Uchwała nr 2366
Senatu Uniwersytetu w Białymstoku
z dnia 27 marca 2019 r.

w sprawie ustalenia programu studiów
dla kierunku Physics,
obowiązującego od roku akademickiego 2019/2020

Na podstawie art. 28 ust. 1 pkt 11 ustawy z dnia 20 lipca 2018 r. *Prawo o szkolnictwie wyższym i nauce* (Dz. U. z 2018 r., poz. 1668 z późn. zm.) w związku z art. 268 ust. 2 ustawy z dnia 3 lipca 2018 r. *Przepisy wprowadzające ustawę – Prawo o szkolnictwie wyższym i nauce* (Dz. U. z 2018 r., poz. 1669 z późn. zm.) Senat Uniwersytetu w Białymstoku uchwala, co następuje:

§ 1

1. Senat Uniwersytetu w Białymstoku ustala, obowiązujący od roku akademickiego 2019/2020, program studiów dla kierunku *Physics* na poziomie studiów pierwszego stopnia o profilu ogólnoakademickim, prowadzonych w języku angielskim.
2. Program studiów stanowi Załącznik do niniejszej Uchwały.

§ 2

Uchwała wchodzi w życie z dniem podjęcia.

Przewodniczący
Senatu Uniwersytetu w Białymstoku

Prof. dr hab. Robert W. Ciborowski

Załącznik
do Uchwały nr 2366
Senatu UwB
z dnia 27 marca 2019 r.

LEARNING OUTCOMES
for the field of study Physics
first degree study – general academic profile

Setting the field of study in scientific disciplines, to which the learning outcomes refer to: physical sciences, astronomy, automation, electronics and electrical engineering, mathematics, computer science, biological sciences, chemical sciences, medical sciences, legal studies, management and quality-control studies, security and safety studies, physical education, language studies, history.

Identification of the leading discipline: physical sciences.

Table 1

Description symbol of the second degree Polish Qualification Framework (PQF) in the scope of above mentioned disciplines	DESCRIPTION OF THE SECOND DEGREE PQF	Symbol of the field outcome	DESCRIPTION OF THE FIELD LEARNING OUTCOMES	Disciplines
KNOWLEDGE, a graduate is familiar with and understands:				
P6S_WG	w zaawansowanym stopniu – wybrane fakty, obiekty i zjawiska oraz dotyczące ich metody i teorie wyjaśniające złożone zależności między nimi, stanowiące podstawową wiedzę ogólną z zakresu dyscyplin naukowych tworzących podstawy teoretyczne oraz wybrane zagadnienia z zakresu wiedzy szczegółowej – właściwe dla programu studiów	K_W01	See table 2	physical sciences
		K_W02		physical sciences
		K_W03		physical sciences
		K_W04		physical sciences
		K_W05		physical sciences
		K_W06		physical sciences: 50% mathematics: 50%
		K_W07		physical sciences: 50% mathematics: 50%
		K_W08		physical sciences
		K_W09		physical sciences
		K_W10		physical sciences
		K_W11		physical sciences
		K_W12		physical sciences
		K_W13		physical sciences
		K_W14		physical sciences
		K_W32		physical sciences

		K_W15		physical sciences
		K_W16		physical sciences
		K_W17		physical sciences
		K_W18		astronomy
		K_W19		physical sciences
		K_W21		physical sciences
		K_W22		physical sciences
		K_W23		computer science
		K_W24		computer science
		K_W25		computer science
		K_W26		physical sciences: 30% computer science: 70%
		K_W27		physical sciences: 50% automation, electronics and electrical engineering: 50%
		K_W28		physical sciences: 80% automation, electronics and electrical engineering: 20%
		K_W29		security and safety studies
		K_W33		physical sciences
		K_W34		physical sciences
		K_W35		physical sciences
		K_W36		physical sciences: 80% computer science: 20%
		K_W37		physical sciences
		K_W40		physical sciences
		K_W41		physical sciences
		K_W42		physical sciences
		K_W43		physical sciences
		K_W44		physical sciences
		K_W45		chemical sciences
		K_W46		chemical sciences
		K_W47		biological sciences
		K_W48		biological sciences
		K_W49		biological sciences
		K_W50		biological sciences
		K_W51		biological sciences

		K_W54		history: 50% philosophy: 50%
		K_W55		language studies
		K_W56		physical education
		K_W57		physical education
P6S_WK	fundamentalne dylematy współczesnej cywilizacji podstawowe ekonomiczne, prawnicze, etyczne i inne uwarunkowania różnych rodzajów działalności zawodowej związanej z kierunkiem studiów, w tym podstawowe pojęcia i zasady zakresu ochrony własności przemysłowej i prawa autorskiego podstawowe zasady tworzenia i rozwoju różnych form przedsiębiorczości.	K_W38		physical sciences
		K_W30		legal studies
		K_W39		legal studies
		K_W31		management and quality-control studies
		K_W52		management and quality-control studies
		K_W53		management and quality-control studies
SKILLS, a graduate can/is able to:				
P6S_UW	wykorzystywać posiadaną wiedzę - formułować i rozwiązywać złożone i nietypowe problemy oraz wykonywać zadania w warunkach nie w pełni przewidywalnych przez: - właściwy dobór źródeł i informacji z nich pochodzących, dokonywanie oceny, krytycznej analizy i syntezy tych informacji, - dobór oraz stosowanie właściwych metod i narzędzi, w tym zawansowanych technik informacyjno-komunikacyjnych	K_U03	See table 2	mathematics
		K_U04		mathematics
		K_U05		computer science: 50% computer science: 50%
		K_U06		physical sciences
		K_U08		physical sciences
		K_U10		physical sciences
		K_U12		physical sciences
		K_U14		physical sciences
		K_U15		physical sciences
		K_U16		astronomy
		K_U17		physical sciences
		K_U21		physical sciences
		K_U27		physical sciences: 20% automation, electronics and electrical engineering: 80%
		K_U18		physical sciences
		K_U19		physical sciences
		K_U20		physical sciences
		K_U22		computer science
		K_U23		computer science
		K_U24		computer science
		K_U25		computer science
		K_U30		physical sciences
		K_U32		physical sciences

		K_U33		physical sciences: 90% security and safety studies: 10%
		K_U35		physical sciences
		K_U36		physical sciences: 90% security and safety studies: 10%
		K_U38		physical sciences
		K_U39		physical sciences
		K_U40		physical sciences
		K_U41		physical sciences
		K_U42		chemical sciences
		K_U43		chemical sciences
		K_U44		chemical sciences
		K_U45		biological sciences
		K_U46		biological sciences
		K_U47		chemical sciences: 50% biological sciences: 50%
		K_U48		management and quality-control studies
		K_U49		management and quality-control studies
		K_U50		physical education
P6S_UK	komunikować się z otoczeniem z użyciem specjalistycznej terminologii	K_U01		physical sciences
	brać udział w debacie - przedstawiać i oceniać różne opinie i stanowiska oraz dyskutować o nich	K_U02		physical sciences
		K_U31		physical sciences
		K_U37		physical sciences
	posługiwać się językiem obcym na poziomie B2 Europejskiego Systemu Opisu Kształcenia Językowego	K_U28		language studies
		K_U29		language studies
		K_K04		physical sciences
	przygotować typowe prace pisemne i wystąpienia ustne, dotyczące zagadnień szczegółowych związanych z kierunkiem studiów, z wykorzystaniem podstawowych ujęć teoretycznych i różnych źródeł	K_K06		legal studies
P6S_UO	planować i organizować pracę indywidualną oraz w zespole	K_U07		physical sciences
		K_U09		physical sciences
	współdziałać z innymi osobami w ramach prac zespołowych (także o charakterze interdyscyplinarnym)	K_U11		physical sciences
		K_U13		physical sciences
		K_U26		physical sciences: 20% automation, electronics and electrical engineering: 80%

		K_U34		physical sciences
		K_K02		physical sciences
P6S_UU	samodzielnie planować i realizować własne uczenie się przez całe życie	K_U04		mathematics
		K_K01		physical sciences
		K_K05		physical sciences: 90% language studies: 10%
		K_K51		physical education
SOCIAL COMPETENCE, a graduate is prepared for:				
P6S_KK	krytycznej oceny posiadanej wiedzy i odbieranych treści uznawania znaczenia wiedzy w rozwiązywaniu problemów poznawczych i praktycznych oraz zasięgania opinii ekspertów w przypadku trudności z samodzielnym rozwiązaniem problemu	K_K01	See table 2	physical sciences
P6S_KO	wypełniania zobowiązań społecznych, współorganizowania działalności na rzecz środowiska społecznego inicjonowania działań na rzecz interesu publicznego myślenia i działania w sposób przedsiębiorczy	K_K07		management and quality-control studies
P6S_KR	odpowiedzialnego pełnienia ról zawodowych w tym: - przestrzegania zasad etyki zawodowej i wymagania tego od innych, - dbałość o dorobek i tradycje zawodu	K_K03		legal studies
		K_K06		legal studies
		K_K08		management and quality-control studies
		K_K09		management and quality-control studies

