MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
Educational Institution
BELARUSIAN STATE MEDICAL UNIVERSITY

APPROVED
by Rector of the Educational Institution «Belarusian State Medical University»
_____ S.P.Rubnikovich
24.06.2023
Reg. # UD-091-033/2324/edu.

Контрольный экземпляр

BIOMEDICAL PHYSICS

Curriculum of the educational institution in the academic discipline for the specialty

7-07-0912-01 «Pharmacy»

2023

Curriculum is based on the educational program «Biomedical Physics», approved 27.06.2023, registration # УД-091/033/2324/уч.; on the educational plan in the specialty 7-07-0912-01 «Pharmacy», approved 17.05.2023, registration # 7-07-0912-01 /2324/mf.

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RECOMMENDED FOR APPROVAL:

by the Department of the Medical and Biological Physics of the educational institution «Belarusian State Medical University»
(protocol # 10 of 18.05.2023);

by the Scientific and Methodological Council of the educational institution «Belarusian State Medical University»
(protocol # 6 of 27.06.2023)

EXPLANATORY NOTE

«Biomedical Physics» is an academic discipline of the Natural Science Module, which contains systematized scientific knowledge about the physical properties and phenomena in the whole human body, its individual organs, tissues, cells, as well as the physical and chemical foundations of life processes.

The aim of the discipline «Biomedical Physics» i s the formation of basic professional competence for the student application of scientific knowledge about the physical foundations of the structure and living organism function under identification and evaluation of medicine quality indicators using physical methods.

The objectives of the discipline «Biomedical Physics» are to form students' scientific knowledge about the physical properties and phenomena in the human body, the latest physical discoveries and the prospects for their use in professional activities, the skills necessary for:

the work with the physical devices used in pharmacy;

the physical methods of identification and evaluation of medicine quality indicators;

the interpretation of the experimental results.

The knowledge, skills, and abilities acquired during the study of the academic discipline «Biomedical Physics» are necessary for successful mastering of the following academic disciplines: «Analytical Chemistry», «Physical and Colloidal Chemistry», «Pharmaceutical Chemistry», «Pharmacognosy».

Studying the educational discipline «Biomedical Physics» should ensure the formation of students' basic professional competency:

BPC. Apply knowledge of the basic physical, chemical and biological laws for quality control of medicines and medicinal plant raw materials.

As a result of studying the discipline «Biomedical Physics» the student should

know:

the fundamental principles and laws of physics;

the action mechanisms of physical factors on living organisms.

be able to:

investigate the physical properties of substances and determine their physical characteristics.

master:

methods for measuring the values of physical quantities;

skills in using instruments and equipment for physical analysis of substances;

methodology for estimating measurement errors.

Total number of hours for the study of the discipline is 207 academic hours. Classroom hours according to the types of studies: lectures - 26 hours (including 9 hours of supervised student independent work), laboratory classes - 75 hours, practical classes –15, student independent work (self-study) – 91 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (1 semester), examination (2 semester).

Form of higher education – full-time.

ALLOCATION OF ACADEMIC TIME ACCORDING TO SEMESTERS OF STUDY

Code, name of the specialty	semester	Number of academic hours						Form of intermediate assessment
		total	in-class	including			out-of-class self-studies	
				lectures (including supervised independent work)	supervised student independent work	laboratory and practical classes		
7-07-0912-01 «Pharmacy»	1	**112**	59	14	4	45	53	credit
	2	**95**	57	12	5	45	38	examination

THEMATIC PLAN

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
1. Introduction to the discipline «Biomedical physics». Mathematical modeling of biomedical and pharmaceutical processes. Mechanics	**2**	**-**	**21**
1.1. Physics and biomedical physics, subject and methods. Introduction to the work-shop	-	-	3
1.2. Mathematical modeling of biomedical and pharmaceutical processes. Study of the functional relationships. Determination of the rates of function change and gradient of function	-	-	6
1.3. Elements of probability theory. Random variables, their distributions and numerical distribution characteristics	-	-	3
1.4. Fundamentals of mathematical statistics. Sampling procedure. Methods of distribution parameters calculation. Graphical representation of a statistical distribution. Elements of correlation analysis. Determination of a correlation between two sets of random variables	-	-	3
1.5. Methods of body mass measurement	-	-	3
1.6. Mechanical oscillations. Oscillations decomposition into a harmonic spectrum	1	-	-
1.7. Mechanical waves. Energy characteristics of a mechanical wave		-	-
1.8. Acoustics. Biophysical basics of the acoustic sensation formation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasound methods of the examination and treatment in medicine	1	-	3
2. Molecular physics	**4**	**-**	**9**
2.1. General properties and features of the molecular structure of liquids. Molecular motion in liquids. The phenomenon of transport in liquids. Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination	1	-	3
2.2. Distribution of blood pressure and velocity in the vascular system. Physical basics of hemodynamics	1		
2.3. Surface tension	1	-	3
2.4. Elastic bodies. Elastic properties of solids. Determination of the elasticity modulus of materials	1	-	3

