowledge about the benefits and the limitations of adopting a humanistic perspective in the perception of reality. The student learns to implement the paradigms of a humanistic thinking to his/her scientific activity and creatively solves the problems posed during the course. The student learns the ability of critical integration of approaches characteristic of humanities with the viewpoints belonging to areas of science and scientific disciplines appropriate for the programme. In the course of study, the student identifies the ways of iactive participation in current and future cultural formations, recognising in the presented and experienced activities the paths of a deepened individual participation in the life of a relevant human communities.
Prerequisites	

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
HMO2_w_1	assessment	written or oral assessment described in the syllabus	HMO2_1, HMO2_2, HMO2_3, HMO2_4
HMO2_w_2	continuous assessment	continuous assessment of student’s individual work; an average score from activities performed in-class – details in the syllabus	HMO2_1, HMO2_2, HMO2_3, HMO2_4

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
HMO2_fs_1	depending on the choice	Depending on the type of classes the following methods can be used: expository method, problem solving, task, project, analysis of source material	45	Profound analysis of the reading list indicated in the syllabus, repetition and consolidation of knowledge or skills acquired during the classes	45	HMO2_w_1, HMO2_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: General Academic Module in Social Sciences

Module code: SMO1

1. Number of the ECTS credits: 2

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
SMO1_1	The student knows selected issues concerning subject specific of social sciences, understands their nature, place and importance in the system of science and their connections with the fields of science and scientific disciplines for the studying programme, allowing for the integration of perspectives characteristic of scientific disciplines.	U_OOD W_OOD	3 3
SMO1_2	The student can choose, interpret and make assessment of the knowledge from selected disciplines in social sciences, integrate and apply the knowledge in a scientific activity and professional practice in a way which allows original and creative problem solving that experiences as a participant of a social life.	U_OOD W_OOD	3 3
SMO1_3	The student can creatively take, analyze and involve in current socio-cultural discourses using the knowledge of modern humanities and acquired communication skills, argumentation taking into account various scientific approaches and types of scientific reflection	U_OOD W_OOD	3 3
SMO1_4	The student as a participant of social life in its various forms, indicates a need for a continuous learning and improvement of the dispositions that result from the choice of his/her own path of scientific, professional and social activity.	KS_OOD U_OOD W_OOD	2 2 2

3. Module description	
Description	General Academic Module in Social Sciences allows the to get acquainted with the selected areas of social sciences. The student has the opportunity to compare various methodological and interpretative approaches, gain knowledge about the benefits of adopting social sciences perspective to the perception of reality. The student learns the ability of critical integration of approaches characteristic of social sciences with the viewpoints belonging to areas of science and scientific disciplines appropriate for the programme.
Prerequisites	

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
SMO1_w_1	assessment	written or oral assessment described in the syllabus	SMO1_1, SMO1_2, SMO1_3, SMO1_4
SMO1_w_2	continuous assessment	continuous assessment of student’s individual work; an average score from activities performed in-class – details in the syllabus	SMO1_1, SMO1_2, SMO1_3, SMO1_4

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
SMO1_fs_1	depending on the choice	Depending on the type of classes the following methods can be used: expository method, problem solving, task, project, analysis of source material	30	Profound analysis of the reading list indicated in the syllabus, repetition and consolidation of knowledge or skills acquired during the classes	30	SMO1_w_1, SMO1_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Interaction of Radiation with Matter

Module code: W4-2F-13-20

1. Number of the ECTS credits: 3

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_20_1	learned the basic concepts of crystallography	KF_W02 KF_W08	3 3
2F_20_2	knows the properties of X-ray radiation, its production and interaction with matter	KF_W02 KF_W08	4 4
2F_20_3	knows the physical basics of X-ray diffraction on a crystal lattice	KF_W02 KF_W08	4 4
2F_20_4	can relate the diffraction image with the microscopic structure of crystalline bodies	KF_W02 KF_W08	4 4
2F_20_5	knows the basic procedures for determining the structure of crystals on the basis of the obtained experimental results	KF_U03 KF_U04 KF_U06 KF_U08 KF_W02 KF_W08	4 4 4 4 4 4
2F_20_6	can carry out measurements on X-ray diffractometers	KF_U03 KF_U04 KF_U06 KF_U08 KF_W02	4 4 4 4 4

		KF_W08	4
2F_20_7	can use basic crystallographic programs	KF_U03 KF_U04 KF_U06 KF_U08 KF_W02 KF_W08	3 3 3 3 3 3

3. Module description	
Description	During the lecture, the student will learn about following aspects: 1.Elements of crystallography (crystal lattice concept, symmetry operations, point and space groups, reciprocal lattice) 2.X-ray properties: laboratory production and synchrotron radiation 3.Interaction of X-rays with matter: Compton phenomenon, photoelectric, Rayleigh scattering 4.Geometric conditions of X-ray scattering by crystal: Laue's theory, Ewald's construction, Bragg's equation. 5.Elastic X-ray scattering by electrons, atoms, elementary cells and crystals. The intensity of diffractive radiation. 6.Experimental techniques for studying the structure of crystals (powder and monocrystalline methods) 7.Methods of determining crystalline structure: Fourier, Patterson and Patterson analysis, direct methods, structure clarification. 8.The Rietveld method for determining structure parameters from diffraction on powder samples In the laboratory classes: 1.learn to work on a powder diffractometer 2.perform simple calculations of structure parameters for regular system crystals 3.acquaint himself with the basic programmes for calculating structures Mandatory examination
Prerequisites	Knowledge of: basics of physics, elements of condensed phase physics, selected issues in higher mathematics (Fourier series, distribution functions, matrix account)

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_20_w_1	colloquium	Before starting the exercise, the student has to pass a test on the knowledge of physical phenomena in a given exercise.	2F_20_6, 2F_20_7
2F_20_w_2	activity in class	The student conducts exercises on his own, and the obtained results are developed and presented in the form of a report	2F_20_6, 2F_20_7
2F_20_w_3	written exam (or oral exam)	Written exam on the material presented during the lecture. The exam topics are given three weeks before the exam.	2F_20_1, 2F_20_2, 2F_20_3, 2F_20_4, 2F_20_5

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_20_fs_1	lecture	lecture conducted with the use of audiovisual aids	10	Work with supplementary reading and lecture notes	25	2F_20_w_3
2F_20_fs_2	laboratory classes	Performing basic exercises on the X-ray diffractometer.	10	Preparation of the report	25	2F_20_w_1, 2F_20_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Internship

Module code: W4-2F-17-10.2

1. Number of the ECTS credits: 30

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_10.2_1	Understands the importance of physics and its applications in the progress of science and the development of new technologies	KF_W01	4
2F_10.2_2	Has a profound knowledge of condensed matter physics, quantum mechanics, statistical, theoretical and experimental physics	KF_W02 KF_W03	3 3
2F_10.2_3	Knows theoretical models and mathematical formalism as well as computer methods necessary to solve the problems undertaken in the master thesis	KF_W05 KF_W06 KF_W07	5 5 5
2F_10.2_4	Is able to use the research equipment, carry out experiments, and select the correct measurement method for a specific problem and the expected effect	KF_U04 KF_U05 KF_U06 KF_W08	4 4 4 4
2F_10.2_5	Can make a critical analysis and interpretation of research results	KF_U08 KF_U09 KF_U10	4 4 4
2F_10.2_6	Is able to independently prepare the development of research results, assess their significance against the background of other results obtained from the literature, draw conclusions and formulate opinions	KF_U11 KF_U12	4 4
2F_10.2_7	Is able to prepare written work and multimedia presentations in English in the field of research	KF_K07 KF_U15 KF_U16	4 4 4
2F_10.2_8	Can listen to a different opinion and undertake substantive discussions on a given issue	KF_K07	4

		KF_U15	4
2F_10.2_9	Understands the need for further education, is able to implement the process of self-education	KF_K01 KF_U17	5 5

3. Module description	
Description	In the fourth semester, the internship can be carried out in the laboratories of the University of Le Mans or in the parent unit in English. Completing the module in France is a prerequisite for obtaining a double diploma. The curriculum is determined by the Polish and French coordinator and pedagogical committees of units participating in the double study program. Each student has a supervisors coordinating his work at the partner and home university. The module (210 hours, 30 ECTS) consists of the following classes: • Master's laboratory and execution of MA thesis - 180 hours (27 ECTS), Form of classes - laboratory • Master's seminar - 30 hours (3 ECTS), Form of classes – seminar During his/her stay in France, the student conducts research as part of his/her master's thesis on a selected topic of nanophysics under the guidance of scientific supervisors from France (University of Le Mans) and Poland (University of Silesia). The student prepares a master's thesis in English and its defence takes place in English before a joint Polish-French examination board. In the case of Polish students who will resign from a double diploma and will implement the Internship module at the home university, completing the thesis is equivalent to completing the MA thesis under the supervision of only one supervisor from the home university. In this case, the module classes are also held in English, similarly, the student prepares a master's thesis in English.
Prerequisites	All items and modules included in the study plan are passed by the student.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_10.2_w_1	Master thesis	The thesis is the final verifier of the student's workload and commitment to the module	2F_10.2_1, 2F_10.2_2, 2F_10.2_3, 2F_10.2_4, 2F_10.2_5, 2F_10.2_6, 2F_10.2_7, 2F_10.2_8, 2F_10.2_9

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_10.2_fs_1	internship	Master's laboratory and execution of MA thesis (academic tutor from France and Poland). Master's seminar - The program of classes is determined by the pedagogical committees of the partner units.	210	Before starting the research, the student will read the literature. After completing the research, he/she prepares a report / MA thesis in English. Student presents research results in English.	200	2F_10.2_w_1

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Internships in Research Teams or Industry

Module code: W4-2F-21-BP.11

1. Number of the ECTS credits: 18

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.11_1	Understands the importance of physics and its applications in the progress of science and the development of new technologies	KF_K06 KF_W01	2 4
2F_BP.11_2	Has in-depth knowledge of selected branches theoretical and experimental physics	KF_W02	3
2F_BP.11_3	Knows the theoretical models and mathematical formalisms and computer methods necessary to solve the problems undertaken in the thesis	KF_W05 KF_W06 KF_W07	5 5 5
2F_BP.11_4	Is able to use research apparatus, conduct experiments and select an appropriate measurement method for a specific problem and the expected result	KF_U04 KF_U05 KF_U06 KF_U08	4 4 4 4
2F_BP.11_5	Is able to perform critical analysis and interpret research findings	KF_U08 KF_U09 KF_U10	4 4 4
2F_BP.11_6	Can individually prepare a study of research results, assess their significance in relation to other results obtained from the literature, draw conclusions and formulate opinions	KF_U11 KF_U12	4 4
2F_BP.11_7	Is able to prepare written works and multimedia presentations in native language and English within the scope of the conducted research.	KF_U07 KF_U15 KF_U16 KF_U19	4 4 4 3

2F_BP.11_8	Is able to listen to a different opinion and professionally discuss the issue in question.	KF_K03 KF_U07 KF_U15	2 4 4
2F_BP.11_9	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U17	5 5