Table 2

Symbol of the field outcome	DESCRIPTION OF THE FIELD LEARNING OUTCOMES Following the completion of the first degree studies in Physics a graduate:
KNOWLEDGE	
with the reference to physics and methodology of physical sciences	
K_W01	understands fundamental meaning of physics in technological, economic and civilization development and, if the specialty so requires, its importance in health protection
K_W02	understands the role of the quantitative model and the abstract description of the physical object and physical phenomena in the field of physical sciences
K_W03	becomes aware of the importance of an experiment as a verification means of theoretical concepts as well as experimental uncertainty
K_W04	understands the structure of physics as a scientific discipline, becomes aware of connections between certain domains and theory, knows examples of faulty physical hypotheses and faulty physical theories
K_W05	knows limitations of applications of chosen physical theories, models of physical objects and descriptions of physical phenomena

with the reference to tools of mathematics	
K_W06	has **mathematical knowledge**, including differential and integral calculus, algebra as well as probability theory and statistics necessary to describe laws of physics, to model and to study selected physical systems and to analyse experimental data
K_W07	understands the formal structure of basic physical theories, can use proper mathematical tools for quantitative description of phenomena from chosen areas of physics
with the reference to foundations of physics	
K_W08	has knowledge within the framework of basic concepts and formalism of **classical mechanics**, laws of mechanics and theoretical models of chosen mechanical systems, understands fundamental character of Newton's laws
K_W09	knows ways of experimental verification of physical laws and concepts, knows construction and operation rules of measuring apparatus for selected experiments regarding mechanics
K_W10	knows and understands basic concepts and selected phenomena regarding **electricity and magnetism** – understands contents of Maxwell field equations
K_W11	knows ways of experimental verification of physical laws and concepts, knows construction and operation rules of measuring apparatus for selected experiments regarding electricity and magnetism
K_W12	has knowledge of basic concepts, phenomena and formalism of thermodynamics, laws of **thermodynamics** as well as theoretical models of chosen thermodynamic systems
K_W13	knows construction and operation rules of measuring apparatus for selected experiments regarding thermodynamics
K_W14	has knowledge of basic concepts and formalism of **optics and physics of electromagnetic wave phenomena** and theoretical models of selected optical and wave systems, knows and understands limitations of their applications
K_W32	has basic knowledge of theory of electromagnetic radiation, knows theoretical approach to selected problems regarding the theory of radiation and chosen mathematical tools for their analysis in the range provided by the curriculum of a major
K_W15	knows ways of experimental verification of physical laws and concepts, knows construction and operation rules of measuring apparatus for selected experiments regarding optics and physics of electromagnetic wave phenomena
K_W16	has basic knowledge regarding **atomic physics, molecule, solid-state physics, physics of atomic nuclei, elementary particles and basic interactions in nature**
K_W17	knows ways of experimental verification of physical laws and concepts, knows construction and operation rules of measuring apparatus for selected experiments regarding physics of microcosm
K_W18	has basic knowledge of **astronomy** and knows the rules of astronomical observations in the range provided by the curriculum of a major
K_W19	understands the structure of physics as a scientific discipline, acquires awareness of individual connections between particular fields of physics and physical theories in the range provided by the curriculum of a major
with the reference to elements of theoretical physics	
K_W20	has knowledge of foundations of **theoretical mechanics**, knows theoretical approaches to the chosen problems and formulation of mechanics in the range provided by the curriculum of a major
K_W21	has knowledge of foundations of **classical electrodynamics**, knows theoretical approaches to the chosen problems within it as well as mathematical tools for analysis in the range provided by the curriculum of a major
K_W22	has knowledge of foundations of **quantum mechanics**, formalism and probabilistic interpretation of the theory, knows a theoretical description as well as mathematical tools for analysis of chosen quantum systems
with the reference to tools of information technology	
K_W23	knows the rules of operating systems usage and the package of selected specialist application software, including environments for data analysis and symbolic computation
K_W24	has basic knowledge of algorithms and data structures
K_W25	knows foundations of programming in a chosen high-level programming language
K_W26	knows foundations of numerical methods used in issues of physics and their applications
with the reference to technical applications of physics	
K_W27	knows construction and understands physical foundations of operations of selected analogue and digital electronic sub-assemblies in the range covered by the curriculum of a chosen major

K_W28	knows the construction of selected electronic measuring devices and understands their rules of operation in the range covered by the curriculum of a chosen major
K_W33	has basic knowledge of related disciplines, appropriate for a chosen major and knows their relations to physics
K_W34	knows construction and operational rules of selected electronic measuring devices as well as diagnostic devices appropriate for a chosen major in the range covered by the curriculum of a chosen major
K_W35	knows basic rules of metrology and its application in the range covered by the curriculum of a chosen major
K_W36	has knowledge allowing to model and simulate chosen physical phenomena as well as properties of physical matter in the range provided by the curriculum of a chosen major
K_W37	knows the supervision rules of contemporary devices used in research laboratories and the ones connected with selected applications of physics in the range covered by the curriculum of a chosen major
K_W40	knows the distribution of forces in the human body movement system and knows the physical aspects of the mechanism of the skeletal and muscular system
K_W41	knows the physical processes related to the flow of liquids and diffusion processes in relation to the human circulatory system
K_W42	knows the causes of potential differences in cells and processes of propagation of electromagnetic impulses in the human nervous system,
K_W43	obtains a wide knowledge in the field of radiological protection, dosimetry and its legal regulations; knows the rules of radiological safety and is familiar with its legal regulations in Poland
K_W44	knows the types of ionizing radiation and knows how this radiation interacts with matter; knows the basic concepts of doses of ionizing radiation and knows what physical quantities describe radiation doses
in the field of basic chemical and biological sciences	
K_W45	understands the terminology and chemical nomenclature; knows the basic properties of elements, inorganic and organic compounds
K_W46	understands the impact of changes in the system parameters on the state of chemical equilibrium
K_W47	understands and knows how to characterize the structure and functions of cellular organelles
K_W48	understands and knows how to characterize basic tissues
K_W49	knows the human anatomy to the basic level; understands the principles of operation and human physiology
K_W50	knows and characterizes the structure, dynamics, and interactions of biological macromolecules
K_W51	knows the basics of physicochemical methods used in biophysical research; knows the basics of physicochemical biological processes, using the most important mathematical, chemical, and physical laws
in the field of social sciences and humanities	
K_W30	has basic knowledge of ethical and legal aspects of scientific and educational activity connected with practical applications of scientific achievements, including the basics of patent law in the range provided by the curriculum of a chosen major
K_W31	knows the rules of individual entrepreneurship and commercialization of used research results
K_W39	has basic knowledge of ethical and legal aspects connected with practical applications of physics in industrial production, including non-disclosure rules and protection against competition in the range provided by the curriculum of a chosen major
K_W52	knows the concept of quality management and characterizes the various methods and techniques used in quality management
K_W53	is familiar with the legal requirements and obligations related to quality assurance at work (for ex. in radiotherapy, nuclear medicine, interventional radiology); knows selected methods and management tools in the area of quality management
K_W54	has a basic knowledge of a chosen subject belonging to the field of humanities
moreover	
K_W29	knows the basic rules of health and safety in laboratories corresponding to a chosen major
K_W38	knows the rules of protection of chosen devices against undesirable environmental impact and the rules of environmental protection against the influence of devices in the range covered by the curriculum of a chosen major
K_W55	knows the English language at the B2 level of the Common European Framework of Reference for Languages

