Appendix 2 of the Act number 167
Physics Faculty Council, University of
Bialystok, May 29th, 2017.

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 300 didactic hours, including 75 hours of lectures, 30 hours of practical exercises, 75 hours of colloquium seminars, and 120 hours of foreign language courses. It is assigned 16 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**				