3. Module description	
Description	The course aims to introduce students to work in research, R&D groups, or modern industry. A student may complete the internship in research groups of Polish or foreign academic units, research institutes or companies. The internship's scope may cover theoretical physics, experimental physics, computer modelling in physics, physics applications in industry or medicine. As part of the 120 hours provided in the course, the student is expected to become familiar with a research group's specific work of their choice and actively participate in the group's work. The internship supervisor will assign tasks to the student (e.g., performing calculations, simulations, participating in an experiment, developing a research procedure, testing the equipment, analysing the results of conducted research). After completing the assignment, the student prepares a report on the accomplished activities.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.11_w_1	Report	The final verification of the student's workload and student’s written report is by the internship supervisor and internships academic coordinator who approve the report and the traineeship.	2F_BP.11_1, 2F_BP.11_2, 2F_BP.11_3, 2F_BP.11_4, 2F_BP.11_5, 2F_BP.11_6, 2F_BP.11_7, 2F_BP.11_8, 2F_BP.11_9

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.11_fs_1	internship	The internship supervisor will introduce the student to the specifics of working in chosen research group. Supervisor will assign and assist the student in solving given task or elaborate the project.	160	The student takes an active part in research/ development conducted in a selected team. The student elaborates the results and prepares a report. At the team's request, the student presents the results of the undertaken activities in the form of a seminar.	240	2F_BP.11_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Introductory Master Thesis Seminar

Module code: W4-2F-21-BP.07

1. Number of the ECTS credits: 1

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.07_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.07_2	The student can independently prepare a study of the research results, assess their significance against other results obtained from the literature, draw conclusions and formulate opinions	KF_K04 KF_U11 KF_U12	3 3 3
2F_BP.07_3	He/she can prepare written works and multimedia presentations in the native language and English within the research scope.	KF_K07 KF_U01 KF_U15 KF_U16	4 5 4 4
2F_BP.07_4	The student can listen to another opinion and undertake a substantive discussion on a given issue	KF_K07 KF_U15	4 4
2F_BP.07_5	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U04 KF_U17	5 3 5

3. Module description

Description	The course aims to prepare students to present and write a master thesis. In the introductory part, the student will know formal aspects of master's theses preparation at the Faculty of Science and Technology of the University of Silesia (and other higher education institutions). The thesis structure will be discussed with rules for formulating hypotheses and describing research methods, creating bibliography based on articles and scientific monographs, taking into account copyright issues, cross-references. Discussion of the topics proposed by potential supervisors is performed. In the course's central part, students based on selected topics of their future master's thesis present: the literature review of the chosen topic, the purpose and

	scope of research or/and research hypothesis, the research methodology, the concept, and prospectus of future master's thesis. The proseminar's primary goal is developing the ability to formulate research problems by students, select appropriate methods of solutions, and develop competencies related to disseminating knowledge, with the preparation of a presentation.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.07_w_1	Activity in class	Evaluation of involvement in seminar discussion.	2F_BP.07_1, 2F_BP.07_2, 2F_BP.07_3, 2F_BP.07_5
2F_BP.07_w_2	Credit	Credit based on a prepared and presented seminar.	2F_BP.07_1, 2F_BP.07_2, 2F_BP.07_3, 2F_BP.07_4, 2F_BP.07_5

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_BP.07_fs_1	proseminar	Proseminar in the form of meetings with students, presentation of requirements, deadlines, and proposed thesis topics. Presentation of the research problem, participation in the discussion.	15	Preparation of the seminar	10	2F_BP.07_w_1, 2F_BP.07_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Laboratory Training

Module code: W4-2F-12-03

1. Number of the ECTS credits: 8

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_03_1	has in-depth knowledge of experimental physics based on experience gained while taking measurements	KF_W02	4
2F_03_2	enriched the knowledge of condensed phase physics and consolidated the knowledge of modern research methods	KF_W04	5
2F_03_3	knows the mathematical formalism and mathematical methods useful in the construction and analysis of physical models with an average level of complexity; understands the consequences of using approximate methods and their impact on the interpretation of measurement results	KF_W06	4
2F_03_4	knows the structure and principles of operation of selected scientific equipment; is able to choose the appropriate apparatus necessary to determine specific physico-chemical properties of materials	KF_W08	4
2F_03_5	is able to plan and conduct various types of measurements and experiments with the use of specialized scientific equipment	KF_U05	4
2F_03_6	is able to critically analyze and interpret measurement results, indicate the sources of measurement errors and formulate conclusions and relate them to the hypothesis	KF_U07	3
2F_03_7	is able to independently develop and present the results of measurements in the form of a work containing: justification of the purpose of the work, the adopted methodology, description, analysis and discussion of the obtained results and their significance in comparison to similar studies	KF_U11	5
2F_03_8	has the ability to prepare and present an oral presentation in physics, using modern multimedia techniques; is able to take up a discussion and answer questions related to conducted research	KF_U15	4

3. Module description

Description	The laboratory will be held at a partner Le Mans University in France or in the laboratories of the Institute of Physics. The student will be familiarized with modern research equipment and take part in experimental work. Under the guidance of the lecturer/supervisor of the realized project he/she will perform research, discuss, interprets and analyze the obtained results. The project will be implemented in a team, which will allow the student to be familiar with the specifics of team research. The subject of the laboratory/project may concern the synthesis and analysis also modelling of physical properties of nanostructures. The detailed research program depends on the topic of the realized project and is agreed with the Polish/French supervisor. Each class,

	in individual laboratories, will be preceded by a theoretical introduction regarding the tested properties of materials and applied research techniques (principle of operation, design of instruments, possibilities of application and measurement accuracy). The basis for getting credit will be preparing a report in English and presenting the obtained results to the research team as an examination board.
Prerequisites	The student should have basic knowledge of atomic and molecular physics as well as solid state physics covered by the first degree of education.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_03_w_1	activity in class	During the course, students will take part in planning measurements, their elaboration and interpretation of the results. The method of carrying out the research, the ability to compile it numerically and the quality of answers to the questions will be assessed on a scale of 2-5 (average of grades from individual laboratories).	2F_03_1, 2F_03_2, 2F_03_3, 2F_03_4, 2F_03_5, 2F_03_6
2F_03_w_2	report	The student will prepare and present the developed research results in the form of a report in English, which will be presented in the form of a presentation. The quality of the study, the method of presentation and answers to questions from colleagues and the teacher will be assessed on a scale of 2-5.	2F_03_1, 2F_03_2, 2F_03_3, 2F_03_4, 2F_03_5, 2F_03_6, 2F_03_7, 2F_03_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_03_fs_1	laboratory classes	A short lecture containing a theoretical introduction to modern experimental methods of the condensed phase, conducted before each type of research (presentations and familiarization with devices in laboratories). Joint performance of measurements under the supervision of a specialist in a given research technique. Initial discussion of the results by the tutor and indication of the methods of their development, and specification of the requirements for the report. Presentation by students of the prepared measurement studies, discussion of the results, evaluation of the quality of reports.	100	Familiarization with materials concerning equipment (instructions, manuals and study). Supplementary reading and work with the textbook in order to deepen the knowledge of the discussed issues. Development of measurement results and preparation of presentations.	100	2F_03_w_1, 2F_03_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Laboratory 1

Module code: W4-2F-21-BP.09

1. Number of the ECTS credits: 8

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.09_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.09_2	Has in-depth knowledge of condensed phase physics, quantum mechanics, statistical, theoretical and experimental physics	KF_U03 KF_W02 KF_W03	3 3 3
2F_BP.09_3	Knows the theoretical models and mathematical formalisms and computer methods necessary to solve the problems undertaken in the thesis	KF_W05 KF_W06 KF_W07	3 3 3
2F_BP.09_4	Is able to use research apparatus, conduct experiments and select an appropriate measurement method for a specific problem and the expected effect	KF_U04 KF_U05 KF_U06 KF_W08	3 3 3 3
2F_BP.09_5	Is capable of critically analyzing and interpreting research findings	KF_U08 KF_U09 KF_U10	3 3 3
2F_BP.09_6	Student is able to independently prepare a report on research results, assess their significance in comparison with other results obtained from the literature, draw conclusions and formulate opinions	KF_U11 KF_U12	3 3
2F_BP.09_7	Student is able to listen to others and engage in a meaningful discussion about an issue	KF_K05 KF_K07 KF_U15	3 4 4

2F_BP.09_8	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U17	5 5

3. Module description	
Description	Under the course scope and the supervisor's guidance, a student acquaints with the problem realised within the thesis framework, research methodology, and professional literature. Then the student will work on the topic of the thesis. Student activities can include calculations, data collection and processing, interpretation, and discussion of obtained results. Depending on the thesis topic's choice, the course may consist of theoretical research, experimental research, applied research or computer simulations.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.09_w_1	Credit	Evaluation based on research progress and thesis preparation.	2F_BP.09_1, 2F_BP.09_2, 2F_BP.09_3, 2F_BP.09_4, 2F_BP.09_5, 2F_BP.09_6, 2F_BP.09_7, 2F_BP.09_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.09_fs_1	laboratory classes	Performing research under the direction of the supervisor.	60	The student reviews the literature. After completing specific sections of research, analyze results, write reports.	120	2F_BP.09_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Laboratory 2

Module code: W4-2F-21-BP.15

1. Number of the ECTS credits: 5

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.15_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.15_2	Has in-depth knowledge of selected branches theoretical and experimental physics	KF_U03 KF_W02	3 3
2F_BP.15_3	Knows the theoretical models and mathematical formalisms and computer methods necessary to solve the problems undertaken in the thesis	KF_W05 KF_W06 KF_W07	3 3 3
2F_BP.15_4	Is able to use research apparatus, conduct experiments and select an appropriate measurement method for a specific problem and the expected result	KF_U04 KF_U05 KF_U06 KF_W08	3 3 3 3
2F_BP.15_5	Is capable of critically analyzing and interpreting research findings	KF_U08 KF_U09 KF_U10	3 3 3
2F_BP.15_6	Can prepare the research report, assess their impact on the background of other results obtained from the literature, draw conclusions, formulate and justify opinions.	KF_U11 KF_U12	3 3
2F_BP.15_7	Is able to listen to a different opinion and professionally discuss the issue in question	KF_K05 KF_K07 KF_U15	3 4 4

2F_BP.15_8	Understands the need for further education, can implement self-education by reading complex scientific texts and manuals in English.	KF_K01 KF_U17 KF_U19	5 5 4

3. Module description	
Description	Under the course scope and the supervisor's guidance, a student acquaints with the problem realised within the thesis framework, research methodology, and professional literature. Then the student will work on the topic of the thesis. Student activities can include calculations, data collection and processing, interpretation, and discussion of obtained results. Depending on the thesis topic's choice, the course may consist of theoretical research, experimental research, applied research or computer simulations.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.15_w_1	Diploma thesis	Evaluation of progress in writing the thesis.	2F_BP.15_1, 2F_BP.15_2, 2F_BP.15_3, 2F_BP.15_4, 2F_BP.15_5, 2F_BP.15_6, 2F_BP.15_7, 2F_BP.15_8
2F_BP.15_w_2	Credit	Evaluation based on research progress and thesis preparation.	2F_BP.15_1, 2F_BP.15_2, 2F_BP.15_3, 2F_BP.15_4, 2F_BP.15_5, 2F_BP.15_6, 2F_BP.15_7, 2F_BP.15_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.15_fs_1	laboratory classes	Performing research under the direction of the supervisor.	60	Individual work on issues related to the thesis (data analysis, reports).	60	2F_BP.15_w_1, 2F_BP.15_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Laboratory 3