K_W56	has basic knowledge of the popular individual and team sports, games and other forms of physical activity, emphasizes and promotes healthy lifestyle choices based on physical activity.
K_W57	has necessary basic knowledge of the terminology of health sciences and physical education
SKILLS	
with the reference to structures of physics and methodology of physical sciences	
K_U01	can intelligibly present basic facts regarding known areas of physics, outline the structure of physics as a scientific discipline and show the impact of selected discoveries in the field of physics on development of technology, economy and civilization
K_U02	can prepare a study, including the one addressed to wide public, regarding research in the scope of known areas of physics, using acquired knowledge as well as literature and information technology resources
with the reference to tools of mathematics	
K_U03	can use known tools of mathematics to formulate and solve chosen problems within the framework of theoretical and experimental physics
K_U04	can independently complete and broaden mathematical knowledge
K_U05	can use computer tools for symbolic computation
with the reference to foundations of physics	
K_U06	can analyse problems in the scope of **mechanics**, find and present their solutions on basis of acquired knowledge and using known tools of mathematics run quantitative analysis and draw qualitative conclusions
K_U07	can plan and do simple experiments referring to mechanics, critically analyse their results and present them
K_U08	can analyse problems regarding **electricity and magnetism**, find and present their solutions on basis of acquired knowledge and using known tools of mathematics run quantitative analysis and draw qualitative conclusions
K_U09	can plan and do simple experiments referring to **electricity and magnetism**, critically analyse their results and present them
K_U10	can analyse problems regarding **thermodynamics**, find and present their solutions on basis of acquired knowledge and using known tools of mathematics run quantitative analysis and draw qualitative conclusions
K_U11	can plan and do simple experiments referring to **thermodynamics**, critically analyse their results and present them
K_U12	can analyse problems regarding **optics and physics of wave phenomena**, find and present their solutions on basis of acquired knowledge and using known tools of mathematics run quantitative analysis and draw qualitative conclusions
K_U13	can plan and do simple experiments referring to **optics and physics of wave phenomena**, critically analyse their results and present them
K_U14	can analyse problems regarding **microscopic structure of matter**, find and present their solutions on basis of acquired knowledge and using known tools of mathematics run quantitative analysis and draw qualitative conclusions
K_U15	can plan and do simple experiments referring to the **physics of microcosm**, critically analyse their results and present them
K_U16	can clearly present basic problems referring to **astronomy and astrophysics**, make basic astronomical observations and interpret their results in the range provided by the curriculum of a chosen major
K_U17	can critically and with understanding use literature and information technology resources with the reference to foundations of physics
with the reference to elements of theoretical physics	
K_U18	can present theoretical formulation of chosen issues of **classical mechanics** and run theoretical analysis of selected phenomena using suitable mathematical tools in the range provided by the curriculum of a chosen major
K_U19	can present theoretical formulation of chosen issues of **classical electrodynamic** and run theoretical analysis of selected phenomena using suitable mathematical tools in the range provided by the curriculum of a chosen major
K_U20	can present theoretical formulation of chosen issues of **quantum mechanics**, and run theoretical analysis of selected quantum systems using suitable mathematical tools in the range provided by the curriculum of a chosen major
K_U21	can critically and with understanding use literature and information technology resources with the reference to issues of theoretical physics in the range provided by the curriculum of a chosen major

with the reference to tools of information technology	
K_U22	can work in the environment of different operating systems and use selected application software can write a simple computer programme in a chosen programming language, compile it and start it
K_U23	can use computer programmes to solve physics and mathematical problems, data analysis as well as symbolic and numerical calculations
K_U24	can find and use specialist computer software in the internet resources with respect for intellectual property and rules of use
K_U25	can work in the environment of different operating systems and use selected application software
with the reference to technical applications of physics	
K_U26	can plan and do simple experiments referring to electronics, critically analyse their results and present them in the range provided by the curriculum of a chosen major
K_U27	can critically and with understanding use literature and the internet resources with the reference to issues of electronics in the range provided by the curriculum of a chosen major
K_U30	can analyse chosen problems regarding selected applications of physics on basis of the knowledge of physics and related disciplines in the range covered by the curriculum of a chosen major
K_U31	can come to an agreement and cooperate with the staff of a business entity participating in the process of education in the scope of chosen issues referring to its activity in the range covered by the curriculum of a chosen major
K_U32	can present operation rules as well as identify and assess dangers connected with the use of selected laboratory and diagnostic devices in the range covered by the curriculum of a chosen major
K_U33	can identify and eliminate events potentially dangerous for laboratory and diagnostic devices in the range covered by the curriculum of a chosen major
K_U34	can plan and take simple measurements of values specific to selected phenomena and physical properties of chosen bodies in the range covered by the curriculum of a chosen major
K_U35	can optimally choose a set of tools for a measurement task in the range covered by the curriculum of a chosen major
K_U36	can identify and analyse environmental dangers for selected devices and corresponding dangers for the environment in the range covered by the curriculum of a chosen major
K_U38	can analyze medical data and determine quantitative parameters within a given hypothesis
K_U39	is able to analyze simple problems in the field of radiological protection and find solutions based on the acquired knowledge, perform appropriate quantitative analysis and formulate qualitative conclusions
K_U40	can explain the principle of operation of selected measuring sets in the scope of dosimetry and safe handling of ionizing radiation,
K_U41	can prepare and oversee radiation protection procedures in the organization unit, as well as prepare and check documentation; can perform dosimetry control
K_U37	can analyse a chosen problem referring to applications of physics on basis of the internet and literature resources and present a way of its solution in the form of a concise study in the range covered by the curriculum of a chosen major
in the field of basic chemical and biological sciences	
K_U42	can use terminology and chemical nomenclature
K_U43	can explain the equilibrium found in the solutions of acids, bases and salts and their importance for living organisms
K_U44	can use the concepts of kinetics and chemical equilibrium to explain phenomena related to the course of chemical reactions
K_U45	can recognize basic tissues
K_U46	can use terminology and biological nomenclature
K_U47	can describe the methods and techniques used in laboratory research in chemistry and biology; acquires practical skills to work with the basic apparatus used in laboratory research in chemistry and biology
in the field of social sciences and humanities	
K_U48	can identify and analyze individual processes in a unit, taking into account quality and safety requirements, and plan appropriate activities

K_U49	can apply selected methods and management tools in the area of quality, including preparation of selected documents
	moreover
K_U28	knows the English language at the B2 level of the Common European Framework of Reference for Languages
K_U29	is able to use knowledge sources in English in the field of physical science and find their practical applications
K_U50	can perform and demonstrate physical exercises in a safe manner
K_U51	can independently plan self-education and improves his/her motor skills by training and maintaining physical fitness
	SOCIAL COMPETENCE
K_K01	knows the limitations of their knowledge and understands the need of further learning, raising professional, personal and social skills
K_K02	can work in teams in different assigned positions, especially in a managerial position or of an experiment coordinator, knows how to take on responsibility for team work; is ready to improve team work skills in laboratory settings
K_K03	understands the meaning of intellectual honesty in their own actions and actions of other people
K_K04	understands the need to share knowledge, including the need of presenting achievements in physics
K_K05	can independently find information in literature and the internet resources, including in foreign languages
K_K06	can express opinions about fundamental issues of physics and its applications, understands social aspects of applications in physics and responsibility connected with it
K_K07	can think and act in an entrepreneurial manner
K_K08	is ready to show care for own work safety and those of other people
K_K09	is ready to take on responsibilities related to professional duties

Explanation of the symbols

P6S_WG – *description symbol of the second degree PQF*

P6 or P7 – PQF level *(6 – first degree study, 7 – second degree study and uniform master degree study)*
S – *specification typical of qualifications obtained in higher education*
W – knowledge *(descriptive category)*
G – *depth and extent*
K – *context*
U – skills *(descriptive category)*
W – *use of knowledge*
K – *communicating*
O – *work organization*
U – *learning*
K – social competence *(descriptive category)*
K – *critical evaluation*
O – *responsibility*
R – *professional role*

K_W01 – *symbol of the field outcome*

K – *field learning outcomes*

W – knowledge *(descriptive category)*

U – skills *(descriptive category)*

K – social competence *(descriptive category)*

STUDY PROGRAMME - Part A

I. GENERAL INFORMATION

1. Setting the field of studies in discipline/scientific disciplines, which the learing outcomes refer to: physical sciences, astronomy, automation, electronics and electrical engineering, mathematics, computer science, biological sciences, chemical sciences, medical sciences, legal studies, management and quality-control studies, security and safety studies, physical education, language studies, history
2. Name of the field of study: ***Physics***
3. Specializations offered: ***Medical physics***
4. Level of education: ***first degree studies***
5. Educational profile: ***General academic***
6. Form of study: ***full time***
7. A number of semesters: *6*
8. Total number of ECTS points required to achieve the equivalent level of relevant qualifications: **180**
9. Total number of teaching hours: ***2298***
10. Programme is effective from the academic year: **2019/2020**

II. EDUCATION MODULES

Modules (module code: MK_1 and module name)	*Field learing outcomes* Knowledge Skills Social competence (symbols)	*Teaching methods and verification*	*Courses/modules*	a number of ECTS points per course/modul	*QUANTITATIVE INDICATORS - ECTS points included in courses:*						
					that require direct participation of teachers or other people conducting the classes	in basic science specific for a given field of study, which learning outcomes for a given field, level and profile of education refer to	classes shaping practical skills/classes connected with scientific activity conducted at the university in discipline/disciplines, which the field of study is assigned to	in discipline of humanities or social sciences (min. 5 ECTS points) - for the fields from other discipline of science*	in a foreign language (language classes)	in apprenticeships	that are elective
MK_1 (Foundations of physics)	K_W01,K_W02, K_W03 K_W04, K_W05, K_W08, K_W09, K_W10, K_W11, K_W12, K_W13, K_W14,K_W15, K_W16, K_W17, KW_18, K_W19, K_W20, K_W29, K_U01, K_U02, K_U06, K_U07,K_U08, K_U09,K_U10, K_U11, K_U12, K_U13, K_U14, K_U15,K_U16, K_U17, K_U18, K_01, K_K02, K_K03, K_K04, K_K05, K_K06	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Introduction to physics	9,0	6,0	9,0	0,6				
			Classical Mechanics	8,0	5,4	8,0	1,2				8,0
			Analysis of the Experimental Uncertainty	2,0	1,8	2,0	0,6				
			Electricity and magnetism with optics	8,0	5,4	8,0	1,2				8,0
			Thermodynamics	8,0	5,4	8,0	1,2				8,0
			Astronomy	2,0	1,8	2,0	0,6				2,0
			Structure of matter	6,0	3,9	6,0	0,3				6,0
			total	43,0	29,7	43,0	5,7	0,0	0,0	0,0	32,0