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
3. Cell biophysics. Biological processes modeling	**4**		**6**
3.1. Physical properties of biological membranes. Substance transport across biological membranes	2	-	1
3.2. Resting biopotentials and their ionic nature. Formation of cell membrane potentials during its excitation	1	-	1
3.3. Generation and propagation of action potential	1	-	4
4. Electricity and magnetism	**4**	**6**	**15**
4.1. Physical basis of electrography of human tissues and organs	1	-	3
4.2. Methods of biomedical information monitoring. Sensors	1	-	3
4.3. Amplification of bioelectrical signals	-	-	3
4.4. Alternating current. Various loads in the AC circuit. Living tissue impedance to alternating current. Physical basis of rheography	1	-	3
4.5. Characteristics of impulse currents. Physical basis of tissue and organ electrostimulation	1	-	-
4.6. Effect of high-frequency current and field on the human organism. The use of UHF oscillations in medicine. Study of the methods and equipment for high-frequency therapy	-	6	3
5. Optics	**4**	**-**	**21**
5.1. Electromagnetic oscillations and waves	1	-	3
5.2. Refraction and refractometry	-	-	3
5.3. Optical microscopy. Fundamentals of electron and scanning probe microscopy	-	-	3
5.4. Optical system of the eye. Biophysical foundations of vision	-	-	3
5.5. Laws of light absorption and light scattering. Fundamentals of photocolorimetry and spectrophotometry	1	-	3
5.6. Atomic and molecular spectra. Emission and absorption spectra. Spectral instruments	1	-	3
5.7. Stimulated emission. Lasers. The effect of laser radiation on biological tissues	1	-	3
6. Physics of atoms and molecules	**4**	**6**	**-**
6.1. Thermal radiation	1	-	-

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
6.2. Luminescence. Types and basic characteristics of luminescence	1	-	-
6.3. X-rays	2	6	
7. Nuclear physics	**4**	**3**	**3**
7.1. Radioactivity	1	1	-
7.2. Interaction of ionizing radiation with matter	1	-	-
7.3. Radiation dosimetry	2	2	3
Total hours	**26**	**15**	**75**

CONTENT OF THE EDUCATIONAL MATERIAL

1. Introduction to the discipline «Biomedical physics». Mathematical modeling of biomedical and pharmaceutical processes. Mechanics

1.1. Physics and Biomedical physics, subject and methods. Introduction to the workshop

Aims and objectives of studying the academic discipline «Biomedical Physics». The role of biomedical physics as a fundamental science in the knowledge of the surroundings.

1.2. Mathematical modeling of biomedical and pharmaceutical processes. Study of the functional relationships. Determination of the rates of function change and gradient of function

The derivative of a function as a measure of the process rate, its geometric and physical interpretation, the rules for finding, gradients. Higher-order derivatives. The use of derivatives to study an extremum of functions. Function differential of a single variable. Partial derivatives and total differential of multivariable functions. Body state as a multivariable function. Antiderivative function and indefinite integral. The definite integral, its application for calculating the areas of figures and the work of a variable force. Methods for finding indefinite and definite integrals. Newton-Leibniz formula. The concept of ordinary differential equations. General and particular solutions. Integration of the differential equations with separable variables. Examples of compiling mathematical models of medical and biological processes (bacterial growth, accumulation and drug clearance, radionuclides, etc.).

1.3. Elements of probability theory. Random variables, their distributions and numerical distribution characteristics

Random events, their types. Probability of a random event. Probabilistic nature of biomedical processes. Probabilities addition and multiplication rules, Bayes formula. Principles of probabilistic approaches to the problems of diagnosis and prediction of diseases. Discrete and continuous random variables, their laws of distribution. Numerical parameters of random variables distributions: expectation,

mode, median, variance, standard deviation. Examples of various laws of random variables distribution. Normal law of distribution and its properties.

1.4. Fundamentals of mathematical statistics. Sampling procedure. Methods of distribution parameters calculation. Graphical representation of a statistical distribution. Elements of correlation analysis. Determination of a correlation between two sets of random variables

General population and sample. Variational and interval statistical series. Graphical representation of the sample: frequency polygon and histogram. Estimation of the general population parameters according to the sample parameters. Medical data processing methods. Processing of the results of direct and indirect measurements of physical quantities. Elements of correlation analysis. Plotting a correlation field, regression line and calculation of the correlation coefficient.

1.5. Methods of body mass measurement

The study of weight measuring instruments, their classification. Prospects for the application of the acquired knowledge in the study of pharmaceutical disciplines.

1.6. Mechanical oscillations. Oscillations decomposition into a harmonic spectrum

Free, damped and forced mechanical oscillations. Forced oscillations. Resonance. Auto oscillations. Harmonic oscillations. Energy of harmonic oscillations. The superposition of harmonic oscillations directed along straight line. Complex oscillation and its harmonic spectrum, Fourier's theorem. Application of harmonic analysis for processing diagnostic data.

1.7. Mechanical waves. Energy characteristics of a mechanical wave

Types of mechanical waves. Kinematic and differential equations of a mechanical wave. Energy flux, intensity (energy flux density).

1.8. Acoustics. Biophysical basics of the acoustic sensation formation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasound methods of the examination and treatment in medicine

Characteristics of the auditory sensation and their relationship to the physical characteristics of sound. Audition diagram. Weber-Fechner law. Reflection and absorption of sound waves. Acoustic impedance. Audiometry. Registration of the spectral characteristics of ear sensitivity at the threshold of hearing. Methods for obtaining ultrasonic oscillations. Features of propagation and action of ultrasound on matter. Biophysical foundations of the ultrasound action on cells and tissues of the human body. Surgical and therapeutic applications of ultrasound. Cavitation. The use of ultrasonic oscillations in biology, medicine and pharmacy. Doppler effect and its application for non-invasive measurement of blood flow velocity.