Module code: W4-2F-21-BP.17

1. Number of the ECTS credits: 6

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_BP.17_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.17_2	Has in-depth knowledge of condensed phase physics, quantum mechanics, statistical, theoretical and experimental physics	KF_U03 KF_W02 KF_W03	3 3 3
2F_BP.17_3	Knows the theoretical models and mathematical formalisms and computer methods necessary to solve the problems undertaken in the thesis	KF_W05 KF_W06 KF_W07	3 3 3
2F_BP.17_4	Is able to use research apparatus, conduct experiments and select an appropriate measurement method for a specific problem and the expected effect	KF_U04 KF_U05 KF_U06 KF_W08	3 3 3 3
2F_BP.17_5	Is capable of critically analyzing and interpreting research findings	KF_U08 KF_U09 KF_U10	3 3 3
2F_BP.17_6	Student is able to independently prepare a report on research results, assess their significance in comparison with other results obtained from the literature, draw conclusions and formulate opinions	KF_U11 KF_U12	3 3
2F_BP.17_7	Student is able to listen to others and engage in a meaningful discussion about an issue	KF_K05 KF_K07 KF_U15	3 4 4

2F_BP.17_8	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U17	5 5

3. Module description	
Description	Under the course scope and the supervisor's guidance, a student acquaints with the problem realised within the thesis framework, research methodology, and professional literature. Then the student will work on the topic of the thesis. Student activities can include calculations, data collection and processing, interpretation, and discussion of obtained results. Depending on the thesis topic's choice, the course may consist of theoretical research, experimental research, applied research or computer simulations.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.17_w_1	Diploma thesis	Evaluation of progress in writing the thesis.	2F_BP.17_1, 2F_BP.17_2, 2F_BP.17_3, 2F_BP.17_4, 2F_BP.17_5, 2F_BP.17_6, 2F_BP.17_7, 2F_BP.17_8
2F_BP.17_w_2	Credit	Evaluation based on research progress and thesis preparation.	2F_BP.17_1, 2F_BP.17_2, 2F_BP.17_3, 2F_BP.17_4, 2F_BP.17_5, 2F_BP.17_6, 2F_BP.17_7, 2F_BP.17_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.17_fs_1	laboratory classes	Performing research under the direction of the supervisor.	60	Individual work on issues related to the thesis (data analysis, reports).	90	2F_BP.17_w_1, 2F_BP.17_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Seminar 1

Module code: W4-2F-21-BP.10

1. Number of the ECTS credits: 2

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_BP.10_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.10_2	Can prepare the research report, assess their impact on the background of other results obtained from the literature, draw conclusions, formulate and justify opinions.	KF_K04 KF_U11 KF_U12	3 3 3
2F_BP.10_3	Is able to prepare written reports and multimedia presentations in native language and English within the scope of the conducted research.	KF_K07 KF_U01 KF_U15 KF_U16	4 5 4 4
2F_BP.10_4	Is able to listen to a different opinion and professionally discuss the issue in question.	KF_K07 KF_U15	4 4
2F_BP.10_5	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U04 KF_U17	5 3 5
2F_BP.10_6	communicates in a foreign language using advanced language communication competences and has the ability to comprehensively read complex scientific texts, and has an in-depth ability to prepare oral presentations in English.	KF_U13 KF_U19	5 5

3. Module description	
Description	The diploma seminar's primary goal is to prepare students to present obtained research results, their interpretation, and conclusions. Additionally, the student should learn how to participate in scientific open discussions and formulate exact questions.

Prerequisites	No prerequisites.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.10_w_1	Activity in class	Evaluation of student's engagement in discussions, expressing opinions and formulate conclusions, quality of the research presentation. Evaluation of engagement and participation in seminar discussions, including the ability to express opinions and formulate conclusions.	2F_BP.10_1, 2F_BP.10_2, 2F_BP.10_3, 2F_BP.10_5, 2F_BP.10_6
2F_BP.10_w_2	Credit	The evaluation is based on the preparation and presentation of the seminar.	2F_BP.10_1, 2F_BP.10_2, 2F_BP.10_3, 2F_BP.10_4, 2F_BP.10_5, 2F_BP.10_6

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_BP.10_fs_1	seminar	Presentation of the research problem, participation in the discussion.	15	Preparation of the seminar.	45	2F_BP.10_w_1, 2F_BP.10_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Seminar 2

Module code: W4-2F-21-BP.14

1. Number of the ECTS credits: 2

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.14_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.14_2	The student is able to independently prepare a study of the research results, assess their significance against other results obtained from the literature, draw conclusions and formulate opinions	KF_K04 KF_U11 KF_U12	3 3 3
2F_BP.14_3	He/she is able to prepare written works and multimedia presentations in native language and English within the scope of the conducted research.	KF_K07 KF_U01 KF_U15 KF_U16	4 5 4 4
2F_BP.14_4	The student is able to listen to another opinion and to undertake a substantive discussion on a given issue.	KF_K07 KF_U15	4 4
2F_BP.14_5	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U04 KF_U17	5 3 5
2F_BP.14_6	communicates in a foreign language using advanced language communication competences and has the ability to comprehensively read complex scientific texts, and has an in-depth ability to prepare oral presentations in English.	KF_U13 KF_U19	5 5

3. Module description

Description	The diploma seminar's primary goal is to prepare students to present obtained research results, their interpretation, and conclusions. Additionally, the student should learn how to participate in scientific open discussions and formulate exact questions.

Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.14_w_1	Activity in class	Evaluation of engagement and participation in seminar discussions, including the ability to express opinions and formulate conclusions.	2F_BP.14_1, 2F_BP.14_2, 2F_BP.14_3, 2F_BP.14_5, 2F_BP.14_6
2F_BP.14_w_2	Credit	The evaluation is based on the preparation and presentation of the seminar.	2F_BP.14_1, 2F_BP.14_2, 2F_BP.14_3, 2F_BP.14_4, 2F_BP.14_5, 2F_BP.14_6

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.14_fs_1	seminar	Presentation of the research problem, participation in the discussion.	15	Preparation of the seminar.	45	2F_BP.14_w_1, 2F_BP.14_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master Thesis Seminar 3

Module code: W4-2F-21-BP.16

1. Number of the ECTS credits: 3

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.16_1	Understands the importance of physics and its applications in the advancement of science and the development of new technologies	KF_W01	4
2F_BP.16_2	The student is able to independently prepare a study of the research results, assess their significance against other results obtained from the literature, draw conclusions and formulate opinions	KF_K04 KF_U11 KF_U12	3 3 3
2F_BP.16_3	He/she is able to prepare written works and multimedia presentations in native language and English within the scope of the conducted research.	KF_K07 KF_U01 KF_U15 KF_U16	4 5 4 4
2F_BP.16_4	The student is able to listen to another opinion and to undertake a substantive discussion on a given issue.	KF_K07 KF_U15	4 4
2F_BP.16_5	Understands the need for further education, can implement the process of self-education	KF_K01 KF_U04 KF_U17	5 3 5
2F_BP.16_6	Communicates in a foreign language using advanced language communication competences and has the ability to comprehensively read complex scientific texts, and has an in-depth ability to prepare oral presentations in English.	KF_U19	5

3. Module description

Description	The diploma seminar's primary goal is to prepare students to present obtained research results, their interpretation, and conclusions. Additionally, the student should learn how to participate in scientific open discussions and formulate exact questions.

Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.16_w_1	Activity in class	Evaluation of engagement and participation in seminar discussions, including the ability to express opinions and formulate conclusions.	2F_BP.16_1, 2F_BP.16_2, 2F_BP.16_3, 2F_BP.16_5, 2F_BP.16_6
2F_BP.16_w_2	Credit	The evaluation is based on the preparation and presentation of the seminar.	2F_BP.16_1, 2F_BP.16_2, 2F_BP.16_3, 2F_BP.16_4, 2F_BP.16_5, 2F_BP.16_6

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_BP.16_fs_1	seminar	Presentation of the research problem, participation in the discussion.	15	Preparation of the seminar.	60	2F_BP.16_w_1, 2F_BP.16_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Master's Laboratory

Module code: W4-2F-17-10

1. Number of the ECTS credits: 4

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_10.1_1	Understands the importance of physics and its applications in the progress of science and the development of new technologies	KF_W01	4
2F_10.1_2	Has in-depth knowledge of condensed phase physics, quantum mechanics, statistical, theoretical and experimental physics	KF_W02 KF_W03	3 3
2F_10.1_3	He knows the theoretical models and mathematical formalism as well as computer methods necessary to solve the problems undertaken in the thesis	KF_K09 KF_W05 KF_W06 KF_W07	1 3 3 3
2F_10.1_4	He can use research equipment, conduct experiments and choose the right measurement method for a specific one	KF_U04 KF_U05 KF_U06 KF_U18 KF_W08 KF_W09	3 3 3 2 3 3
2F_10.1_5	Can critically analyze and interpret research results	KF_U08 KF_U09 KF_U10	3 3 3
2F_10.1_6	Is able to independently prepare the study of research results, assess their significance in comparison to other results obtained from the literature, draw conclusions and formulate opinions	KF_K04 KF_K05 KF_U11	4 3 4

		KF_U12	4
2F_10.1_7	Can, in the scope of research topics, prepare written works and multimedia presentations in the mother tongue and in English	KF_K07 KF_U15 KF_U16	4 4 4
2F_10.1_8	Can listen to a different opinion and undertake substantive discussions on a given issue	KF_K07 KF_U15	4 4
2F_10.1_9	Understands the need for further education, is able to implement the process of self-education	KF_K01 KF_U17	5 5

3. Module description	
Description	During the master's laboratory student: •Under the guidance of a supervisor, he / she gets acquainted with: the problem implemented within the thesis, research methodology and literature •Conducts scientific research as part of implementing the thesis topic •Is able to use research equipment, carry out experiments and choose the right measurement method for a specific one problem and expected effect •Develops, interprets, discusses and can critically analyze the obtained results •Is able to independently prepare the development of research results, assess their significance against the background of other results obtained from the literature, draw conclusions and formulate opinions
Prerequisites	All items and modules included in the study plan are passed by the student.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_10.1_w_1	credit	The completion of the master's thesis is the final verifier of the workload and student involvement in the implementation of the module	2F_10.1_1, 2F_10.1_2, 2F_10.1_3, 2F_10.1_4, 2F_10.1_5, 2F_10.1_6, 2F_10.1_7, 2F_10.1_8, 2F_10.1_9

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_10.1_fs_1	laboratory classes	Performing research under the guidance of the teacher	100	before starting the research, the student becomes acquainted with the literature on the subject matter. After performing research, he prepares the report	30	2F_10.1_w_1

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Mathematical Methods in Physics

Module code: W4-2F-17-15

1. Number of the ECTS credits: 5

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_15_1	understanding the civilization meaning of differential and integral calculus and its role in physics;	KF_U01 KF_W01	4 4
2F_15_2	the student has a good theoretical and practical intuition related to mathematical analysis; is able to perform basic calculations;	KF_U02 KF_W02	4 4
2F_15_3	understands the meaning and can give examples of the physical application of differential equations in physics and technology;	KF_U01 KF_U02	3 3
2F_15_4	understands and is able to perform simple calculations on Hilbert spaces;	KF_U03 KF_W05	3 3
2F_15_5	understands the need to use the distribution theory tools in various branches of physics - can calculate the Fourier transform, convolution, derivatives, e.g. for the Dirac delta.	KF_U03 KF_W05	3 3
2F_15_6	knows the concept of Fourier analysis and its applications in various fields of physics.	KF_U03 KF_W05	3 3
2F_15_7	The student understands (through examples) the need to develop mathematical formalism in order to better describe and understand the physical world.	KF_W01	4

3. Module description

Description	The lecture includes a coherent and uniform presentation of elements of the theory with justifications and many examples derived from physics and engineering within the following topics: 1. Elements of distribution theory: basic concepts, differentiation of distribution, the Dirac delta, and related distributions, the principal value of the integral; operations on distributions; Sochocki formulas, the convolution of distributions and their Fourier transform.