MK_2 (Mathematical tools)	K_W08 K_W12, K_W13 K_U14 K_U15 K_U16 K_U17 K_U18 K_K02	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Introduction to mathematics	6,0	4,2	6,0					
			Differential and integral calculus I	5,0	3,6	5,0					5,0
			Differential and integral calculus II	6,0	4,2	6,0					6,0
			Algebra with geometry	6,0	4,2	6,0					
			Statistical data analysis	5,0	3,6	5,0	1,8				
			total	28,0	19,8	28,0	1,8	0,0	0,0	0,0	11,0
MK_3 (Chosen problems of theoretical physics)	K_W10, K_W12, K_W17, K_W18, K_W20, K_U05, K_U09, K_U10, K_U11, K_U14, K_U15, K_U17, K_K02	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Elements of classical electrodynamics	6,0	3,6	6,0					6,0
			Elements of quantum mechanics	6,0	3,6	6,0					6,0
			total	12,0	7,2	12,0	0,0	0,0	0,0	0,0	12,0
MK_4 (Tools of computer science)	K_W14 K_W15 K_W16 K_U17 K_U19 K_U20 K_K01 K_K04	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Computer tools	3,0	2,4	3,0	1,2				
			Computer-aided computations	3,0	1,2	3,0	1,2				
			Programming I	5,0	3,0	5,0	1,8				
			Programming II	5,0	3,0	5,0	1,8				
			Algorithms and data structures	5,0	3,0	5,0	1,8				
			Numerical methods	5,0	3,0	5,0	1,8				
			total	26,0	15,6	26,0	9,6	0,0	0,0	0,0	0,0
MK_5 (Applications of physics in medicine and technology)	K_W11 K_U01 K_U02 K_U12 K_U13 K_U17 K_U19 K_K01 K_K03	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Electronics	5,0	3,6	5,0	1,8				
			Physics in medicine I	2,0	1,8	2,0					
			Physics in medicine II	2,0	1,8	2,0					
			Equipment of medical diagnostics and therapy	3,0	2,0	3,0	1,2				
			total	12,0	9,2	12,0	3,0	0,0	0,0	0,0	0,0

MK_6 (Practical and specialist education)	K_W01 K_W21 K_W22 K_W23 K_W24 K_U21 K_U22 K_U23 K_U25 K_K01 K_K02 K_03 K_K04 K_K06	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Elements of chemistry	3,0	2,4	3,0	0,6				
			Cell physiology and histology	3,0	2,4	3,0	0,0				
			Human anatomy and physiology	3,0	2,4	3,0	0,0				
			Introduction to biophysics	4,0	3,0	4,0	1,2				
			Radionuclids in medicine	3,0	2,4	3,0	0,6				
			Image diagnostics	2,0	1,8	2,0	0,6				
			Elements of histopatology	2,0	1,8	2,0	0,0				
			Radiation hygiene	2,0	1,8	2,0	0,0				
			total	22,0	18,0	22,0	3,0	0,0	0,0	0,0	0,0
MK_7 (General education)	K_W25 K_W27 K_W32 K_U22 K_U24 K_U32, K_U33 K_K01 K_K05 K_K03 K_K07	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Foreign language course	6,0	4,8	6,0			6,0		
			Physical excercises	0,0	0,0	0,0					0,0
			Ethic and law in medicine	1,0	1,0	1,0		1,0			
			Quality management	1,0	1,0	1,0		1,0			
			Basics of entepreneurship	2,0	2,0	2,0		2,0			
			History of physics	3,0	1,8	3,0		3,0			3,0
			Legal aspects of scientific and professional activity	1,0	1,0	1,0		1,0			
			total	14,0	11,6	14,0	0,0	8,0	6,0	0,0	3,0
MK_8 (Recapitulation of learning)	K_W01 K_W04,K_U01, K_U02,K_K01, K_K04, K_K03 K_K05, K_K06	Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Elements of contemporary phycics	3,0	1,8	3,0	1,2				
			Diplomma semminar	16,0	3,2	16,0	12,8				16,0
			total	19,0	5,0	19,0	14,0	0,0	0,0	0,0	16,0
MK_9 (Practical Training)		Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Practical Training	4,0	4,0	4,0	4,0			4,0	4,0
			total	4,0	4,0	4,0	4,0	0,0	0,0	4,0	4,0
MK_10 (Elective)		Egzamin lub zaliczenie w formie ustnej i/lub pisemnej lub indywidualny projekt zaliczniowy/egzaminacyjny lub zbiorowy projekt zaliczeniowy/egzaminacyjny.	Monographic lecture *	*a*	*a*						*a*
			Lecture on the other Faculty	*a*							*a*
			total								
			TOTAL NUMBER OF ECTS points for ALL MODULES	180,0	120,1	180,0	41,1	8,0	6,0	4,0	78,0

* refers to the fields that are not assigned to the disciplines of humanities or social sciences

a Number of the ECTS credits, time of realisation, type (lecture,excercise,etc) of subject depend on the offer

III PROPORTIONAL INDICATORS (percentage)

1. Percentage share of ECTS points for the classes that require direct participation of teachers or other people conducting classes:	67%
2. Percentage share of ECTS points earned for elective modules (min. 30%):	43%
3. Percentage share of ECTS points earned for the classes conducted in a foreign language (in a total number of ECTS points envisaged by the study programme):	a) 50%
4. Percentage share of ECTS points earned for the modules of classes shaping practical skills for practical educational profiles (above 50%):	nie dotyczy
5. Percentage share of ECTS points earned for the modules of classes connected with scientific activity conducted at the university in discipline/disciplines, to which the field of study is assigned for general academic profile (above 50%):	62,0%
6. Percentage shares of individual (all) discipline of science, which the study programme refers to: a) physical sciences	62,0%
b) astronomy	0,6%
c) automation, electronics and electrical engineering	1,4%
d) mathematics	12,4%
e) computer science	8,9%
f) biological sciences	3,6%
g) chemical sciences	1,7%
h) medical sciences	2,6%
i) legal sciences	1,1%
j) management and quality-control studies	1,3%
k) security and safety studies	0,3%
l) physical education	0,0%
m) language studies	3,3%
n) history	0,8%

IV. CONDITIONS OF GRADUATION AND CONFERRED PROFESSIONAL TITLE

Student is obliged to get at least 180 ECTS credits and pass a bachelor's exam.

Course of Study - Part B

1. *Name of Discipline: Physics*
2. *Level of Study: undergraduate studies*
3. *Educational Profile: general*
4. *Specification: Physics in medicine*

PROGRAM CONTENT OF MODULES

MK_1 (Foundations of physics)

The module includes 503 didactic hours, including 195 hours of lectures, 165 hours of colloquium seminars, and 143 hours of laboratories. The module is assigned 43 ECTS credits. Subjects included in the module (1. Introduction to Physics, 2. Classical Mechanics, 3. Analysis of Experimental Uncertainty, 4. Electricity and Magnetism with Optics, 5. Thermodynamics, 6. Astronomy, 7. Structure of Matter) are implemented in semesters 1-5.

1. Introduction to Physics (lecture, colloquium seminar, laboratory): Introduction to basic physical phenomena, the scientific method in physics, and basic physical quantities and their units. Conservation laws in physics. Classical and quantum physics. The lectures are supplemented by demonstrations related to the subject matter under study. During laboratory hours, students conduct basic experiments and prepare reports including analysis of measurement uncertainty.

2. Classical Mechanics (lecture, colloquium seminar, laboratory): Basic concepts, laws, and physical theories based on classical physics (formal mechanics of material points and rigid bodies, basic conservation laws in nature, gravitational forces, statics and dynamics of fluids, elastic waves. Understanding of the importance of physical experiments as a way of verifying theoretical concepts. Lectures are supplemented by demonstrations, calculational exercises, and laboratory work, during which, students individually conduct mechanical experiments of low level of complexity.

3. Analysis of Experimental Uncertainty (lecture, laboratory): Current methods of presenting measurement results and estimation of uncertainty of results, with the inclusion of elements of statistical data analysis. Methods of presenting measurement findings, introduction to methods of testing of statistical hypothesis. Lectures are supplemented with practical laboratory work including computer tools.

4. Electricity and Magnetism with Optics (lecture, colloquium seminar, laboratory): Basic concepts and formalism connected with description of electric, magnetic and electromagnetic field sources. Basic electromagnetic phenomena. Laws of electric current flow. Formation of optical images, including the consequences of the wave nature of light: reflection, refraction, coherence, interference, diffraction,

polarization, scattering, and other interactions of light and matter. Basic optical elements and their use in optical equipment. Optical transformations - the theory of image formation in microscopes. Holography. Lectures are supplemented with practical demonstrations, calculational exercises, and laboratory experiments connected with subject matter.