2. Molecular physics

2.1. General properties and features of the molecular structure of liquids. Molecular motion in liquids. The phenomenon of transport in liquids. Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination

Fundamental concepts of hydrodynamics. Bernoulli's equation. Viscosity of a liquid. Newton's equation. Newtonian and non-Newtonian fluids. Viscous fluid flow. Poiseuille's formula. Hydraulic resistance. Laminar and turbulent flow. Reynolds

number. Methods of Stokes, Ostwald, rotational method for determining the liquid viscosity. The Ostwald viscometer construction. The use of Ostwald viscometer to determine the liquid viscosity. Investigation of the liquid viscosity dependence on temperature.

2.2. Distribution of blood pressure and velocity in the vascular system. Physical basics of hemodynamics

Rheological properties of blood. Factors affecting blood viscosity in the human body. Measuring methods of pressure and blood flow velocity. The role of vascular elasticity, pulse wave. Heart work and heard power.

2.3. Surface tension

Physical fundamentals of the surface tension phenomenon. Coefficient of surface tension and methods for its determination. Capillary phenomena, their significance in biological systems. Pressure excess across a curved liquid interface. Laplace's formula. Gas embolism. Surface-active material. Adsorption. The use of surface-active materials in pharmacy.

2.4. Elastic bodies. Elastic properties of solids. Determination of the elasticity modulus of materials

Elastic bodies. Elastic properties of solids. Hooke's law. Young's modulus. Crystalline bodies. Types of crystal lattices. Amorphous and liquid-crystalline state of matter. Elastic, viscous and viscoelastic media, their mechanical characteristics and models. Mechanical properties of bone tissue, muscles, tendons, vessel walls.

3. Cell biophysics. Biological processes modeling

3.1. Physical properties of biological membranes. Substance transport across biological membranes

Biophysics of the cell. Structure and main functions of biomembranes. Model lipid membranes. Liposomes: application in pharmacy. Membrane research methods (nuclear magnetic resonance, electron paramagnetic resonance, fluorescent and spin probes, electron microscopy, infrared spectroscopy, X-ray diffraction analysis). Transport of substances across biological membranes. Transfer phenomena. General transport equation. Passive transport. Mathematical description of passive transport of substances. Theorell's equation. Diffusion. Simple and facilitated diffusion, osmosis, filtration. Physical methods for studying the substance transfer through membranes. Active transport. Molecular organization of the membrane system of active transport on the example of the sodium-potassium pump.

3.2. Resting biopotentials and their ionic nature. Formation of cell membrane potentials during its excitation

Nernst's equation. The Goldman-Hodgkin-Katz equation for the resting membrane potential.

3.3. Generation and propagation of action potential

Propagation of the action potential along unmyelinated and myelinated axons. Modeling of biological processes as a method of inquiry.

4. Electricity and magnetism

4.1. Physical basis of electrography of human tissues and organs

Electrocardiography. Einthoven's theory. Formation of the electrocardiogram, its form. Determination of the amplitude and time parameters of the ECG.

4.2. Methods of biomedical information monitoring. Sensors

The dependence of metal and semiconductor resistance on temperature. Thermoelectric phenomena. Contact potential difference. Thermoelectromotive force. Thermocouple. The Peltier phenomenon. Thermocouple and thermistor calibration.

4.3. Amplification of bioelectrical signals

Determination of the frequency (bandwidth) and amplitude (dynamic range) characteristics of the amplifier. Differential amplifier.

4.4. Alternating current. Various loads in the AC circuit. Living tissue impedance to alternating current. Physical basis of rheography

Ohmic, inductive and capacitive resistance in an alternating current circuit. Total resistance (impedance) in a circuit with a series connection of a resistor, coil and capacitor. Biological tissue impedance. Equivalent electrical circuit of living tissue. Assessment of tissue viability. Rheography.

4.5. Characteristics of impulse currents. Physical basis of tissue and organ electrostimulation

Impulse currents and their characteristics. Determination of the parameters of pulse currents (pulse duration, frequency, duty cycle) using an oscilloscope. Electrical excitability of tissues, rheobase, chronaxia. Weiss-Lapic equation, Dubois-Reymond law. The study of the apparatus of amplipulse therapy. Types of electrical stimulation of the heart.

4.6. Effect of high-frequency current and field on the human organism. The use of UHF oscillations in medicine. Study of the methods and equipment for high-frequency therapy

Physical basis of diathermy, local d'arsonvalization, inductothermy, ultra-high-frequency therapy, microwave therapy. Dielectrics and electrolytes heating under an ultrahigh frequency field apparatus.

5. Optics

5.1. Electromagnetic oscillations and waves

Electromagnetic wave equation. Electromagnetic spectrum. Natural and polarized light. Methods for obtaining polarized light based on the phenomena of Brewster, birefringence, absorption dichroism. Brewster's Law. Polaroids. Malus' law. Optical activity of a substance. Determination of the concentration of optically active substances with a polarimeter. Wave properties of light.

5.2. Refraction and refractometry

Laws of reflection and refraction of light. Construction of refractometer. Determination of the solution concentration by a refractometer. The phenomenon of total internal reflection of light, the principles of fiber optics, the design of modern endoscopes. Interaction of electromagnetic radiation with matter. Dispersion of light.

5.3. Optical microscopy. Fundamentals of electron and scanning probe microscopy

Optical microscope, ray tracings, magnification. Methods of optical microscopy. Resolution and resolution limit of optical microscopes. Abbe formula. Fundamentals of an electron microscopy. De Broglie's wavelength. Resolution limit of the electron microscope. Determination of the linear dimensions of micro-objects by an optical microscope. Atomic force microscopy.