	2. Green's functions of differential operators: boundary issues, related to eigenvalue problem; examples coming from physics and engineering (e.g. Sturm Liouville systems). 3. Elements of Hilbert space theory: basic concepts and examples; orthonormal and Schauder bases; unitary and self-adjoint operators; spectra and eigenvalues; subtleties of the formalism of quantum theory. 4. Fourier series and their properties. 5. Integral transforms; Fourier and Laplace transform and their properties. 6. Elements of signal analysis. The classes and seminars are devoted to solving selected examples and explaining theories in specific physical situations. Students participate in deriving and discussing some formulas and examples from lectures, as well as the discussions of the significance of the discussed formalisms in various physical problems. As part of the student's work the student: 1. strives to consolidate acquired knowledge based on lecture notes and supplementary literature; 2. improves the mathematical skills necessary to solve physical problems; 3. tries to accomplish the tasks proposed by the lecturer. The exam is compulsory.
Prerequisites	Knowledge of basic problems of mathematical analysis and algebra (mathematics courses at first-cycle studies).

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_15_w_1	colloquium	Optional verification method; the date of the colloquium or written test announced to students two weeks earlier; tasks of a similar type to the tasks solved during the seminar	2F_15_2, 2F_15_3, 2F_15_4, 2F_15_5
2F_15_w_2	activity in class	problem solving and discussion of the discussed problems (basic method)	2F_15_1, 2F_15_6, 2F_15_7
2F_15_w_3	written exam (or oral exam)	the condition for taking the exam is passing the conservatory; scope of the material - all issues discussed during the lectures	2F_15_1, 2F_15_4, 2F_15_5, 2F_15_6

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_15_fs_1	lecture	lecture of selected basic issues with the use of audiovisual aids	30	supplementary reading, work with the textbook	40	2F_15_w_3
2F_15_fs_2	discussion classes	solving tasks at the blackboard	30	supplementary reading	40	2F_15_w_1, 2F_15_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Microsensors

Module code: W4-2F-13-25

1. Number of the ECTS credits: 5

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_25_1	has a good understanding of the civilization significance of physics and its applications as well as its historical development and role in the progress of science	KF_W01	3
2F_25_2	knows and understands the description of physical phenomena within the framework of selected theoretical models; is able to independently recreate the basic physical laws	KF_W05	4
2F_25_3	knows the structure and principle of operation of scientific equipment	KF_W08	5
2F_25_4	on the basis of the acquired knowledge, knows how to explain the operation of research equipment	KF_U04	5
2F_25_5	is able to choose the appropriate measurement method for a specific problem in the expected effect	KF_U06	5
2F_25_6	has the in-depth ability to prepare and present an oral presentation on physics or interdisciplinary issues, in Polish and English, using modern multimedia techniques	KF_U16	5

3. Module description

Description	Modern microelectronic technologies have enabled the production of many types electronic sensors using the specific properties of materials semiconductor devices most often exposed in MOS (Metal Oxide Semiconductor). These sensors are not similar to known solutions due to their occurrence in them physical phenomena typical of microelectronic structures. This lecture aims to discuss the basic groups of modern sensors microelectronics after a brief reference to known classical solutions in the each group. Because full understanding of the operation and application of micro sensors requires understanding of technological processes and knowledge in the field of digital buses coupling and special programming languages this lecture will begin the discussion microelectronic technology, and will complete the separation of electronic digital circuits and programming microcontrollers. Laboratory exercises: 1. Construction of a microprocessor based control system for operating sensors. 2. Programming of AT MEGA series systems in BASCOM language 3. Use of the completed system for measuring temperature using integrated sensors.

	4. Pressure measurement with a semiconductor sensor KPY32 (Siemens). 5. Stress measurement with a semiconductor strain gauge in a LabView environment. Obligatory exam
Prerequisites	Fundamentals of solid state physics, basics of electronics.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_25_w_1	activity in class	participation in the discussion	2F_25_1, 2F_25_2, 2F_25_3, 2F_25_4, 2F_25_5, 2F_25_6
2F_25_w_2	written exam (or oral exam)	Oral exam in the field of knowledge presented during the lectures.	2F_25_1, 2F_25_2, 2F_25_3, 2F_25_4, 2F_25_5, 2F_25_6

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_25_fs_1	lecture	Lecture of selected basic issues with the use of audiovisual aids	20	Supplementary reading, work with the textbook	30	2F_25_w_1, 2F_25_w_2
2F_25_fs_2	laboratory classes	Laboratory exercises	30	Supplementary reading	30	2F_25_w_1, 2F_25_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Nanophysics

Module code: W4-2F-12-22

1. Number of the ECTS credits: 5

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_22_1	Understands the civilization importance of physics in applications to objects with nanometric dimensions, its applications as well as its historical development and role in the progress of science	KF_W01	4
2F_22_2	Has in-depth knowledge of theoretical and experimental physics regarding nanosystems,	KF_W02	4
2F_22_3	Has in-depth knowledge of condensed phase physics, properties of nanostructures resulting from quantum mechanics	KF_W03 KF_W04	4 4
2F_22_4	Knows and understands the description of the diffraction phenomenon within the selected theoretical models; can independently recreate the basics diffraction theory.	KF_W04 KF_W06	3 3
2F_22_5	knows the structure and principle of operation of scientific equipment as well as the methods of research and production of nanostructures	KF_W08	4
2F_22_6	on the basis of the acquired knowledge, knows how to explain the operation of research equipment	KF_U04	4
2F_22_7	He is able to comprehensively, in speech and writing, present the basic properties of nanostructures	KF_U01	5
2F_22_8	Has the ability to self-educate, acquiring information from literature, databases and other sources; can integrate the obtained information and interpret it, draw conclusions as well as formulate and justify opinions	KF_U12	4
2F_22_9	is able to apply the acquired knowledge of physics to the discussion of problems in related fields and scientific disciplines	KF_U14	4

3. Module description

Description	During lectures student is teached in the fields of: 1.Introduction to physics of nanostructures and nanomaterials - Nanotechnologies and nanomaterials - General classification of nanosystems

	2.Quantitative description of the structure of nanomaterials -Shape description methods and size measurements of nanomaterials - Local and global parameters -Parameters describing size and shape -Image analysis and determining the size of parameters - analysis of the number of objects, analysis of the size of objects, analysis of the volume of objects, analysis of distribution of objects -Measurement of the size distribution of nanomaterials / nanoparticles by dynamic laser light scattering -Measurement of crystallite size by X-ray diffraction method - Scherrer method, Williamson-Hall method - Determination of nanocrystallite size distribution by X-ray diffraction method - diffraction peak shape analysis, method limitations, estimation and reduction of measurement errors - Scattering by structurally disordered systems - the pair correlation function - definitions, determination methods and interpretation 3.Synthesis methods of 3D nanomaterials - top-down and bottom-up approaches 4.Nanomagnetism. - types of anisotropy, the role of surface, mechanism of hysteresis in nanomaterials, types of 3D magnetic nanomaterials - nanopowders, nanoparticles 5.Thin films and nanoelectronics - Atomic structure of surfaces, description, investigation methods. - Preparation methods of thin films and examples of their studies. - Multilayer systems. - Electronic structure of materials with reduced dimensions. - Specificity of thin films of metals. - Magnetic properties of thin films. - Modifications of thin films - nanoelectronics - litographic methods 6.Nanowires - types of synthesis and basic properties 7.Analysis methods of nanostructures - scanning techniques • Tunneling in the arrangement tip-conducting surface. The Tersoff-Haman model for low and high voltage. • Introduction to theory of atomic force microscopy. The Hamakerr constant. • Types of scanning probe microscopies and their application in physics, chemistry, biology, medicine and materials engineering. • Construction of scanning tunneling microscopy, resolution, stability and limitations. • Atomic force microscopy - similarities and differences in comparison with scanning tunneling microscopy. • Predominant role of atomic force microscopy methods in modern studies of surface properties with atomic resolution. • Atomic force microscopy in studies of local electrical conductivity and its application for an analysis of switching resistivity processes in nano-scale. 8.Analysis methods of nanostructures - TEM microscopy - TEM, STEM, HRTEM and cryoTEM 9.Physical properties of carbon nanosystems and their applications in information processing. • Geometrical and topological basis of nanostructure formation • Basic properties of carbon nanostructures • Molecular orbitals and classification of fullerenes • Electronic structure of fullerenes • Electrical and magnetic properties of nanotubes

	• Graphene and other carbon nanomaterials Basic ideas of nanophysics and more detailed examples of this field as well investigation methods will be introduced during lectures. All subjects of exam will be provided for students. The 2-5 marks range will be used. Exam is obligatory.
Prerequisites	Classical and quantum mechanics, Introduction to atomic and molecular phases, Introduction to condensed phase physics

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_22_w_1	oral exam	The scope of the material given in the form of a set of all issues discussed in the lectures, grading scale 2-5. Compulsory exam	2F_22_1, 2F_22_2, 2F_22_3, 2F_22_4, 2F_22_5, 2F_22_6, 2F_22_7, 2F_22_8, 2F_22_9

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_22_fs_1	lecture	The lecture introduces the basic concepts of nanophysics and discusses some important examples in more detail.	60	Acquiring the knowledge from the lecture, supplementary reading	50	2F_22_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Non-linear Optics

Module code: W4-2F-17-26

1. Number of the ECTS credits: 3

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_26_1	Understands the importance of nonlinear optics for technology and its influence on the development of physics	KF_W01	3
2F_26_2	Understands the basic theories describing the appearance of nonlinear effects in optics	KF_W02 KF_W05	5 5
2F_26_3	Knows the mathematical formalism useful in the analysis of applied physical models; knows how to use a mathematical apparatus for solving nonlinear optics problems	KF_W02 KF_W06	4 4
2F_26_4	Knows and is able to comprehensively present the most important phenomena in the field of nonlinear optics	KF_U01 KF_U15 KF_W05	5 5 5
2F_26_5	Has the ability to self-educate, acquiring information from literature, databases and other sources; knows the limitations of his own knowledge	KF_K01 KF_U12 KF_U13	3 3 3

3. Module description	
Description	During the lecture, the student becomes familiar with the following issues: • linearity in optics • the beginning of the laser age as a milestone in the emergence of nonlinear optics • the effect of the second harmonic generation with particular emphasis on phase matching • phenomena of self-focusing and autolimation of light • frequency mixing; parametric light generation • refractive index as a function of light intensity • non-linear effects associated with molecular orientation

	• Raman and Brillouin forced scattering processes Obligatory exam
Prerequisites	Knowledge of the basics of physics, quantum mechanics and statistical physics, atomic and molecular physics, and solid state physics.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_26_w_1	written exam (or oral exam)	Written exam consisting in elaborating selected issues from the lecture; scope of the material - all issues discussed during the lectures; grading scale 2-5;	2F_26_1, 2F_26_2, 2F_26_3, 2F_26_4, 2F_26_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_26_fs_1	lecture	lecture of selected issues with the use of audiovisual aids	20	supplementary reading, work with the textbook	45	2F_26_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Numerical Methods

Module code: W4-2F-13-11

1. Number of the ECTS credits: 4

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_11_1	knows the basics of computational and IT techniques, supporting work of a physicist and understands their limitations	KF_W07	5
2F_11_2	knows the mathematical formalism useful in the construction and analysis of models physical of medium complexity; understands the consequences of using approximate methods	KF_W06	2
2F_11_3	knows how to use a mathematical apparatus to solve problems of medium complexity	KF_U02	3