5. Thermodynamics (lecture, colloquium seminar, laboratory): Formalism, qualitative and quantitative methods of analysis of many-body systems. Laws of thermodynamics. Elements of statistical physics. Introduction to the physics of phase transitions. Lectures are supplemented with demonstrations, calculational exercises using computer tools as well as laboratory work.

6. Astronomy (lecture, laboratory): Introduction to contemporary astronomy. Basic concepts related to the Solar System, stars, galaxies, and cosmology. Lectures are supplemented with demonstrations and hands-on laboratory work at the Department's astronomical observatory. Students conduct individual astronomical observations at a basic level of complexity and solve mathematical problems.

7. Structure of Matter (lecture, colloquium seminar, laboratory): Introduction to nuclear and particle physics (basic understanding of atomic nuclei, selected nuclear models, nuclear transformations and reactions, radioactivity, origin of the elements, basic ideas of the Standard Model), physics of atoms and molecules (wave functions of the hydrogen atoms, magnetic moments of atoms, structure of multi-electron atoms), solid state physics (electronic band structure, superconductivity, chemical bounds, magnetic properties of solids) and basic interactions in nature. Lectures are supplemented with demonstrations, calculations and laboratory work.

MK_2 (Mathematical Tools)

This module includes 360 didactic hours, including 150 lecture hours, 165 colloquium seminar hours, and 45 hours of laboratory work. It is assigned 28 ECTS credits. Subjects included in the module (1. Introduction to mathematics, 2. Calculus I, 3. Calculus II, 4. Algebra and Geometry, 5. Statistical data analysis) are conducted in semesters 1-3.

1. Introduction to Mathematics (lecture, colloquium seminar): Selected concepts of elementary mathematics: calculations and relations of number systems, basics of logic and set theory - methodology of mathematical reasoning. Elements of analytical geometry. Complex numbers. Elements of combinatorial analysis. Introduction to probability calculus and mathematical statistics. Lectures are supplemented with calculational exercises: students individually solve problems in order to gain mathematical proficiency, develop critical thinking, and independent formulation of mathematical tasks.

2. Calculus I (lecture, colloquium seminar): The goal is to introduce students to basic analysis of functions of one real variable. The real number set and its subsets. Sequences and series. The base of natural logarithms. Functions of one real variable. Limits, continuity, differentiability. Derivatives of elementary functions. Derivatives of function compositions. Derivatives of inverse functions. Taylor series. Local and global extrema. Analysis of functions of one real variable. Indefinite integrals. Definite integrals (the Riemann integral). Approximate methods of computing integrals. The lectures are supplemented by calculational exercises with aimed at developing proficiency in using the tools of analysis to formulate and solve practical problems.

3. Calculus II (lecture, colloquium seminar): Functions of many variables and ordinary differential equations. Partial and directional derivatives. Local and global extrema of functions of two variables. Implicitly defined functions. Elements of the theory of curves in space. Curvature. Doble and triple integrals. Changes of variable, jacobians. Calculation of gradients, divergence and rotation. Line integrals (work, rotation). Surface integrals (flux). Theorems of Green, Gauss and Stokes. Solving first order differential equations. Solving linear ordinary differential equations with constant coefficients. Nonhomogenous linear equations. Systems of equations, matrix methods. Applications of differential equations in physics. Basics of Fourier series and transform.

4. Algebra and geometry (lecture, colloquium seminar): Basic constructions and problems of linear algebra, with particular emphasis on practical applications. Matrix spaces and algebra of real and complex matrices. Basic operations and properties. Classes of matrices. Determinants and matrix inversion. Systems of linear equations, classification and methods of solution. Geometric interpretation of solutions. Linear spaces, linear independence, bases, dimension. Components of vectors in a given basis. Coordinate transformations under basis transformations. Linear maps and their arrays. Properties of linear mappings. Euclidean and unitary spaces. Orthogonalization of bases of vector spaces. Diagonalization of self-adjoint mappings - orthogonal projections and spectral decompositions. Dual spaces, multilinear mappings, elements of tensor algebra projections, tensor base basis - mathematical basis of the Dirac calculus. Selected applications of algebra: the homomorphism SU(2) and SO (3). CCR Algebra. Lectures are supplemented with calculational exercises, with the goal of developing proficiency in use of algebra to formulate and solve practical problems.

5. Statistical data analysis (lecture, laboratory): Further development of probability and mathematical statistics based on the experience acquired in the earlier course Introduction to Mathematics. Random events and probabilities (event space, set of random events, probabilistic measure, conditional probability, Bayes' formula,

event independence). One-dimensional random variables. The cumulative distribution function of a random variable. Discrete and continuous random variables - overview of basic distributions. Functions of a random variable. Random vectors (multidimensional random variables). Discrete and continuous random vectors. Marginal distribution. Functions of a random vector. Covariance and correlation coefficient of two random variables. Covariance matrix of a random vector. Main problems of statistical inference. Basic concepts. Probability distributions in statistics. Point estimation. Properties of point estimators. Methods of constructing estimators. Interval estimation. Construction of confidence intervals for expectation value and variance. Testing of statistical hypotheses (verification of selected hypotheses on expected value, variance, expected value, variance of two normal distributions, verification of hypothesis on distribution form: chi-squared and Kolmogorov compliance tests). Lectures are supplemented with laboratory work, during which students solve and analize simulated problems and real data using appropriate computer software.

MK_3 (Selected Problems of Theoretical Physics)

The module includes 120 didactic hours, including 60 hours of lectures and 60 hours of colloquium seminars. It is assigned 12 ECTS credits. Subjects included in the module (1. Elements of classical electrodynamic. 2. Elements of quantum mechanics) are executed in semesters 4-5.

1. Elements of classical electrodynamics (lecture, colloquium seminar): Coulomb's law for point charges and continuous distributions of electric charge. Gauss' law in the vacuum in the differential and integral form. Electrostatic potential. Work and energy in electrostatics. The properties of conductors within the framework of electrostatics. Electric current and charge conservation. Lorentz force. Biota-Savart Law. Ampere's law in differential and integral form. Static equations of Maxwell. Vector potential of the magnetic field. Electric and magnetic dipoles. Paramagnetism and diamagnetism. Dielectric polarization. Magnetization, induced currents. Ampere's law in magnetic materials. Magnetic domains, ferromagnetism phenomenon, hysteresis loop. Ohm's law, in field and potential formulations. Electromotive force, flux law. Electromagnetic induction, Faraday's law. Lenz Law - universal flux law. Mutual and self-induction of circuits. Maxwell's modification of Ampere's law. Maxwell equations with sources in vacuum and linear dielectric media. Maxwell's equations for potentials, gauge transformation, Lorentz condition. Electromagnetic waves in vacuum and in a linear dielectric medium. Lienard-Wiechert potentials for point charges. Electromagnetic field for point charge moving at constant velocity. Point charge radiation. Radiation of electric dipole. The lecture is supplemented with calculation exercises with the possibility of using computer tools.

2. Elements of quantum mechanics (lecture, colloquium seminar): Empirical basis. Photon polarization and probability. Wave function as probability amplitude. Superposition principle. State description at a fixed time. Time evolution and Schrödinger equation. Probability current. Physical quantities as operators. Hilbert space. Eigenfunctions and eigenvalues. Continuous and discrete spectra. Postulates of Quantum Theory. The harmonic oscillator. Angular momentum. Hydrogen atom. Dirac notation. Ehrenfest's theorem. Approximate methods. The lecture is supplemented with calculational exercises with the possibility of using computer tools.

MK_4 (Tools of Computer Science)

The module includes 315 didactic hours, including 75 hours of lectures and 340 hours of laboratory work. It is assigned 26 ECTS credits. The subjects included in the module (1. Computer Tools, 2. Computer Aided Calculations, 3. Programming I, 4. Programming II, 5. Algorithms and Data Structures, 6. Numerical Methods) are taught in semesters 1-5.

1. Computer Tools (lecture, laboratory): Classes introduce students to basic computer tools useful during scientific studies (not only related to physics). Students are introduced to free software (which can also be used at home) that can be used to write final thesis and reports, which can contain mathematical formulas, tables, graphs, and raster graphics. The tools will allow students to get acquainted with basic creation and modification of raster and vector graphics, quick creation of charts and their analysis (for example, error calculation). Students will be introduced to Linux/Unix operating system, which will be used during further studies. The goal of this course is to develop the awareness of IT (Systematization of IT concepts, differences between popular operating systems: Windows and Linux). Lectures are supplemented with practical applications in computer labs.
2. Computer Aided Calculations (lecture, laboratory): Calculations in computer algebra, algebra and mathematical analysis using Mathematica. Basic information about the Mathematica package. Numbers and variables. Lists, vectors and matrices. Fundamentals of graphics, animations. Solving problems in mathematical analysis. Elements of programming. Solving differential equations of first and higher orders. Solving systems of ordinary and partial differential equations. Orthogonal polynomials and Fourier series. Integral transformations. Examples of numerical calculations (solving equations, integration, searching for extrema, approximation and interpolation). Classes in the computer lab are closely correlated with practical problems encountered in courses taken concurrently.
3. Programming I (lecture, laboratory): Fundamentals of programming in a higher level language: C ++. Creating a program in C ++. Declaring and using variables. Arithmetic operators. Defining and using simple functions. Compound types (arrays, strings, pointers). Loops, relational expressions, conditional statements, and logical operators. Creation of functions, recursion. Memory models, namespaces, objects, and classes. Classes and inheritance.