5.4. Optical system of the eye. Biophysical foundations of vision

Eye accommodation. The eye refraction defects and eyesign improvement. Eye sensitivity to light and color. The mechanism of eye adaptation to different illumination. Biophysical foundations of visual photoreception.

5.5. Laws of light absorption and light scattering. Fundamentals of photocolorimetry and spectrophotometry

Light absorption. Lambert–Beer–Bouguer law. Laws of light absorption by matter. Linear decay constant of a substance, its dependence on the wavelength and the solution concentration. Molar extinction coefficient.Transmittance and optical density, their dependence on wavelength and concentration. Colorimetry. Construction of a photoelectrocolorimeter. Determination of the solution concentration with the photoelectrocolorimeter. Light scattering. Tyndall effect. Molecular scattering. Rayleigh's law. Nephelometry.

5.6. Atomic and molecular spectra. Emission and absorption spectra. Spectral instruments

Bohr's theory. Emission and absorption spectra. The spectrum of the hydrogen atom. Fundamentals of atomic and molecular spectral analysis. Calibration of the spectroscope by mercury lamp radiation and study of the absorption spectra of blood hemoglobin.

5.7. Stimulated emission. Lasers. The effect of laser radiation on biological tissues

Stimulated emission and its properties. The construction of optical quantum generators - lasers. Laser radiation properties, its use in medicine. The use of lasers in medicine. Photodynamic therapy. Diffraction of light. Determining the laser wavelength and small objects size from the diffraction pattern.

6. Physics of atoms and molecules

6.1. Thermal radiation

The main characteristics of thermal radiation. The laws of thermal radiation (Kirchhoff's law, Stefan-Boltzmann's law, Wien's displacement law). Planck's formula. Thermal radiation of the human body. The use of infrared imagery and thermography in medicine.

6.2. Luminescence. Types and basic characteristics of luminescence

Photoluminescence. Quantum yield, the delay time. Stokes and Vavilov laws. Luminescence of biological systems. Luminescent analysis.

6.3. X-rays

X-rays properties. Bremsstrahlung and characteristic x-rays. Moseley's law. X-rays spectra. Interaction of X-rays with matter. X-ray diffraction analysis. The use of x-rays in diagnostics and radiotherapy. Fundamentals of x-ray computed tomography.

7. Nuclear physics

7.1. Radioactivity

The fundamental law of radioactive decay. Activity of radioactive preparations. The main types of radioactive decay.

7.2. Interaction of ionizing radiation with matter

Characteristics of the ionizing radiation interaction with matter: linear specific ionization, linear energy transfer, mean linear range. Biological effects of radiation. Protection against ionizing radiation.

The use of ionizing radiation to study the substance structure and the cell properties. Radionuclide methods of diagnostics and radiation therapy.

7.3. Radiation dosimetry

Exposure, absorbed and equivalent doses, the relationship between them and their units. Effective equivalent dose, tissue weighting factor. Collective effective dose. Dose rate. Ionizing radiation detectors. Dosimeters The construction of dosimeters and radiometers. Determination of exposure rate. Biological and effective half-live times of radionuclides from the human body.

ACADEMIC DISCIPLINE CURRICULAR CHART

Section, topic #	Section (topic) name	number of hours				Self-studies	Form of control
		lectures (including supervised student independent work)	supervised student independent work	practical	laboratory		
	1 Semester						
1.	**Introdnction to the discipline «Biomedical physics». Mathematical modeling of biomedicai and pharmaceutical processes. Mechanics**	**2**	**0,5**	**-**	**24**	**21**	
	Mechanical oscillations. Decomposition of oscillations into a harmonic spectrum. Acoustics. Biophysical basis of the formation of auditory sensation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasonic methods of research and influence in medicine. Elastic bodies. Elastic properties of solids. Mechanical properties of biological tissues	2	0,5	-	-	3	
1.1	Physics and biomedical physics, subject and methods. Introduction to the work-shop Laboratory work (L.w.) «Elements of the errors theory»	-	-	-	3	2	Interview, written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work, control questioning
1.2	Mathematical modeling of biomedical and pharmaceutical processes. L.w. «Determination of the rates of function change and	-	-	-	3	2	Written classroom (home) practical exercises, accounts of home practical exercises with

	gradient of function. Calculation of definite integrals»						oral defense, written account of laboratory work
1.3	Study of the functional relationships. Determination of the rates of function change and gradient of function L.w. «Mathematical models compilation of medical and biological processes»	-	-	-	3	2	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work
1.4	Elements of probability theory. Random variables, their distributions and numerical distribution characteristics L.w. «Determination of the numerical parameters of random variables distributions: expectation, mode, median, variance, standard deviation»	-	-	-	3	3	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work
1.5	Fundamentals of mathematical statistics. Sampling procedure. Methods of distribution parameters calculation. Graphical representation of a statistical distribution. Elements of correlation analysis. Determination of a correlation between two sets of random variables L.w. «Graphical representation of a statistical distribution. Plotting a correlation field, regression line and calculation of the correlation coefficient»	-	-	-	3	3	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work
1.6	Final lesson on mathematical modeling of biomedical and pharmaceutical processes, elements of probability theory and fundamentals of mathematical statistics	-	-	-	3	-	Colloquium. Test
1.7	Methods of body mass measurement L.w. «Body weight measurement»	-	-	-	3	3	Written classroom (home) practical exercises, written account of laboratory work, control questioning
1.8	Acoustics. Biophysical basics of the acoustic sensation formation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasound methods of the examination and	-	-	-	3	3	Interview, electronic practicals, control questioning, written account of laboratory work