3. Module description

Description	The lecture will present the basics of programming in scientific applications and basic methods in the following issues: - numerical differentiation; - numerical integration (including adaptive scheme and Monte Carlo method); - numerical solving of nonlinear equations (bisection, Newton-Raphson method); - numerical solving of differential equations (Euler and Runge-Kutta methods, schemes used in MD); - matrix calculations (diagonalization, solving systems of linear equations). Multivariate minimization methods and numerical solving of N-body problem, as well as parallel computations, program optimization and use of numerical libraries will also be discussed. During the laboratory classes the student: - learns the basics of using the Linux environment; - learns how to compile and run programs; - learns how to analyze and present the obtained results (including creating plots); - implements numerical methods and studies their properties; - compares the usage of different numerical methods to solve the same problem;

	- uses computational methods to solve physical problems. Part of the time is devoted to discussing the algorithm for solving a given problem, the rest of it students spend at the computers, implementing and testing selected numerical methods. As part of his/her own work, the student gains experience by writing and running programs independently and consolidate acquired knowledge by reading suggested literature. Assessment is based on reports written by students after completing each laboratory assignment and oral exam.
Prerequisites	Ability to program in any language that allows procedural programming (C/C++ recommended). Basic knowledge of mathematical analysis (differentiation and integration) and linear algebra.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_11_w_1	colloquium	Four times a semester; the tasks consist in writing several programs using the known numerical methods	2F_11_1, 2F_11_2, 2F_11_3
2F_11_w_2	written exam (at the computer)	The condition for taking the exam is passing the laboratory classes; scope of the material - all issues discussed during the lectures; grading scale 2-5;	2F_11_1, 2F_11_2, 2F_11_3

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_11_fs_1	lecture	discussion of the issues that are the subject of the lecture with the use of multimedia presentations and "live" illustrations of the operation of programs. Lecture materials available on the e-learning platform.	10	Getting familiar with the materials posted on the e-learning platform and lecture notes; work with the textbook	30	2F_11_w_1, 2F_11_w_2
2F_11_fs_2	laboratory classes	independent writing and running of computer programs; discussion at the blackboard: methods of approaching specific physical problems, algorithmization of the problem and emerging problems.	30	Solving tasks (writing programs) placed on the e-learning platform,	30	2F_11_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Numerical Modeling of Solids

Module code: W4-2F-12-24

1. Number of the ECTS credits: 4

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_24_1	has in-depth knowledge of condensed phase physics	KF_W04	3
2F_24_2	knows the basics of programming in scientific applications and selected numerical algorithms	KF_W07	4
2F_24_3	knows the structure, principle of operation and the scope of application of software for atomistic computer simulations	KF_W08	4
2F_24_4	can write own implementations of selected procedures and functions	KF_U02	4
2F_24_5	is able to independently prepare the study results	KF_U11	4
2F_24_6	can work in a group; is able to define priorities for the implementation of the task	KF_K03	5
2F_24_7	is able to undertake a substantive discussion on the issue	KF_K07	4

3. Module description

Description	Predicting of the solid state material properties such as electronic structure (e.g. whether the material is an insulator or conductor), magnetic and elastic properties (e.q. Bulk modulus or the equilibrium lattice constant) obtained from computer calculations based on Density Functional Theory using Plane Waves or Linear Augmented Plane Waves methods. The relation between optical and spectroscopic properties with electronic structure. Lecture ends with an exam, the computer laboratory exercises finishes with reports (depicting the modelled compounds).
Prerequisites	Basic solid state course Basic quantum mechanics Basic abilities computer science - knowledge of Linux

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_24_w_1	activity in class	execution of exercises; participation in the discussion; grading scale 2-5	2F_24_2, 2F_24_3, 2F_24_4, 2F_24_6, 2F_24_7
2F_24_w_2	report	report on the exercises carried out; grading scale 2-5	2F_24_5
2F_24_w_3	oral exam (or test exam)	the condition for taking the exam is passing the laboratory; scope of the material - all issues discussed; grading scale 2-5	2F_24_1, 2F_24_2, 2F_24_3

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_24_fs_1	lecture	lecture of selected basic issues with the use of audiovisual aids	10	supplementary reading, work with the textbook	20	2F_24_w_3
2F_24_fs_2	laboratory classes	writing own programs or own implementations of selected computational procedures; performing calculations using proprietary software and / or other available software packages; presentation of the obtained results and discussion	30	preparation of the report	40	2F_24_w_1, 2F_24_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Physics of Magnetic Materials

Module code: W4-2F-12-19

1. Number of the ECTS credits: 3

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_19_1	has in-depth knowledge of the condensed phase	KF_W04	4
2F_19_10	is able to independently prepare a study of research results containing: justification of the research, adopted methodology, description	KF_U11	5
2F_19_2	has in-depth knowledge of the theory of magnetism and knows the methods of experimental study of magnetic properties	KF_W02 KF_W05	5 5
2F_19_3	knows the structure and principle of operation of scientific equipment used in magnetic research	KF_W08	5
2F_19_4	on the basis of the acquired knowledge, knows how to explain the operation of research equipment used to study magnetic properties	KF_U04	5
2F_19_5	is able to plan and carry out various types of magnetic measurements	KF_U05	5
2F_19_6	is able to choose the appropriate measurement method for testing specific magnetic properties	KF_U06	5
2F_19_7	is able to critically analyze and interpret measurement results	KF_U07	4
2F_19_8	can discuss measurement errors, determine their sources and assess the consequences	KF_U08	4
2F_19_9	on the basis of the acquired knowledge and conducted research, is able to describe the micro and macroscopic magnetic properties of matter	KF_U10	4

3. Module description

Description	During the lecture, the student becomes familiar with such issues as: 1.Introduction – history of magnetism 2.Source of magnetism. Origin of atomic magnetic moments (spin and orbital electron states, vector model). 3.Diamagnetism, quantum diamagnetism.

	4.Paramagnetism of free ions (Brillouin function, Curie law). 5.Magnetically ordered states (spin-orbit coupling, types of exchange interactions, Weiss field). 6.Ferromagnetism, antiferromagnetism, ferrimagnetism, band magnetism. własności magnetyczne materiałów, a ich struktura elektronowa 7.Magnetism in amorphous systems 8.Magnetism in systems containing rare earths 4f and transition metals 3d. Models of magnetism in 4f-3d systems. 9.Domain structure and magnetization processes (free energy, types of magnetic anisotropy) 10.Progress and future of magnetic materials: •New hard and soft magnetic materials •Magnetic nanoparticles and their properties (e.g. core-shell systems, exchange bias phenomenon) •Superparamagnetism and 2D magnetism (Stoner-Wohlfarth model, magnetoresistance, 2D magnetic materials for spintronic applications) •Magnetocaloric effect and its application The lecture ended with an obligatory exam. During conversational classes students participate in the discussion of problems presented in the lecture. During five two-hour meetings, issues related to magnetism in various magnetic materials are discussed in detail, current literature data is presented. At the beginning of semester students are informed about the range of issues to be discussed. The final grade of the conversational classes is determined by the student activity. During laboratory classes, students are acquainted with Magnetic Measurement Techniques (static, dynamic, magnetometers, SQUID magnetometer). They conduct experiments under the guidance of the teacher. Using devices such as magnetic balances and the SQUID magnetometer, they examine the properties of various magnetic substances in various temperature ranges and magnetic fields. The selection of the research method is discussed in terms of obtaining the desired result as well as the conditions (temperature, magnetic field) in which the experiment will be performed. At the beginning of semester students are informed about the research methods they will use. After completing the experiment, the student presents a report containing theoretical introduction to the problem, the methodology adopted, the description of the study, analysis and discussion of the results and their relevance to similar studies. Module prerequisites: knowledge of general physics and quantum mechanics at an intermediate level The module grade is the average of the exam, conversational and laboratory classes.
Prerequisites	knowledge of general physics and quantum mechanics at an intermediate level

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_19_w_1	activity in class	Involvement and participation in discussions at the seminar; grading scale: 2-5	2F_19_2, 2F_19_9
2F_19_w_2	oral exam	Compulsory exam, grading scale: 2-5 The scope of the material covers the issues discussed during the lectures	2F_19_1, 2F_19_2, 2F_19_3, 2F_19_4, 2F_19_6, 2F_19_9
2F_19_w_3	report	For each experiment performed, a mandatory report containing a theoretical introduction to a given problem, the methodology adopted, description of the study, analysis and discussion of the results and their significance in relation to similar studies	2F_19_10, 2F_19_2, 2F_19_3, 2F_19_4, 2F_19_5, 2F_19_6, 2F_19_7, 2F_19_8, 2F_19_9

5. Forms of teaching						
code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_19_fs_1	lecture	Discussing issues with the use of computer presentations	10	analysis of lecture notes; work with textbooks and other professional literature	15	2F_19_w_2
2F_19_fs_2	discussion classes	Discussion of the problems presented in the lecture	10	analysis of lecture notes; work with textbooks and other professional literature, including articles published in scientific journals	15	2F_19_w_1
2F_19_fs_3	laboratory classes	Performing experiments under the guidance of the teacher	10	before the laboratory, getting acquainted with the literature on the theory and technique of the experiment. After the study is completed, the report is prepared	15	2F_19_w_3

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Physics of Mesoscopic Materials

Module code: W4-2F-12-23

1. Number of the ECTS credits: 6

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_23_1	Understands the civilization importance of mesoscopic and nanoscopic physics and its applications.	KF_W01	4
2F_23_2	Has basic knowledge of classical and quantum physics.	KF_W03	4
2F_23_3	Can explain the operation of basic devices using nano- and mesystems on the basis of known laws	KF_W05	5
2F_23_4	Can understand in an understandable way the basic laws and principles of nano- and mesophysics.	KF_U01	4
2F_23_5	Can describe the basic meso- and nanoscopic properties of matter.	KF_U03	5

3. Module description

Description	During the course students are learning the following topics: -fundamental terms and scales at nanoscale - quantum coherence and interference -persistent currents in mesorings -quantum dots and Coulomb blockade - quantum transport at nano and mesoscale -fundamentals of quantum information – nanosysytem applied as qubits - quantum entanglent and teleportation - decoherence The course is finalized by an exam
Prerequisites	Classical and quantum mechanics.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_23_w_1	colloquium	Twice a semester; deadlines for tests given at the beginning of the semester, Tasks of a similar type to the solved tasks; grading scale 2-5.	2F_23_1, 2F_23_2, 2F_23_4
2F_23_w_2	activity in class	Oral answers, participation in discussions, solving problems, grading scale 2-5.	2F_23_1, 2F_23_2, 2F_23_3, 2F_23_5
2F_23_w_3	written exam	The final grade is equal to the average of the final grades. scope of material given in the form of a set of issues discussed in lectures, grading scale 2-5.	2F_23_1, 2F_23_2, 2F_23_3, 2F_23_4

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_23_fs_1	lecture	lecture on basic concepts and selected issues in the physics of mesoscopic materials and their applications	40	supplementary reading, work with the textbook	45	2F_23_w_3
2F_23_fs_2	discussion classes	Problem solving at the blackboard, discussion of the results, detailed discussion of selected examples	20	supplementary reading, work with the textbook, solving assigned tasks	30	2F_23_w_1, 2F_23_w_2

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Physics of Semiconducting Materials