4. Programming II (lecture, laboratory): Enhancements of programming techniques by working with objects. Students can choose to program in Java, C ++ or C / C++ robotics programming (Arduino, Raspberry Pi, simple electronics).
5. Algorithms and Data Structures (lecture, laboratory): Properties of selected algorithmic solutions and their implementation using advanced data structures in the object-oriented programming language C++. Ways to write algorithms. An overview of data structures and algorithms. Tables. Computational complexity. Simple sorting algorithms. Stacks and queues. Linked lists. Recursion. Advanced sorting algorithms. Binary trees. Stacks. Balanced binary trees. Non-binary trees. Hash tables. Graphs. Types of STL containers (C ++).
6. Numerical Methods (lecture, laboratory): Overview of selected methods of analysis, algebra and numerical probability, and their implementation using a higher level programming language. Numerical analysis (searching for zeros of a function of a single variable by the secant method, by bisection, by the Newton-Raphson method). Numerical integration (Newton-Cotes quadrature, Gauss quadrature). Minima of functions of multiple variables (conjugate gradient method, coupled gradient method, simulated annealing). Solving ordinary differential equations (Euler's method, multistep methods, implicit, leapfrog method, Runge-Kutta method, stability of algorithms). Differential equations (elliptic equations - relaxation method, hyperbolic equations - Lax method, parabolic equations - Crank-Nicholson method, stability of algorithms). Integral equations. Numerical Algebra (solving systems of linear equations by the Gauss-Jordan elimination method, LU decomposition, iterative methods). Systems of nonlinear equations (iterative methods). Eigenvalues and eigenvectors (Jacobi's Method for Symmetric Matrices). Fourier transform: differential, integration (convolution, correlation). Solving partial differential equations (split operator method). Numerical probability: generalized pseudorandom numbers, Monte Carlo integration, generation of pseudorandom numbers with non-uniform distributions (von Neumann and Metropolis algorithms), Monte Carlo method.

MK_5 (Application of physics in medicine and technology)

The module includes 180 didactic hours, including 105 hours of lectures and 75 hours of laboratory. It is assigned 12 ECTS credits. Subjects included in the module (1. Electronics, 2. Physics in medicine I, 3. Physics in medicine II, 4. Equipment of medical diagnostics and therapy) are conducted in semesters 4-6.

1. Electronics (lecture, laboratory): Students get acquainted with the basic electronic systems: analog and digital. These include: passive filters (e.g. RC); diodes; transistor amplifiers (BJT and FET); operational amplifiers; comparators and power supplies, as well as the physical bases of solid state electronics. The digital parts of course introduce elements of digital technique: gates, flip-flops, counters and (more complex) ADC and DAC converters. Students build circuits and take measurements of circuit variables using tools such as oscilloscopes, multimeters, and signal generators. Compare the measurements with the behavior predicted by mathematic models and explain the discrepancies;

2. Physics in medicine I (lecture): The lecture deals with physical issues that are relevant in the description of the functioning of the human body and in the methods of diagnosis and treatment. Issues of the mechanics of the human body (the forces subjected to muscles and bones in different situations, the issues related to the elasticity of different bodies), the flow problems in the human blood system using the fluid mechanics diffusion problems by neutral membranes and osmosis effect. Issues of electrical pulses in the nervous system (processes of electrical potential of the cell and its effect on the transport of ions in the body's cells) and electrical activity of the heart (use of ECG techniques for cardiac work) and the brain. Detection of weak magnetic fields accompanying electrical activity of humans. The problem of modeling biological processes using differential equations. Exponential growth and exponential population decline, coupling problems between different processes, and time constants of biological processes. Examples of application of the method of matching functional relations to experimental data and obtaining information about values of parameters characterizing the phenomenological data.
3. Physics in medicine II (lecture): Preliminary issues (development of diagnostic methods and medical therapy using physical phenomena. Selected issues of atomic nucleus physics (atomic nucleus properties, radioactive decays and transformations, cross-section quantity). The interaction of X and gamma radiation with matter. Impact of particles charged with matter. Calculation of the intensity of diffused and absorbed radiation (X and gamma). Energy losses of particles charged per unit of track length. Diagnostic methods using X-rays and nuclear radiation (radiography, computer tomography, scintigraphy, positron emission tomography). Therapeutic methods utilizing X-rays and nuclear radiation. Idea and application of nuclear magnetic resonance in medical diagnostics. Elements of physics of environmental hazards (noise, electromagnetic radiation, lighting, ionizing radiation). Modern (experimental) diagnostic and therapeutic methods (synchrotron radiation, laser use).
4. Equipment of medical diagnostics and therapy (lecture, laboratory): Basic tests of medical analytics and principles of operation of the equipment used in them (blood morphology, biochemistry, glucose in body fluids, use of polarimeter and urometer). Physical basics of electrocardiography. Physical basis of ultrasound. The physical basis of X-ray diagnostics with a detailed discussion of the operation of the X-ray machine. The basics of the X-ray scanner. Positron emission tomography. Use of magnetic resonance imaging in medical imaging. During the laboratory classes at medical institutions, students will learn basic practical tests of medical analytics, ECG, blood pressure measurement, ultrasonography. Students take sample X-ray pictures, use rehabilitation equipment to evaluate and treat patients (assessment of hand muscle strength, balance platform, podoscopy), and get acquainted with the apparatus for bone densitometry.

MK_6 Practical and Specialist Education

The module includes 345 didactic hours, including 200 lecture hours, 70 hours of colloquium seminars and 75 hours of laboratory work. It is assigned 22 ECTS credits. The subjects include (1. Elements of chemistry, 2. Cell physiology and histology, 3. Human

anatomy and physiology, 4. Introduction to biophysics, 5. Radionuclids in medicine, 6. Image diagnostics, 7. Elements of histopathology 8. Radiological safety) are conducted in semester 1-5.

1. Elements of chemistry (lecture, laboratory): Basic concepts and laws of chemistry. Materia, elements, relationships, definition, classification, characteristics, metabolism. Chemical compounds, aggregate, structural, electron, resonance; classification and nomenclature of compounds, basic chemical laws. Chemical reactions, kinetics of chemical reactions, action of catalysts, enzymes. Chemical equilibrium. Elements of chemical thermodynamics. Quantum-mechanical model of atoms. Periodic table of elements. Classification and characterization of chemical bonds. Intramolecular interactions. General characteristics of elements and inorganic compounds. Systematics and nomenclature of inorganic compounds. Chemical properties of oxides, peroxides and peroxides. Structure of water and ice. Hydrides - division and properties. Properties of acids and bases, use of selected acids and their salts. Hydrolysis of salt. Buffer solutions and their function in living organisms. The lecture is supplemented by classes in the chemistry laboratory
2. Cell physiology and histology (lecture, laboratory): Construction of prokaryotic and eukaryotic cells (essential features of plant and animal cells). Chemical cell components (water in the cell, properties of water molecules, functions, inorganic ions in the cell and their importance, low molecular weight organic compounds and macromolecules in the cell). Cellular metabolism - catabolic and anabolic reactions. Enzymes and activated energy carriers - structure and role in regulation of metabolic processes in the cell. Cellular photosynthesis and cellular respiration as examples of anabolic and catabolic reactions. Transport through the membrane and within cells. Intra-and intercellular communication. Genes as information carriers. DNA and chromosomes (DNA replication, DNA to protein, genetic code, gene expression control). Cell cycle and its regulation (cell division - mitosis and meiosis, aging and cell death). Differentiation of cells, formation of tissues, basic types of tissues in mammals. Body fluids (blood and bone marrow, blood group, Rh factor). Tissue renewal (stem cells, therapeutic cloning). Cancerous cells. Lecture supplemented with colloquium seminars.
3. Human anatomy and physiology (lecture, colloquium seminar): Tissues, organs, organ systems - the human body as a whole. Basic systems of the human body. Defenses of the human organism. Lecture supplemented with colloquium seminar classes.
4. Introduction to biophysics (lecture, colloquium seminar): Molecular biophysics (spatial structure of biopolymers, forces stabilizing their structure and intramolecular and intermolecular forces, hydrodynamic properties of macromolecules: translational and rotational diffusion, sedimentation, viscosity, cooperative interactions, methods used in macromolecular structure studies). Biophysics of biological membranes (structure and functions of membranes, basics of organization of lipid structures, liposomes as carriers of drugs, contrasting compounds, membrane protein characteristics). Mechanisms of transport of substances through biological membranes (passive and active transport, carriers and channels, channels and pathology, types of ATPase, P-glycoprotein, drug-resistant ATPase). The role of biological membranes in the xenobiotic

detoxification processes (cytochrome P450). Physical basics of biological processes (energy production and storage, structure and function of the respiratory chain and ATP synthase). Postulates of chemiosmotic theory (bioenergetics of normal and neoplastic cells, reception and transmission of information in the nervous system, molecular mechanism of cell signaling, ionotropic, metabotropic and kinase receptors: structure, function and regulation, death receptors and apoptosis). Free radicals (FR) and their origin in biological systems (mechanisms of oxidation of biomolecules, methods of free radical determination, role of free radicals in pathogenesis of diseases, use of substances producing FR for cancer). Characteristics of electromagnetic radiation and its interaction with matter (types and stages of photobiological processes, mechanisms of energy migration). Physico-chemical basics of photobiological processes (photoreceptors, vision process). Effects of ultraviolet radiation (ultraviolet radiation on lipids, proteins and nucleic acids, fatal, mutagenic and pathophysiological effects, mechanism of initiation of apoptosis by UV). Photomedicine (photopophysiology and phototherapy, photochemistry therapy, laser therapy in biology and medicine). Bioluminescence (biochemiluminescence on phagocyte activation and lipid oxidation, use of biochemiluminescence in diagnostics). Electric and magnetic fields (EMF) (constant and variable) and their characterizing values (low and high EMF influence on organisms, harmful and beneficial effects of EMF, use in medicine). Lecture supplemented with laboratory classes.