	treatment in medicine L.w. «Registration of the spectral characteristics of ear sensitivity at the threshold of hearing»						
2.	**Molecular physics**	**4**	**1**	**-**	**9**	**15**	
	Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination. Fundamental concepts of hydrodynamics. Continuity equation. Bernoulli's equation. Viscous fluid flow. Newton's equation. Poiseuille's formula. Hydraulic resistance. Physical basics of hemodynamics. Factors affecting blood viscosity in the human body. Distribution of blood pressure and velocity in the vascular system. Pulse wave. Heart work and heard power	2	0,5	-	-	3	
2.1	General properties and features of the molecular structure of liquids. Molecular motion in liquids. The phenomenon of transport in liquids. Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination L.w. «Determination of the liquid viscosity with an Ostwald viscometer»	-	-	-	3	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
	Liquid surface tension. Coefficient of surface tension and methods for its determination. Capillary phenomena. Laplace's formula. Gas embolism. Surface-active material. Adsorption. The use of surface-active materials in pharmacy	2	0,5	-	-	3	
2.2	Surface tension L.w. «Determination of the surface tension by maximum bubble pressure method»	-	-	-	3	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
2.3	Elastic bodies. Elastic properties of solids. Determination of the elasticity modulus of materials L.w. «Determining the elasticity modulus of the bone by bending deformation»	-	-	-	3	3	Visual laboratory classes, interview, control questioning, written account of laboratory work

3.	**Cell biophysics. Biological processes modeling**	**4**	**1,5**	**12**	**-**	**17**	
	Structure and physical properties of biological membranes. Transport of substances across biological membranes. Passive transport of substances through biomembranes, its types and mathematical description. Theorell's equation, Nernst-Planck equation and Fick equation. Active transport. Sodium-potassium pump	2	0,5	-	-	3	
	Formation of cell membrane potentials at rest and during excitation. Nernst equation and Goldman-Hodgkin-Katz equation. The mechanism of generation of rest potential and action potential. Mechanism of action biopotential generation, its main phases. Refractory period. Action potential propagation along unmyelinated and myelinated axons	2	1	-	-	3	
3.1	Structure and physical properties of biological membranes. Transport of substances across biological membranes. Passive transport of substances through biomembranes, its types and mathematical description. Theorell's equation, Nernst-Planck equation and Fick equation. Active transport. Sodium-potassium pump	-	-	3	-	3	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
3.2	Formation of cell membrane potentials at rest and during excitation. Nernst equation and Goldman-Hodgkin-Katz equation. The mechanism of generation of rest potential and action potential. Mechanism of action biopotential generation, its main phases. Refractory period. Generation and propagation of action potential along unmyelinated and myelinated axons. Modeling of biological processes as a method of cognition	-	-	3	-	4	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test

3.3	Final lesson on topics «Introduction to the discipline «Biomedical Physics». Mathematical modeling of biomedical and pharmaceutical processes. Mechanics», «Molecular physics», «Cell biophysics. Modeling of biological processes»	-	-	3	-	1	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay
3.4	Final lesson on topics «Introduction to the discipline «Biomedical Physics». Mathematical modeling of biomedical and pharmaceutical processes. Mechanics», «Molecular physics», «Cell biophysics. Biological processes modeling»	-	-	3	-	3	Colloquium. Electronic tests Credit
4	**Electricity and magnetism**	**4**	**1**				
	Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography Einthoven's theory, ECG registration methods. Methods for registration of biomedical information. Sensors. The dependence of metal and semiconductor resistance on temperature. Contact potential difference. Thermoelectromotive force. Thermocouple. The Peltier phenomenon. Amplification of bioelectrical signals. Determination of the frequency (bandwidth) and amplitude (dynamic range) characteristics of the amplifier. Differential amplifier	2	0,5	-	-	-	
	Physical basis of tissue and organ electrostimulation. Impulse currents and their characteristics. Electroexcitability of tissues. Strength-duration curve, rheobase and chronaxy. Weiss–Lapicque law. Du Bois–Reymond law. Types of the heart electrical stimulation. Effect of high-frequency current and field on the human organism. Physical basis of diathermy, local d'arsonvalization, inductothermy, ultra-high-frequency therapy, microwave therapy	2	0,5	-	-	-	

	Semester 2						
4	**Electricity and magnetism**	**-**	**1**	**3**	**12**	**8**	
4.1	Physical basis of electrography of human tissues and organs L.w. «Physical basis of electrography of human tissues and organs»				1,5	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
4.2	Methods of biomedical information monitoring. Sensors L.w. «Temperature sensors»				3	1	Visual laboratory classes, interview, control questioning, written account of laboratory work
4.3	Amplification of bioelectrical signals L.w. «The study of the properties of electrical signals amplifier»	-	-	-	1,5	`1	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
4.4	Alternating current. Various loads in the AC circuit. Living tissue impedance to alternating current. Physical basis of rheography L.w. «Determination of the dependence of biological tissue impedance on current frequency»	-	-	-	3	1	Visual laboratory classes, interview, control questioning, written account of laboratory work
4.5	Effect of high-frequency current and field on the human organism. The use of UHF oscillations in medicine. Study of the methods and equipment for high-frequency therapy L.w. «Physical principles of high-frequency electrotherapy»	-	1	-	3	1	Visual laboratory classes, interview, control questioning, written account of laboratory work
4.6	Final lesson on topic « Electricity and magnetism»	-	-	**3**	-	2	Colloquium. Electronic tests
5.	**Optics**	**4**	**1,5**	**-**	**21**	**18**	
	Electromagnetic oscillations and waves. General properties of electromagnetic waves. Natural and polarized light. Types of polarization. Methods for obtaining polarized light. Malus' law. Optical activity. Polarimetry	2	0,5	-	-	1	