Module code: W4-2F-17-18

1. Number of the ECTS credits: 4

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_18_1	It presupposes an in-depth knowledge of the physics of the condensed phase	KF_W04	4
2F_18_2	It requires knowledge of mathematical formalism, which is useful in the construction and analysis of physical models of medium complexity and an understanding the consequences of using approximation methods	KF_W06	3
2F_18_3	Student can use mathematical formalism to construct and analyze physical models	KF_U09	3
2F_18_4	The participant of the module is able to apply the knowledge acquired in physics when discussing problems from related scientific fields and disciplines	KF_U14	4
2F_18_5	It requires advanced knowledge in quantum mechanics and statistical physics	KF_W03	3

3. Module description

Description	Brief introduction to the crystallographic, electronic structure and lattice dynamics of the most widely used semiconductors and their alloys. Example of some important crystallographic structures for semiconductors: diamond and zinc blende structure. Covalent bonds in semiconductors, the nature of sp3 hybridization for the group IV semiconductor. Electronic defect state, thermodynamics of point defects (Schottky and Frenkel disorder), extended defects. Concentration of carriers as a function of temperature; Fermi distribution/Boltzmann distribution. Intrinsic and doped semiconductors in equilibrium. The role of donors or acceptors at low doping levels. Compensation and amphoteric impurities. Change of the band structure due to high levels of doping. Diffusion of carriers: Fick's first law, Einstein-Smoluchowski relation. Phenomena of electrical transport for intrinsic and doped semiconductors. Mobility of electrons and holes - Hall mobility. Generation and recombination processes. Dependence of the lifetime of the generated carriers on scattering processes. Hetero structure, space charge model. Band bending due to the existence of the surface state. Schottky model of metal-semiconductor contact and metal-oxide-semiconductor interface (solution by Poisson equation). "p-n" junction: an ideal case (solution using Poisson's equation). Determination of the current-voltage characteristics of an ideal p-n junction for forward and reverse current for the electrons and the holes. Applications of semiconductors in nanoelectronics: an example of the use of extended defects and phase change materials for 1 TB resistively switching RAM-s; a concept developed at the Forschungszentrum Juelich and Institute of Physics University of Silesia.
Prerequisites	Basic knowledge of solid state physics.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_18_w_1	written exam (or oral exam)	Scope of the material - all topics discussed during the lectures: rating scale (2-5)	2F_18_1, 2F_18_2, 2F_18_3, 2F_18_4, 2F_18_5
2F_18_w_2	report	For each experiment performed, a mandatory report containing a theoretical introduction to a given problem, the methodology adopted, description of the study, analysis and discussion of the results and their significance in relation to similar studies	2F_18_1, 2F_18_2, 2F_18_3, 2F_18_4, 2F_18_5
2F_18_w_3	activity in class	Participation and involvement in the discussion at the conversatorium: rating scale (2-5)	2F_18_1, 2F_18_2, 2F_18_3, 2F_18_4, 2F_18_5

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_18_fs_1	lecture	Lecture on selected topics of the physics of semiconductors with audiovisual means	10	Supplementary literature: working with the textbook “The Physics of Semiconductors”, M.Grundmann, Springer 2006, ISBN-13 978-3-540-25370-9 (E-Book)	20	2F_18_w_1
2F_18_fs_2	discussion classes	Independent preparation of selected topics on the current problems of semiconductor physics of nano-devices	10	Short presentation and discussion coordinated by the tutor. Supplementary literature: “Nanoelectronics and Information Technology” ed.R.Waser, Wiley-VCH 2012, ISBN:978-3-527-40927-3	20	2F_18_w_3
2F_18_fs_3	laboratory classes	Taking measurements	20	supplementary reading	20	2F_18_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Quantum Physics

Module code: W4-2F-17-12

1. Number of the ECTS credits: 5

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_12_1	has extensive knowledge of quantum physics	KF_W03	4
2F_12_2	can use mathematical formalism to build and analyze physical models	KF_U09	4
2F_12_3	on the basis of knowledge acquired and research carried out can describe the microscopic properties of matter	KF_U10	3
2F_12_4	knows and understands the description of physical phenomena within selected theoretical models; can independently reproduce the basic physical laws	KF_W05	3
2F_12_5	has in-depth knowledge of selected branches of theoretical physics	KF_W02	3

3. Module description	
Description	During the lecture, the student will learn about the following issues: Rayleigh-Schrödinger time-independent perturbation theory: nondegenerate case quadratic Stark effect discrete symmetries: parity time-independent perturbation theory: the degenerate case linear Stark effect variational methods the temporal Heisenberg inequality the Ammonia molecule time-dependent perturbation theory, Fermi golden rule time-independent scattering theory: the Lippmann-Schwinger equation, differential cross section, the Born approximation identical particles: permutation symmetry, multi-particle wavefunctions , bosons and fermions, exchange density Dirac equation and Zitterbewegung second quantization During seminar classes a student:

	masters the techniques of performing calculations in the perturbation calculus in the non-degenerated and degenerate cases learns calculations in the interaction picture learns to apply the Fermi golden rule learns to apply the variational methods learns to use multi-particle wavefunctions learns to understand the limitations of first quantization models learns to understand the language of second quantization Obligatory exam
Prerequisites	Completed course of quantum mechanics, knowledge of the foundations of mathematical analysis and algebra

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_12_w_1	colloquium	three times a semester; date of the colloquium announced to students two weeks earlier; tasks of a similar type to those at the seminar; grading scale 2-5	2F_12_1, 2F_12_2, 2F_12_3, 2F_12_4, 2F_12_5
2F_12_w_2	activity in class	solving a task - oral answer; participation in the discussion; grading scale 2-5; final grade equal to the average of partial grades	2F_12_2, 2F_12_3
2F_12_w_3	written exam	the condition of taking the exam is passing the seminar; scope of material - all issues discussed in lectures; grading scale 2-5	2F_12_1, 2F_12_2, 2F_12_3, 2F_12_4, 2F_12_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_12_fs_1	lecture	lecture on selected issues using audiovisual aids	30	work with a textbook; supplementary reading	40	2F_12_w_1, 2F_12_w_3
2F_12_fs_2	discussion classes	solving of tasks on the board:analysis,method selection, calculation and discussion of results;deriving some formulas and discussing selected examples signaled during lectures,discussion;the possibility of using computers	20	acquire knowledge of lectures; work with a textbook and task sets	45	2F_12_w_1, 2F_12_w_2, 2F_12_w_3

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Research Project Laboratory

Module code: W4-2F-21-BP.06

1. Number of the ECTS credits: 7

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_BP.06_1	Understands the importance of physics and its applications in the progress of science and the development of new technologies	KF_W01	4
2F_BP.06_2	Has in-depth knowledge of selected branches theoretical and experimental physics	KF_W02	3
2F_BP.06_3	Knows the theoretical models, mathematical formalisms, and computer methods necessary to solve the problems undertaken in the thesis	KF_W05 KF_W06 KF_W07	5 5 5
2F_BP.06_4	Is able to use research apparatus, conduct experiments and select an appropriate measurement method for a specific problem and the expected result	KF_U04 KF_U05 KF_U06 KF_U08 KF_W09	4 4 4 4 4
2F_BP.06_5	Is able to perform critical analysis and interpret research findings.	KF_U08 KF_U09 KF_U10	4 4 4
2F_BP.06_6	Can prepare the research report, assess their impact on the background of other results obtained from the literature, draw conclusions, formulate and justify opinions.	KF_U11 KF_U12	4 4
2F_BP.06_7	Is able to prepare written reports and multimedia presentations in native language and English within the scope of the conducted research.	KF_K07 KF_U15 KF_U16	4 4 4
2F_BP.06_8	Is able to listen to a different opinion and professionally discuss the issue in question	KF_K07	4

		KF_U15	4
2F_BP.06_9	Understands the need for further education, can implement the process of self-education	KF_K01 KF_K08 KF_U17	5 1 5

3. Module description	
Description	The course aims to prepare students to face complex challenges as active researchers. The subject is oriented towards the student's creative problem-solving, innovative, and critical thinking skills. The module is divided into three types of classes: lecture, laboratory, and seminar. Lectures will outline a methodology of solving cutting-edge problems and will be based on a deep understanding of recent science and environmental issues and needs. Methods of transferring creative ideas and innovative concepts to real implementations will be discussed. Additionally, possible ways of application for research funds in forms of fellowships and grants will be addressed. The laboratory classes will be divided into parts related to scientific problems solvable within the scope of theoretical physics, experimental physics, and computer science. Students will learn about research projects and challenges in theoretical, experimental, and applied research, analyse the studies' results, and discuss the findings with other students. The instructor will also discuss applied practices for writing grant proposals within the topics discussed. The seminars will be devoted to discussing a representative research project. Based on their academic preference, each student will choose a suitable topic and prepare a presentation. The seminar should include a selected scientific project that could be a base for grant applications, e.g. NCN early researchers grants.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.06_w_1	Activity in class	Engagement and participation in seminar discussion and systematic and thoroughness of research conducted.	2F_BP.06_1, 2F_BP.06_2, 2F_BP.06_3, 2F_BP.06_4
2F_BP.06_w_2	Report	Evaluation of the report on conducted research prepared in the form of a multimedia presentation.	2F_BP.06_1, 2F_BP.06_2, 2F_BP.06_5, 2F_BP.06_6, 2F_BP.06_7, 2F_BP.06_8
2F_BP.06_w_3	Credit	Verification in accordance with the requirements specified in the syllabus.	2F_BP.06_1, 2F_BP.06_2, 2F_BP.06_3, 2F_BP.06_4, 2F_BP.06_9

5. Forms of teaching						
code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.06_fs_1	lecture	Lecturer's discussion of issues that are the subject of the syllabus . Supporting multimedia presentation will be used.	5	Reading lecture notes, studying the recommended literature.	10	2F_BP.06_w_3
2F_BP.06_fs_2	laboratory classes	Performing research under the direction of the instructor.	50	Individual work on issues related to the research.	120	2F_BP.06_w_1
2F_BP.06_fs_3	seminar	Presentation of the research problem, participation in the discussion.	5	Preparation of the seminar.	10	2F_BP.06_w_2, 2F_BP.06_w_3

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Selected Topics in Quantum Physics

Module code: W4-2F-21-BP.01

1. Number of the ECTS credits: 6

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.01_1	The student will learn advanced elements of the formalism of quantum mechanics, which is the primary descriptive tool of modern theoretical physics.	KF_W03	4
2F_BP.01_2	Master the conceptual foundations of computational methods necessary to study further, more specialized topics within particle theory, astrophysics, and solid state theory.	KF_W05	4
2F_BP.01_3	Students will be able to apply mathematical apparatus to solve physical problems in the microworld.	KF_U02	5
2F_BP.01_4	The student can analyze and mathematically describe simple microscopic properties of matter, including in the area of relativistic velocities of objects.	KF_U10	5
2F_BP.01_5	Students will understand and be able to accurately formulate questions related to many of the achievements of civilization in recent decades.	KF_K02	3

3. Module description

Description	This is a joined course for theoretical and experimental students. Its goal is to give a general overview of relativistic quantum mechanics with topics from many-body, quantum field and information theories. Selected topics will be elaborated as proposed in syllabus yearly by a lecturer and class teacher. They can include subtleties of the quantum formalism, a problem of precise determination of the Planck constant, Josephson and quantum Hall effects, Bohm-Aharonov and Casimir effects, entanglement, entropy and information, quantum communication, cryptography.
Prerequisites	Knowledge of the basics of how the microworld works in the non-relativistic case. Familiarity with macroscopic description of phenomena involving objects moving at speeds close to the speed of light.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.01_w_1	Colloquium	Verifying the knowledge and skills in solving tasks and problems from the discussed topics.	2F_BP.01_1, 2F_BP.01_3