5. Radionuclids in medicine (lecture, colloquium seminar, laboratory): Fundamentals of radioisotope technology in medicine (radioactive natural and artificial isotopes, radioactive decay law, radioactive activity and its units, methods of obtaining and characterization of radioisotopes used in medicine, detection of ionizing radiation, radioiodictics of radionuclides). Radioisotope diagnostics in in vitro medicine (quantification of substances by isotope dilution, radioimmunoassay methods, activation analysis). In vivo radioisotope diagnostics (cellular transport and accumulation mechanisms, plasma imaging, single photon emission tomography (SPECT), positron emission tomography (PET), PET and SPECT, Characteristics of radionuclides (RN) used in PET and SPECT. Radiotherapy (interaction of ionizing radiation with matter, biological action of ionizing radiation). Bergony-Tribondeau law, critical organs, early and late effects of irradiation, stochastic and deterministic effects, water radiolysis, direct and indirect effects of ionizing radiation, lipid oxidation, proteins, nucleic acid damage, oxygen effect, cell cycle and mitotic death, apoptotic and necrotic death). Dosimetry (dosimetric units, dose and dose strength). Radiotherapy techniques (external beam - teleradiotherapy, intrahepatic source - brachytherapy, open source - radioisotope therapy). Characteristics of RN used in various radiotherapy techniques. Conventional radiotherapy. Hadron radiotherapy. pProton therapy. Neutron capture therapy (BNCT). Lecture supplemented with exercises and laboratory work.
6. Image diagnostics (lecture, laboratory): Radiological anatomy and radiological symptomatology of diseases. Imaging methods in the diagnosis of selected systems and organs. Image testing optimization procedures. Radiology symptomatology in oncology. Lecture supplemented with practical exercises in medical diagnostic laboratories.

7. Elements of histopathology (lecture, colloquium seminar): Techniques and methods used in pathomorphic research. Presentation of the Department of Pathomorphology in Białystok Center of Oncology. Selected medical conditions: retrograde and adaptive changes, inflammation of the peculiar and non-specific, circulatory disorders, general pathology of the tumors pre-neoplastic states. Selected benign epithelial and non-epithelial neoplasms. Selected epithelial malignancies. Selected non-epithelial malignancies. Hematopoietic and lymphatic neoplasms. Gynecological diagnostics. Non-digital cytodiagnostics. Lectures supplemented with practical exercises in medical diagnostic laboratories.
8. Radiological safety (lecture, colloquium seminar): Lectures and colloquium seminars on procedures and regulations of radiological protection conducted by the Inspectorate for Radiological Protection. Classes prepare for the IOR inspector examination. Introduction - basic concepts used in radiological safety. Review of selected issues in the field of natural and artificial radioactivity. Radiological protection of workers (division of work sites, categories of employees, rules for safe work with ionizing radiation, training, optimization of radiological protection, medical supervision, protection of pregnant women). Control of the work environment. Individual dose control (dosage control, dose control methods, exposure documentation, occupational exposure levels observed). Medical exposure and patient exposure (dose received for different types of studies and therapies, dose-response factors, patient radiological protection, protection of pregnant women, children and adolescents, liability of medical personnel). Conditions of safe use of ionizing radiation for all types of medical exposure. Testing of physical parameters of X-ray apparatus. Quality management system in X-ray diagnostics and surgical radiology. Organization of radiological protection in the Republic of Poland and its supervision. Radiological Protection Inspector (requirements for obtaining allowances, training and examinations, duties of the inspector). European Directives and their implementation in national legislation.

MK_7 General Education

The module includes 285 didactic hours, including 60 hours of lectures, 60 hours of practical exercises, 45 hours of colloquium seminars, and 120 hours of foreign language courses. It is assigned 14 ECTS credits. Subjects included (1. English language course, 2. Physical education, 3. Ethics and law in medicine, 4. Quality management, 5. Basics of entrepreneurship, 6. Legal aspects of scientific and professional activity, 7. History of physics) are taught in semesters 1-4 and 6.

1. English language course (lecture): Students participate in English language education appropriate for level B2.
2. Physical education (exercises): As specified by the Physical Education and Sports Studies Program (SWFiS). Students have the opportunity to choose a sports discipline.
3. Ethics and law in medicine (lecture): The lecture is to combine selected historical themes in medicine with its contemporary problems. During the lecture students will learn about the various dilemmas caused by progress. Normative systems and

their role in society; law and morality. Ethics as a branch of philosophy; concept of axiology, descriptive ethics, normative ethics, applied ethics, main ethical concepts. Medical and paramedical profession as a profession of public trust; norms in medicine: the legal and non-legal basis for their exercise. Doctor ethos in the context of deliberations on the Code of Medical Ethics - a historical outline of ethics in medicine and modern standards. Biotech development in the field of medicine and its implications from the point of view of human rights considerations. Concept and types of medical experiments on the human body. Contemporary moral and legal dilemmas implicated in the advancement of biotechnology in medicine.

4. Quality management (lecture): The aim of the course is to familiarize students with theoretical and practical aspects of quality management with particular emphasis on medical procedures. It will discuss the application of quality management concepts and tools as well as various approaches to quality management. The problems of integrated management will also be addressed.
5. Basics of entrepreneurship (lecture, colloquium seminar): The purpose of the course is to characterize entrepreneurial activities and their determinants, to define the way entrepreneurs and companies operate, to know the means and ways of supporting entrepreneurship and enterprises, and to present principles of undertaking business activity within an enterprise. Commercialization of research results. As part of the seminar, students discuss selected problems.
6. History of physics (colloquium seminar): The lecture presents the basic steps in the historical development of physics in connection with the development of civilization and technology. The beginnings of physics, astronomy and mathematics in antiquity. Medieval physics. Renaissance breakthrough in science. Seventeenth-century physics. Enlightening discoveries in the sciences. Development of natural science in the nineteenth century. The emergence of modern physics at the turn of the nineteenth and twentieth centuries. History of advanced physics of the twentieth century. Students select two topics from the list of suggestions presented by the lecturer for self-study and discussion during colloquium seminars.
7. Legal aspects of scientific and professional activity (lecture): Law in scientific and didactic activity, protection of industrial property, patent law.

MK_8 Review

The module includes 70 didactic hours, including 30 hours of laboratory work and 40 hours of seminars. It is assigned 19 ECTS credits. Subjects included are (1. Elements of contemporary physics, 2. Diploma seminar) are implemented in semesters 4 and 6.

1. Elements of contemporary physics (laboratory): Students are introduced to the subject of research conducted at the faculty of the Department of Physics. They receive proposals for thesis topics, determine the form and scope of tasks covered by their thesis.
2. Diploma seminar (seminar): The subject is related to the writing of the bachelor's thesis. Students participate in the seminar, present issues related to the topic of their thesis. The subject is implemented in close cooperation with the promoter of thesis.

MK_9 Practical Training (Internship)

The module includes 120 hours of apprenticeship following semester 4. Internship in health care units.

MK_10 Elective

The module includes 2 subjects, which do not have to be realized. The first one is the Monographic lecture which size is 30 hours of lecture and/or 15-30 hours of colloquium seminars/laboratories. The item is assigned min. 3 ECTS credits. The second subject is the Lecture on the other Faculty. The item is assigned min. 1 ECTS credits. The final number of ECTS credits, time and type of realization of both subjects depend on our (the first case) or another Faculty (the second case). Subjects included in the module (Monographic lecture, 2. Lecture on the other Faculty) are implemented in semester 1-6.

1. Monographic lecture (lecture or lecture+colloquium seminar/laboratory): Subject related to contemporary physics. Sample topics: X-ray and neutron methods in medicine, Synchrotron radiation and its use in science, Mössbauer spectroscopy, Bose-Einstein condensate, Analysis of surfaces and thin layers.
2. Lecture on the other Faculty (lecture or lecture+colloquium seminar): The list of realized subjects is given every year. Items are implemented, for example, by Faculty of Biology and Chemistry, Faculty of History and Sociology, Faculty of Philology.