	Atomic and molecular spectra. Emission and absorption spectra. Bohr's theory. Quantum numbers. Pauli principle. The spectrum of the hydrogen atom. Fundamentals of atomic and molecular spectral analysis. Fundamentals of luminescent analysis. Luminescence, its types and characteristics. Stokes and Vavilov laws. Quantum yield, the delay time. Intrinsic luminescence of biological objects. Spectra of luminescence. Luminescent analysis in medicine. Luminescent labels and probes. Lasers. Stimulated radiation and its properties. Properties of laser radiation, its use in medicine. Effect of laser radiation on biological tissues. Photodynamic therapy	2	1	-	-	2	
5.1	Electromagnetic oscillations and waves L.w. «Polarimeter use to determine the concentration of optically active substances»	-	-	-	3	1	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.2	Refraction and refractometry L.w.» Determination of the liquid refractive index with a refractometer»	-	-	-	3	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.3	Optical microscopy. Fundamentals of electron and scanning probe microscopy L.w. « Measuring the small objects size with a microscope»	-	-	-	1,5	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.4	Optical system of the eye. Biophysical foundations of vision	-	-	-	1,5	2	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
5.5	Laws of light absorption and light scattering. Fundamentals of photocolorimetry and spectrophotometry L.w. «Absorption and scattering of light. Fundamentals of colorimetric analysis»	-	-	-	3	2	Visual laboratory classes, interview, control questioning, written account of laboratory work

5.6	Atomic and molecular spectra. Emission and absorption spectra. Spectral instruments L.w. «Fundamentals of spectral analysis»	-	-	-	3	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.7	Stimulated emission. Lasers. The effect of laser radiation on biological tissues L.w. «The principle of lasers operation, their propertics and applications»	-	-	-	3	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
	Final lesson on topics «Optics»	-	-	-	3	2	
6.	**Physics of atoms and molecules**	**4**	**1,5**	**3**	**-**	**4**	Colloquium. Electronic tests
	Thermal radiation. The main characteristics of thermal radiation. The laws of thermal radiation (Kirchhoff's law, Stefan-Boltzmann's law, Wien's displacement law). Planck's formula. Laws of absorption and scattering of light. Laws of Bouguer and Bouguer-Lambert-Beer. The linear decay constant of a substance, its dependence on the wavelength of light and the concentration of the solution. Transmittance and optieal density, their dependence on wavelength and concentration. Photoelectrocolorimeter. Determination of the solution concentration with the photoelectrocolorimeter. Light scattering and its types. Rayleigh's law. Nephelometry	2	1	-	-	2	
	X-rays properties. Bremsstrahlung and characteristic x-rays. Moseley's law. X-rays spectra. Interaction of X-rays with matter. X-ray diffraction analysis. The use of x-rays in diagnostics and radiotherapy. Fundamentals of x-ray computed tomography	2	0,5	-	-	2	
6.3	Bremsstrahlung and characteristic X-rays. Moseley's law. X-rays spectra. Interaction of X-rays with matter. X-ray diffraction analysis. The use of X-rays in diagnostics and radiotherapy. Fundamentals of X-ray computed tomography(CT)	-	-	3	-		Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test

7.	**Nuclear physics**	**4**	**1**	**4,5**	**1,5**	**8**	
	Radioactivity. The main types of radioactive decay. The fundamental law of radioactive decay. Half life time. Activity, its units. Drug activity change with time. Interaction of ionizing radiation with matter. Radionuclide methods of diagnostics and radiation therapy. Linear specific ionization, linear energy transfer, mean linear range. Biological effects of radiation	2	0,5	-	-	2	
	Dosimetry. Exposure, absorbed and equivalent doses, the relationship between them and their units. Effective equivalent dose, tissue weighting factor. Collective effective dose. The construction of dosimeters and radiometers. Determination of exposure rate. Background radiation	2	0,5	-	-	2	
7.1	Radioactivity. The main types of radioactive decay. The fundamental law of radioactive decay. Half life time. Activity, its units. Drug activity change with time. Interaction of ionizing radiation with matter. Radionuclide methods of diagnostics and radiation therapy			3			
7.2	Radiation dosimetry L.w. «Determination of the specific mass activity of food and building materials using a radiometer»	-	-	-	1.5	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
7.3	Radioactivity. Radiation dosimetry Final lesson on topic «Nuclear physics»	-	-	1.5	-	3	Written home practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test. Exam
		26	**9**	**90**		**91**	

INFORMATION AND INSTRUCTIONAL UNIT

LITERATURE

Basic (relevant):

1. Remizov, A. N. Medical and biological physics : textbook. / A. N. Remizov. – Moscow : Geotar-Media, 2021. – 568 p.

Additional:

2. Medical and biological physics for medical students / L. V. Kukharenko [et al.-Minsk: BSMU, 2016. – 260 p.

3. Biological physics. Lecture course / L. V. Kukharenko, M. V. Goltsev – Minsk: BSMU, 2018. – 132 p.

4. Endoscopy and refractometry use in medicine/ L. V. Kukharenko, M. V. Goltsev, O. V. Nedzved. – Minsk : BSMU, 2018. – 19 p.