2F_BP.01_w_2	Activity in class	Evaluation of students work based on solutions to homework problems and activities in discussion.	2F_BP.01_2, 2F_BP.01_4
2F_BP.01_w_3	Exam	Verifying knowledge based on the content of lectures, classes problems and indicated in the syllabus literature. Students must pass the class material in order to take the exam.	2F_BP.01_1, 2F_BP.01_2, 2F_BP.01_3, 2F_BP.01_4, 2F_BP.01_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.01_fs_1	lecture	Lecture conducted in a traditional way, blackboard and audiovisual tools.	30	The student will review the material based on previously provided literature.	45	2F_BP.01_w_2, 2F_BP.01_w_3
2F_BP.01_fs_2	discussion classes	Solving assigned problems, discussing results, converting some formulas not derived in lecture.	30	The student systematically prepares previously assigned problems.	45	2F_BP.01_w_1, 2F_BP.01_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Set of Diploma Courses I

Module code: W4-2F-21-BP.08

1. Number of the ECTS credits: 20

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.08_1	has in-depth knowledge of selected branches of theoretical and experimental physics	KF_W02 KF_W10	4 3
2F_BP.08_2	knows and understands the description of physical phenomena within the framework of selected theoretical models; can independently reconstruct the basic physical laws	KF_W05	4
2F_BP.08_3	can clearly present the results of scientific discoveries and theories in the field of physics in speech and writing	KF_U01	4
2F_BP.08_4	understands the need for an interdisciplinary approach to solving problems and integrating knowledge from different disciplines	KF_K09	5
2F_BP.08_5	can critically analyse and interpret results of measurements, observations and theoretical calculations	KF_U07	5
2F_BP.08_6	can acquire information from literature, databases and other sources; is familiar with basic scientific journals in physics; can integrate acquired information and interpret it, draw conclusions and formulate and justify opinions	KF_U12	4
2F_BP.08_7	student is able to apply the acquired knowledge of physics to the discussion of problems from related fields and scientific disciplines	KF_U14	3
2F_BP.08_8	can formulate precise questions to deepen his/her understanding of a topic or to find missing elements of reasoning	KF_K02	4
2F_BP.08_9	understands the need for systematic reading of scientific and popular science journals in order to broaden and deepen knowledge of physics	KF_K04	4

3. Module description

Description	The module includes a set of diploma courses, consisting of a lecture and a discussion part. For specific courses the discussion classes may consist of several hours of laboratory or computer classes. The diploma courses aim to deepen the student's knowledge in selected subjects of theoretical physics, experimental physics, simulation methods, and applied physics. This will be accomplished through a set of topics selected from theoretical physics, atomic and molecular physics, solid-state physics, astrophysics, particle physics, or nuclear physics. The courses' subject will be defined by students with supervisors and approved yearly by physics's didactic council.

Prerequisites	Fundamentals of physics, quantum mechanics.

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.08_w_1	Colloquium or individual projects	Written test verifying the knowledge and skills in solving tasks and problems from the discussed topics.	2F_BP.08_1, 2F_BP.08_2, 2F_BP.08_3, 2F_BP.08_4, 2F_BP.08_5, 2F_BP.08_6, 2F_BP.08_7, 2F_BP.08_8, 2F_BP.08_9
2F_BP.08_w_2	Activity in class	Evaluation of student work on the basis of solving tasks set by the teacher. Performing calculations, experiments.	2F_BP.08_1, 2F_BP.08_2, 2F_BP.08_3, 2F_BP.08_4, 2F_BP.08_5, 2F_BP.08_6, 2F_BP.08_7, 2F_BP.08_8, 2F_BP.08_9
2F_BP.08_w_3	Credit	Verification in accordance with the requirements specified in the syllabus	2F_BP.08_1, 2F_BP.08_2, 2F_BP.08_3, 2F_BP.08_4, 2F_BP.08_5, 2F_BP.08_6, 2F_BP.08_7, 2F_BP.08_8, 2F_BP.08_9

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.08_fs_1	lecture	Lecture on issues that are the subject of the syllabus. Supporting multimedia presentation will be used.	120	Reading lecture notes, studying the recommended literature.	240	2F_BP.08_w_3
2F_BP.08_fs_2	discussion classes	Solving tasks, discussion of the issues raised, performing experiments.	120	Solving tasks assigned by the instructor.	240	2F_BP.08_w_1, 2F_BP.08_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Set of Diploma Courses II

Module code: W4-2F-21-BP.12

1. Number of the ECTS credits: 20

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.12_1	has in-depth knowledge of selected branches of theoretical and experimental physics	KF_W02	4
2F_BP.12_2	knows and understands the description of physical phenomena within the framework of selected theoretical models; can independently reconstruct the basic physical laws	KF_W05	4
2F_BP.12_3	can clearly present the results of scientific discoveries and theories in the field of physics in speech and writing	KF_U01	4
2F_BP.12_4	understands the need for an interdisciplinary approach to solving problems and integrating knowledge from different disciplines	KF_K09	5
2F_BP.12_5	can critically analyse and interpret results of measurements, observations and theoretical calculations	KF_U07	5
2F_BP.12_6	can acquire information from literature, databases and other sources; is familiar with basic scientific journals in physics; can integrate acquired information and interpret it, draw conclusions and formulate and justify opinions	KF_U12	4
2F_BP.12_7	is able to apply the acquired knowledge of physics to the discussion of problems from related fields and scientific disciplines	KF_U14	3
2F_BP.12_8	can formulate precise questions to deepen his/her understanding of a topic or to find missing elements of reasoning	KF_K02	4
2F_BP.12_9	understands the need for systematic reading of scientific and popular science journals in order to broaden and deepen knowledge of physics	KF_K04	4

3. Module description

Description	The module includes a set of diploma courses, consisting of a lecture and a discussion part. For specific courses the discussion classes may consist of several hours of laboratory or computer classes. The diploma courses aim to deepen the student's knowledge in selected subjects of theoretical physics, experimental physics, simulation methods, and applied physics. This will be accomplished through a set of topics selected from theoretical physics, atomic and molecular physics, solid-state physics, astrophysics, particle physics, or nuclear physics. The courses' subject will be defined by students with supervisors and approved yearly by physics's didactic council.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.12_w_1	Colloquium or individual projects	Written test verifying the knowledge and skills in solving tasks and problems from the discussed topics.	2F_BP.12_1, 2F_BP.12_2, 2F_BP.12_3, 2F_BP.12_4, 2F_BP.12_5, 2F_BP.12_6, 2F_BP.12_7, 2F_BP.12_8, 2F_BP.12_9
2F_BP.12_w_2	Activity in class	Evaluation of student work on the basis of solving tasks set by the teacher. Performing calculations, experiments.	2F_BP.12_1, 2F_BP.12_2, 2F_BP.12_3, 2F_BP.12_4, 2F_BP.12_5, 2F_BP.12_6, 2F_BP.12_7, 2F_BP.12_8, 2F_BP.12_9
2F_BP.12_w_3	Credit	Verification in accordance with the requirements specified in the syllabus.	2F_BP.12_1, 2F_BP.12_2, 2F_BP.12_3, 2F_BP.12_4, 2F_BP.12_5, 2F_BP.12_6, 2F_BP.12_7, 2F_BP.12_8, 2F_BP.12_9

5. Forms of teaching						
code	**form of teaching**			**required hours of student's own work**		**assessment of the learning outcomes of the module**
	type	**description (including teaching methods)**	**number of hours**	**description**	**number of hours**	
2F_BP.12_fs_1	lecture	Lecture on issues that are the subject of the syllabus. Supporting multimedia presentation will be used.	120	Reading lecture notes, studying the recommended literature.	240	2F_BP.12_w_3
2F_BP.12_fs_2	discussion classes	Solving tasks, discussion of the issues raised, performing experiments.	120	Solving tasks assigned by the instructor.	240	2F_BP.12_w_1, 2F_BP.12_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Solid State Physics

Module code: W4-2F-12-14

1. Number of the ECTS credits: 5

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_14_1	has in-depth knowledge of selected areas of theoretical and experimental physics	KF_U01 KF_W02	3 3
2F_14_2	has extensive knowledge of quantum mechanics and statistical physics	KF_W03	4
2F_14_3	has in-depth knowledge of condensed phase physics	KF_W04	4
2F_14_4	knows and understands the description of physical phenomena within the selected theoretical models; can independently recreate the basic physical laws	KF_U02 KF_W05	4 4
2F_14_5	knows the mathematical formalism useful in the construction and analysis of physical models with an average level of complexity; understands the consequences of using approximate methods	KF_W06	4

3. Module description	
Description	During the lecture, the student becomes familiar with the following issues: 1. Elementary Crystallography, Solid materials (crystalline, polycrystalline, amorphous), Crystal Lattice, Crystal Structure, Types of Lattices, Unit Cell, Typical Crystal Structures, Bravais Lattices. 2. Diffraction, diffraction condition, Bragg's law, reciprocal lattice, Reciprocal lattice vectors, Brillouin zones, the Structure Factor, Lattice planes, Miller indices. 3. Crystal Dynamics, Lattice vibrations of 1D and 3D crystals, Phonons, Heat capacity from lattice vibrations, Anharmonic effects, Thermal conduction by phonons, Models of Heat Capacity (Einstein, Debye). 4. Interatomic forces, Types of bonds in crystals, Ionic, Covalent, Metallic, Van der Waals, Hydrogen. 5. Free electron Fermi gas, Fermi-Dirac Statistics, The Fermi energy, Electron Gas at $T = 0$ and at $T > 0$. Total Energy of a Gas of N Electrons, The electronic heat capacity. 6. Band Theory of Solids, electrons in a periodic potential, bands and energy gaps, weakly and strongly bound electrons, Conductors, Insulators,

	Semiconductors. 7. The crystal electron under the influence of an external force, the effective mass of an electron, Energy spectrum of crystal electrons in an external magnetic field, Landau levels. 8. Transport Phenomena, Electrical and thermal conductivity in solids, the Wiedemann-Franz law, Thermoelectrical and Galvanomagnetic Effects, 11. Magnetic properties of solids, diamagnetism, paramagnetism, ferro and anitiferromagnetism, Atomistic Description of the Magnetic Moments, spin and orbital moment, spin-orbit coupling, Russell-Saunders coupling, 3d and 4f elements, types of magnetic interactions. 12. Magnetic resonans (ESR, NMR) 13. Nanocrystaline solids
Prerequisites	Completed course of quantum mechanics, knowledge of the foundations of mathematical analysis and algebra

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_14_w_1	colloquium	2 times a semester; grading scale 2-5. The final grade for the discussion classes will be based to a large extent on the results of the test.	2F_14_1, 2F_14_2, 2F_14_3, 2F_14_4
2F_14_w_2	activity in class	Solving previously posed problems and tasks. Performing analytical calculations appearing during classes at the blackboard.	2F_14_1, 2F_14_2, 2F_14_3, 2F_14_4
2F_14_w_3	oral exam	the condition for taking the exam is passing the discussion classes; scope of the material - all issues discussed during the lectures; scale grades 2-5;	2F_14_3, 2F_14_4, 2F_14_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_14_fs_1	lecture	Discussion by the lecturer of issues being the topic of the lecture	25	Reading lecture notes, studying recommended literature	40	2F_14_w_1, 2F_14_w_3
2F_14_fs_2	discussion classes	Solving tasks at the blackboard	25	Solving tasks assigned by the tutor of the seminar	40	2F_14_w_1, 2F_14_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Specialized Lecture (e-learning)