The subject of your choice realized on the other Faculty: the item on the other Faculty (from the module elective).

The subject of your choice realized on the Faculty of Physics: The students are allowed to change the subjects during study according rules mentioned below in the table. A student will declare the change in the first two weeks. Dean seems to agree and the subject is placed in the student's study program and becomes mandatory. List of subjects that can be chosen by student is below.

List of subjects that can be chosen by student

Students are allowed to change the subject into the second one according rules

Academic year	Subjects on specification Physics in Medicine	ECTS	It can be changed by a subject on specification Physics in Medicine	ECTS	It can be changed by a subject on specification Physics in Computer Games and Robots	ECTS	It can be changed by a subject on specification Physics (general)	ECTS
1	Differential and integral calculus I – sem.1 + Differential and integral calculus II – sem.2	5+6					Analysis I – sem.1 + Analysis II – sem.2	8+7
	Classical Mechanics – sem.2	8					Classical Mechanics – sem.2	10
2	Electricity and magnetism with optics – sem.3	8					Electricity and Magnetism – sem.3	10
	Thermodynamics – sem.3	8					Thermodynamics – sem.3	10
	Elements of Classical Electrodynamics – sem.4	6					Elements of Classical Electrodynamics – sem.4	9
	Astronomy – sem.4	2			Introduction to astronomy – sem.4	2	Astronomy – sem.5	3
	Practical Training – sem.4	4	Practical Training – sem.4	4				
3	Structure of Matter – sem.5	6					Structure of Matter – sem.5	8
	Elements of Quantum Mechanics – sem.5	6					Elements of Quantum Mechanics – sem.5	9
	History of physics – sem.6	3			History of science – sem.5	3		
	Diploma seminar – sem.6	16	Diploma seminar – sem.6	16				

UNIVERSITY OF BIALYSTOK

FACULTY: Faculty of Physics

scientific discipline: Physics

specialization: Medical physics

educational profile: General academic

form of study: Full-time, stationary

STUDY PLAN

COURSE: Physics

level of education: first degree study

effective from the academic year: 2019/2020

item	MODULE NAME/COURSE NAME	USOS course code	ECTS	Exam after the sem.	Credit after the sem.	Number of classes								I year						II year						III year								
														1 sem.			2 sem.			3 sem.			4 sem.			5 sem.			6 sem.					
						TOTAL	LECTURES	EXERCISES	COLLOQUIUM SEMINAR	LABS	LANGUAGE COURSES	SEMINARS/ PROSEMINARS	FIELD TRIPS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32			
MODULE 1 (Foundation of physics)																																		
1	Introduction to physics		9	1	1	**105**	45		45	15				45	60	9																		
2	Classical Mechanics		8	2	2	**90**	30		30	30							30	60	8														
3	Analysis of Experimental Uncertainty		2		2	**30**	15			15							15	15	2														
4	Electricity and magnetism with optics		8	3	3	**90**	30		30	30										30	60	8											
5	Thermodynamics		8	3	3	**90**	30		30	30										30	60	8											
6	Astronomy		2		4	**30**	15			15													15	15	2								
7	Structure of matter		6	5	5	**68**	30		30	8																30	38	6					
TOTAL			**43**			**503**	**195**		**165**	**143**				**45**	**60**	**9**	**45**	**75**	**10**	**60**	**120**	**16**	**15**	**15**	**2**	**30**	**38**	**6**					
MODULE 2 (Mathematical tools)																																		
1	Introduction to mathematics		6	1	1	**75**	30		45					30	45	6																		
2	Differential and integral calculus I		5	1	1	**60**	30		30					30	30	5																		
3	Differential and integral calculus II		6	2	2	**75**	30		45								30	45	6														
4	Algebra with geometry		6	2	2	**75**	30		45								30	45	6														
5	Statistical data analysis		5	3	3	**75**	30			45										30	45	5												
TOTAL			**28**			**360**	**150**		**165**	**45**				**60**	**75**	**11**	**60**	**90**	**12**	**30**	**45**	**5**												
MODULE 3 (Chosen problems of theoretical physics)																																		
1	Elements of classical electrodynamics		6	4	4	**60**	30		30														30	30	6								
2	Elements of quantum mechanics		6	5	5	**60**	30		30																	30	30	6					
TOTAL			**12**			**120**	**60**		**60**														**30**	**30**	**6**	**30**	**30**	**6**					
MODULE 4 (Tools of computer science)																																		
1	Computer tools		3		1	**45**	15			30				15	30	3																		
2	Programming I		5		2	**60**	15			45							15	45	5														
3	Computer-aided computations		3		3	**30**				30											30	3											
4	Programming II		5		4	**60**	15			45													15	45	5								
5	Algorithms and data structures		5		5	**60**	15			45																15	45	5					
6	Numerical methods		5	5	5	**60**	15			45																15	45	5					
TOTAL			**26**			**315**	**75**			**240**				**15**	**30**	**3**	**15**	**45**	**5**		**30**	**3**	**15**	**45**	**5**	**30**	**90**	**10**					

item	MODULE NAME/COURSE NAME	USOS course code	ECTS	Exam after the sem.	Credit after the sem.	Number of classes								I year						II year						III year					
														1 sem.			2 sem.			3 sem.			4 sem.			5 sem.			6 sem.		
						TOTAL	LECTURES	EXCERCISES	COLLOQUIUM SEMINAR	LABS	LANGUAGE COURSES	SEMINARS/ PROSEMINARS	FIELD TRIPS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS	LECTURES	EX/CS/L/LC/S&P/FT	ECTS
MODULE 5 (Application of physics in medicine and technology)																															
1	Electronics		5		4	**75**	30			45													30	45	5						
2	Physics in medicine I		2		5	**30**	30																			30		2			
3	Physics in medicine II		2		6	**30**	30																						30		2
4	Equipment of medical diagnostics and therapy		3		6	**45**	15			30																			15	30	3
TOTAL			**12**			**180**	**105**			**75**													**30**	**45**	**5**	**30**		**2**	**45**	**30**	**5**
MODULE 6 (Practical and specialist eduction)																															
1	Elements of chemistry		3	1	1	**45**	30			15				30	15	3															
2	Cell physiology and histology		3	3	3	**45**	30		15											30	15	3									
3	Human anatomy and physiology		3	4	4	**45**	30		15														30	15	3						
4	Introduction to biophysics		4	4	4	**60**	30			30													30	30	4						
5	Radionuclids in medicine		3		5	**45**	15		15	15																15	30	3			
6	Image diagnostics		2		5	**45**	30			15																30	15	2			
7	Elements of histopatology		2		5	**30**	20		10																	20	10	2			
8	Radiation hygiene		2		4	**30**	15		15														15	15	2						
TOTAL			**22**			**345**	**200**		**70**	**75**				**30**	**15**	**3**				**30**	**15**	**3**	**75**	**60**	**9**	**65**	**55**	**7**			
MODULE 7 (General education)																															
1	Foreign language course		6	2	1,2	**120**					120				60	3		60	3												
2	Physical excercises		0		2,4	**60**		60										30	0					30	0						
3	Ethic and law in medicine		1		3	**15**	15													15		1									
4	Quality management		1		4	**15**	15																15		1						
5	Basics of entepreneurship		2		6	**30**	15		15																				15	15	2
6	History of physics		3		6	**30**			30																					30	3
7	Legal aspects of scientific and professional activity		1		6	**15**	15																						15		1
TOTAL			**14**			**285**	**60**	**60**	**45**		**120**				**60**	**3**		**90**	**3**	**15**		**1**	**15**	**30**	**1**				**30**	**45**	**6**
MODULE 8 (Recapitulation of learning)																															
1	Elements of contemporary phycics		3		4	**30**				30														30	3						
2	Diploma seminar		16		6	**40**						40																		40	16
TOTAL			**19**			**70**				**30**		**40**												**30**	**3**					**40**	**16**
MODULE 9 (Practical Training)																															
1	Practical Training		4		4	**120**																		120	4						
TOTAL			**4**			**120**																		**120**	**4**						
MODULE 10 (Elective)																															
1	Monographic lecture		*a*																												
2	Lecture on the other Faculty		*b*																												
TOTAL																															
TOTAL			**180**			**2298**	**965**	**60**	**505**	**608**	**120**	**40**		**150**	**240**	**29**	**120**	**300**	**30**	**135**	**210**	**28**	**180**	**375**	**35**	**185**	**213**	**31**	**75**	**115**	**27**
						Average number of lesson hours per week								10	16		8	20		9	14		12	25		12	14		5	8	
														26			28			23			37			27			13		
						number ex./cr.								4	6		4	6		4	6		3	10		3	8			6	

a Number of the ECTS credits, realisation time, type (lecture, excercise, etc) depend on the offer of the Faculty. Min. ECTS = 3.

b Number of the ECTS credits is determined by the other Faculty. Min. ECTS = 1.