5. Basics of optical, electron and atomic force microscopies / L. V. Kukharenko, M. V. Goltsev, O. V.Nedzved. – Minsk : BSMU, 2019. – 34 p.

LIST OF TOPICS FOR SUPERVISED STUDENT INDEPENDENT WORK

Kinematics and dynamics of rotational motion

The moment of inertia of a body relative to the axis of rotation. Moment of impulse. Basic equation for the dynamics of rotational motion. Law of conservation of angular momentum. Kinetic energy of a rotating body. Centrifugation.

Basic principles of molecular kinetic theory

Clausius equation. Degrees of freedom. Energy distribution over degrees of freedom. Interaction between molecules in real gases. Van der Waals equation. Comparison of experimental and theoretical isotherms of real gas. Critical state of matter.

Magnetic field

Main characteristics of the magnetic field: induction, magnetic field strength, magnetic flux. Magnetic field in matter. The phenomenon of electromagnetic induction. Faraday's law.

Infrared and ultraviolet radiation. Primary mechanisms of interaction with biological objects. Light therapy devices.

Electron paramagnetic resonance, nuclear magnetic resonance, their applications.

Fundamentals of NMR tomography. Principles of obtaining images of organs and tissues in NMR tomography machines.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

The time allocated for independent work can be used by students to:
preparation for lectures, practical and laboratory classes;
preparation for colloquiums, tests and exams in the academic discipline;
elaboration of topics (questions) submitted for independent study;
studying topics and problems that are not covered in lectures and seminars;
problem solving;
performing of research and creative tasks;
preparation of thematic reports, abstracts, presentations;
performing of practical tasks;
taking notes of educational literature;
preparation of reports on laboratory works;
compiling a review of scientific literature on a given topic;
design of information and demonstration materials (information stands, posters, graphs, tables, newspapers, etc.);
production of models, laboratory and teaching textbooks;
compiling a thematic selection of literary sources and Internet sources;
compiling tests for students to organize mutual control.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

Main forms of supervised student independent work:
preparation and presentation of abstracts;
presentation of reports;
studying topics and problems that have not been discussed at the lectures;
taking notes of original sources (sections of anthologies, collections of documents, monographs, textbooks);
computer testing;
preparation of tests for the organization of mutual assessment;
preparation of didactic materials;
participation in active forms of education;
Control of supervised student independent work is carried out in the form of:
test paper;
final class, colloquium in the form of an oral interview, written work, testing;
discussion of abstracts;
defense of educational assignments;
assessment of an oral reply to a question, presentation, report or problem solving;
checking up abstracts, written reports, accounts, prescriptions;
checking up notes of original sources, monographs and articles;
individual interview.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

Oral form:
interviews;
colloquiums.

Written form:
tests;
control questioning;
classroom (home) practical exercises;
accounts of laboratory work;
essays.

Oral-written form:
accounts of home practical exercises with oral defense;
accounts of laboratory work with oral defense;
credits;
examinations.

Technical form:
electronic tests;
electronic practicals;
visual laboratory classes.

LIST OF AVAILABLE TEACHING METHODS

Traditional method (lecture, laboratory practicals);
Active (interactive) methods:
Problem-Based Learning (PBL);
Research-Based Learning (RBL).

LIST OF PRACTICAL SKILLS

1. The use of measuring and electrical measuring instruments.
2. Determination of the liquids surface tension and the study of its dependence on concentration.
3. Determination of the dependence of the liquid viscosity on the concentration by an Ostwald viscometer.
4. Determination of the electromotive force of the current source by the compensation method.
5. Investigation of the dependence of the semiconductor resistance on temperature.
6. Determination of the substance refractive index by a refractometer.
7. Determination of the sugar concentration in a solution by a polarimeter.
8. Determination of the colored solution concentration by a photoelectrocolorimeter spectrophotometer.
9. Spectroscope calibration and study of the emission and absorption spectra.
10. Use of a spectrophotometer to determine the substance optical density.

11. Determination of the microscope magnification and its resolution (working with a microscope with a camera adapter and without a camera adapter).
12. Study of the gas laser operation.
13. Study of emission spectra by a diffraction grating.
14. Photocell calibration as a light meter.

LIST OF EQUIPMENT USED

Educational tables and posters;
tables of derivatives and integrals of functions;
sound generator;
headphones;
audiometer;
viscometer Ostwald;
stopwatch;
installation for determining surface tension;
indicator of small displacements;
a set of cargoes;
calipers;
six-channel electrocardiograph «Altonik-06»;
thermocouple;
resistive temperature sensors;
voltmeter;
ohmmeter for resistive sensors;
reference thermometer;
water bath;
alternating voltage generator;
amplifier;
constant voltage source;
DC microammeter;
DC voltmeter;
galvanizing apparatus;
AC microammeter;
generator of electrical low-frequency sinusoidal oscillations;
apparatus «Amplipulse-4»;
oscilloscopes;
multivibrators (generators of rectangular voltage pulses);
apparatus UHF-30;
polarimeter;
refractometer;
optical microscope;
counting chamber;
photoelectric colorimeter;
spectroscope (monochromator UM-2);
mercury lamp;
continuous spectrum light source;

laser;
diffraction gratings with different constants;
screen;
scale bar;
radiometer KRVP - 3B.