Module code: W4-2F-21-BP.18

1. Number of the ECTS credits: 3

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_BP.18_1	has in-depth knowledge of selected branches of theoretical, experimental and applied physics	KF_W02	4
2F_BP.18_2	knows and understands the description of physical phenomena within the framework of selected theoretical models; can independently reconstruct the basic physical laws	KF_W05	3
2F_BP.18_3	can acquire information from literature, databases and other sources; is familiar with basic scientific journals in physics; can integrate acquired information and interpret it, draw conclusions and formulate and justify opinions	KF_U12	5
2F_BP.18_4	can formulate precise questions to deepen their own understanding of a topic or to find missing elements of reasoning	KF_K02	3
2F_BP.18_5	understands the need for systematic reading of scientific and popular science journals in order to broaden and deepen knowledge of physics	KF_K04	5

3. Module description

Description	The course is designed to enhance students’ knowledge of physics’s latest developments and learn about current research trends. The lecture will cover the most important, new developments in theoretical physics, experimental physics, instrumentation, simulation methods, and applied physics. A set of subjects to choose will cover theoretical physics, atomic and molecular physics, solid-state physics, astrophysics, particle physics, and nuclear physics and their applications. The topics of the lecture will be proposed yearly for the acceptance of the didactic council of physics.
Prerequisites	No prerequisites

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_BP.18_w_1	Credit	Verification in accordance with the requirements specified in the syllabus.	2F_BP.18_1, 2F_BP.18_2, 2F_BP.18_3, 2F_BP.18_4, 2F_BP.18_5

5. Forms of teaching						
code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.18_fs_1	lecture	Content of the lecture presented in verbal form supported by visualization (multimedia presentation). Focusing on conceptually difficult material and indicating sources. Illustrating content with examples.	30	Familiarization with the lecture topics using existing method packages: textbooks, scripts, websites, etc. Preparation for the credit depending on the form taken.	50	2F_BP.18_w_1

1.	**Field of study**	**Physics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Spectroscopic Methods

Module code: W4-2F-13-21

1. Number of the ECTS credits: 4

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_21_1	has extensive knowledge of quantum mechanics and statistical physics	KF_W03	5
2F_21_2	has in-depth knowledge of condensed phase physics	KF_W04	4
2F_21_3	knows the structure and principle of operation of scientific equipment	KF_W08	4
2F_21_4	on the basis of the acquired knowledge, he can explain the physical processes taking place in the world around him	KF_U03	2
2F_21_5	on the basis of the acquired knowledge, knows how to explain the operation of research equipment	KF_U04	5
2F_21_6	understands the need to systematically read scientific and popular science journals,	KF_K04	5

3. Module description

Description	Types of spectroscopy, electronic structure of atoms and molecules, electron transitions, oscillations and rotations, selection rules, absorption spectra, UV / VIS spectrometry and spectrometers, qualitative and quantitative analysis, X-ray (XPS) or ultraviolet (UPS) photoelectron spectroscopy, secondary ion mass spectrometry (SIMS, SNMS, ToF SIMS), Auger Electron Spectroscopy (AES), application of spectrometry to study nanoparticles and thin films. Recommended literature: 1. „Spektrometria UV/VIS w analizie chemicznej” Teresa Nowicka-Jankowska, Elżbieta Wieteska, Krystyna Gorczyńska, Anna Michalik, PWN 1988. 2. „Spektrometria masowa” Włodzimierz Żuk, PWN 1956. 3. „Spektrometria mas” Robert A. W. Johnstone, Malcolm E. Rosse, PWN SA 2001. 4. „Photoelectron Spectroscopy”, S. Huefner, Springer Verlag 2003. Mandatory examination
Prerequisites	Knowledge of physics and mathematics at bachelor's degree in physics

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
		problem solving, calculations and discussion of the results; use of computer programs,	

2F_21_w_1	activity in class	grading scale 2-5	2F_21_1, 2F_21_2, 2F_21_3, 2F_21_4, 2F_21_5, 2F_21_6
2F_21_w_2	reports	elaboration of measurement results, discussion of errors, grading scale 2-5	2F_21_1, 2F_21_2, 2F_21_3, 2F_21_4, 2F_21_5, 2F_21_6
2F_21_w_3	written exam	All issues discussed in lectures, grading scale 2-5	2F_21_1, 2F_21_2, 2F_21_3, 2F_21_4, 2F_21_5, 2F_21_6

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_21_fs_1	lecture	Lecture with the use of audiovisual aids	20	Supplementary reading, work with the textbook	15	2F_21_w_1, 2F_21_w_3
2F_21_fs_2	laboratory classes	preparation, carrying out and processing of measurement results	10	preparation of issues and tasks indicated by the teacher,	30	2F_21_w_2, 2F_21_w_3
2F_21_fs_3	discussion classes	discussion of the issues presented in the lecture and being the subject of the experiment, discussion	10	preparation of issues indicated by the teacher,	20	2F_21_w_1, 2F_21_w_2, 2F_21_w_3

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Statistical Physics

Module code: W4-2F-12-13

1. Number of the ECTS credits: 4

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
2F_13_1	Understands the fundamental importance of statistical physics for understanding physical phenomena;	KF_W01	4
2F_13_2	Acquires in-depth knowledge of the statistical description of experimental physics;	KF_W02	3
2F_13_3	Has in-depth knowledge of statistical physics and understands its relationship with quantum mechanics;	KF_W03	5
2F_13_4	Knows a description of physical phenomena within selected statistical models;	KF_W05	3
2F_13_5	Is able to explain physical processes in the world around him based on statistical physics;	KF_U03	4
2F_13_6	Can use mathematical formalism to build and analyze statistical physics models;	KF_U09	3
2F_13_7	Is able to integrate and interpret information obtained on the basis of statistical physics, draw conclusions and formulate and justify opinions	KF_U12	4

3. Module description

Description	During the lecture, the student will learn about the following issues: •Thermodynamic systems, Thermodynamic parameters, Equation of state, Equilibrium states, Thermodynamic potentials, •Work and heat; Ideal gas , Zero, First, Second and Third laws of thermodynamics, Heat and entropy, Clausius theorem, •Thermodynamic processes, Carnot cycle, Stability conditions, •Probability and frequency, Probability of combined events, Random Variable, Expected values, Transformation of variables, •The main PDFs, Multivariate distributions, •Statistical definition of entropy, Number of microstates, •Liouville's theorem , Microcanonical ensemble, The canonical ensemble, •The partition function, Proof that the statistical entropy equals the thermodynamic entropy, •Virial and equipartition theorems, •Applications of the canonical ensemble: quantum oscillators, The macrocanonical ensemble, •Density operators, Quantum ensembles, Symmetry of many-particle wave functions,

	•Ideal quantum systems, Bose gas, Photon gas, Phonons, •Fermi gas, Relativistic fermions, •General properties of phase transitions, Gas with interacting particles, •Critical exponents, Correlation functions.
Prerequisites	Basic knowledge of quantum mechanics and probability theory

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
2F_13_w_1	colloquium	twice a semester; date of the colloquium announced to students two weeks earlier; tasks of a similar type to those at the seminar; grading scale 2-5;	2F_13_2, 2F_13_3, 2F_13_4, 2F_13_5, 2F_13_6, 2F_13_7
2F_13_w_2	activity in class	solving a task - oral answer; participation in the discussion; grading scale 2-5; final grade equal to the average of partial grades	2F_13_1, 2F_13_2, 2F_13_3, 2F_13_4, 2F_13_5, 2F_13_6, 2F_13_7
2F_13_w_3	written exam (or oral exam)	the condition of taking the exam is passing the seminar; scope of material - all issues discussed in lectures; grading scale 2-5;	2F_13_1, 2F_13_2, 2F_13_3, 2F_13_4, 2F_13_5, 2F_13_6, 2F_13_7

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_13_fs_1	lecture	lecture on selected issues using audiovisual aids	20	work with a textbook; supplementary reading	30	2F_13_w_3
2F_13_fs_2	discussion classes	solving of tasks on the board:analysis,method selection, calculation and discussion of results;deriving some formulas and discussing selected examples signaled during lectures,discussion;the possibility of using computers	20	acquire knowledge of lectures; work with a textbook and task sets;	30	2F_13_w_1, 2F_13_w_2

1.	Field of study	Physics
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second degree studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Statistical Physics

Module code: W4-2F-21-BP.02

1. Number of the ECTS credits: 5

2. Learning outcomes of the module			
code	**description**	**learning outcomes of the programme**	**level of competence (scale 1-5)**
2F_BP.02_1	Understands the fundamental importance of statistical physics for understanding physical phenomena	KF_W01	4
2F_BP.02_2	Has an in-depth knowledge of the statistical description of experimental physics phenomena	KF_W02	3
2F_BP.02_3	Has in-depth knowledge of statistical physics and understands its relationship to quantum mechanics	KF_W02	5
2F_BP.02_4	Knows the description of physical phenomena within the framework of selected statistical models	KF_W05	3
2F_BP.02_5	Can use a mathematical apparatus to solve statistical physical problems of medium complexity	KF_U03	3
2F_BP.02_6	Can use mathematical formalism to build and analyze models of statistical physics	KF_U09	3
2F_BP.02_7	Can, on the basis of statistical physics, integrate acquired information and interpret it, draw conclusions and formulate and justify opinions	KF_U12	4
2F_BP.02_8	Can, based on statistical physics, describe condensed phase physics problems	KF_W04	2

3. Module description	
Description	This course offers an introduction to statistical mechanics with elements of thermodynamics. The main issues discussed will be probability distributions, elements of black body radiation, laws of thermodynamics, phase transitions, micro and grand canonical ensembles, statistics of classical and quantum gases, degenerate fermionic and bosonic states of matter.
Prerequisites	Knowledge of basic quantum mechanics and probability theory.

4. Assessment of the learning outcomes of the module			
code	**type**	**description**	**learning outcomes of the module**
2F_BP.02_w_1	Colloquium	Verifying the knowledge and skills in solving tasks and problems from the discussed topics.	

			2F_BP.02_2, 2F_BP.02_3, 2F_BP.02_4, 2F_BP.02_5, 2F_BP.02_6, 2F_BP.02_7, 2F_BP.02_8
2F_BP.02_w_2	Activity in class	Evaluation of student work on the basis of solving tasks set by the teacher, participation in discussions.	2F_BP.02_1, 2F_BP.02_2, 2F_BP.02_3, 2F_BP.02_4, 2F_BP.02_5, 2F_BP.02_6, 2F_BP.02_7, 2F_BP.02_8
2F_BP.02_w_3	Exam	Verifying knowledge based on the content of lectures, discussion classes and indicated in the syllabus literature. Students must pass the discussion classes in order to take the exam.	2F_BP.02_1, 2F_BP.02_2, 2F_BP.02_3, 2F_BP.02_4, 2F_BP.02_5, 2F_BP.02_6, 2F_BP.02_7, 2F_BP.02_8

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
2F_BP.02_fs_1	lecture	Lecture on selected topics with the use of audiovisual assistance.	20	Individual assimilation of knowledge on the basis of notes and literature indicated in the lecture.	40	2F_BP.02_w_3
2F_BP.02_fs_2	discussion classes	Solving calculation tasks on the blackboard: analysis, choosing the method, performing calculations and discussion of results; derivation of some formulas and discussion of selected examples indicated in lectures, discussion. Possibility of using computers for solving specific problems.	20	Assimilation of knowledge from lectures. Theoretical preparation for the classes. Independent solving of assignments from the set of exercises indicated by the lecturer.	40	2F_BP.02_w_1, 2F_BP.02_w_2