LIST OF LECTURES
1 Semester

Lecture 1. Mechanical oscillations. Oscillations decomposition into a harmonic spectrum. Mechanical waves. Energy characteristics of a mechanical wave. Acoustics. Biophysical basics of the acoustic sensation formation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasound methods of the examination and treatment in medicine.

Lecture 2. Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination. Fundamental concepts of hydrodynamics. Continuity equation. Bernoulli's equation. Viscous fluid flow. Newton's equation. Poiseuille's formula. Hydraulic resistance. Physical basics of hemodynamics. Factors affecting blood viscosity in the human body. Distribution of blood pressure and velocity in the vascular system. Pulse wave. Heart work and heard power.

Lecture 3. Liquid surface tension. Coefficient of surface tension and methods for its determination. Capillary phenomena. Laplace's formula. Gas embolism. Surface-active material. Adsorption. The use of surface-active materials in pharmacy.

Lecture 4. Structure and physical properties of biological membranes. Transport of substances across biological membranes. Passive transport of substances through biomembranes, its types and mathematical description. Theorell's equation, Nernst-Planck equation and Fick equation. Active transport. Sodium-potassium pump.

Lecture 5. Formation of cell membrane potentials at rest and during excitation. Nernst equation and Goldman-Hodgkin-Katz equation. The mechanism of generation of rest potential and action potential. Mechanism of action biopotential generation, its main phases. Refractory period. Action potential propagation along unmyelinated and myelinated axons.

Lecture 6. Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography Einthoven's theory, ECG registration methods. Methods for registration of biomedical information. Sensors. The dependence of metal and semiconductor resistance on temperature. Contact potential difference. Thermoelectromotive force. Thermocouple. The Peltier phenomenon. Amplification of bioelectrical signals. Determination of the frequency (bandwidth) and amplitude (dynamic range) characteristics of the amplifier. Differential amplifier.

Lecture 7. Physical basis of tissue and organ electrostimulation. Impulse currents and their characteristics. Electroexcitability of tissues. Strength-duration curve, rheobase and chronaxy. Weiss–Lapicque law. Du Bois–Reymond law. Types of the heart electrical stimulation. Effect of high-frequency current and field on the human organism. Physical basis of diathermy, local d'arsonvalization, inductothermy, ultra-high-frequency therapy, microwave therapy.

2 Semester

Lecture 8. Electromagnetic oscillations and waves. General properties of electromagnetic waves. Natural and polarized light. Types of polarization. Methods for obtaining polarized light. Malus' law. Optical activity. Polarimetry.

Lecture 9. Atomic and molecular spectra. Emission and absorption spectra. Bohr's theory. Quantum numbers. Pauli principle. The spectrum of the hydrogen atom. Fundamentals of atomic and molecular spectral analysis. Fundamentals of luminescent analysis. Luminescence, its types and characteristics. Stokes and Vavilov laws. Quantum yield, the delay time. Intrinsic luminescence of biological objects. Spectra of luminescence. Luminescent analysis in medicine. Luminescent labels and probes. Lasers. Stimulated radiation and its properties. Properties of laser radiation, its use in medicine. Effect of laser radiation on biological tissues. Photodynamic therapy.

Lecture 10. Thermal radiation. The main characteristics of thermal radiation. The laws of thermal radiation (Kirchhoff's law, Stefan-Boltzmann's law, Wien's displacement law). Planck's formula. Laws of absorption and scattering of light. Laws of Bouguer and Bouguer-Lambert-Beer. The linear decay constant of a substance, its dependence on the wavelength of light and the concentration of the solution. Transmittance and optical density, their dependence on wavelength and concentration. Photoelectrocolorimeter. Determination of the solution concentration with the photoelectrocolorimeter. Light scattering and its types. Rayleigh's law. Nephelometry.

Lecture 11. X-rays properties. Bremsstrahlung and characteristic x-rays. Moseley's law. X-rays spectra. Interaction of X-rays with matter. X-ray diffraction analysis. The use of x-rays in diagnostics and radiotherapy. Fundamentals of x-ray computed tomography.

Lecture 12. Radioactivity. The main types of radioactive decay. The fundamental law of radioactive decay. Half life time. Activity, its units. Drug activity change with time. Interaction of ionizing radiation with matter. Radionuclide methods of diagnostics and radiation therapy. Linear specific ionization, linear energy transfer, mean linear range. Biological effects of radiation.

Lecture 13. Dosimetry. Exposure, absorbed and equivalent doses, the relationship between them and their units. Effective equivalent dose, tissue weighting factor. Collective effective dose. The construction of dosimeters and radiometers. Determination of exposure rate. Background radiation.

LIST OF LABORATORY AND PRACTICAL STUDIES

1 Semester

1. Physics and biomedical physics, subject and methods. Introduction to the work-shop.

L.w. « Elements of the errors theory».

2. Mathematical modeling of biomedical and pharmaceutical processes.

L.w. «Determination of the rates of function change and gradient of function. Calculation of definite integrals».

3. Study of the functional relationships. Determination of the rates of function change and gradient of function.

L.w. «Mathematical models compilation of medical and biological processes».

4. Elements of probability theory. Random variables, their distributions and numerical distribution characteristics.

L.w. «Determination of the numerical parameters of random variables distributions: expectation, mode, median, variance, standard deviation».

5. Fundamentals of mathematical statistics. Sampling procedure. Methods of distribution parameters calculation. Graphical representation of a statistical distribution. Elements of correlation analysis. Determination of a correlation between two sets of random variables.

L.w. «Graphical representation of a statistical distribution. Plotting a correlation field, regression line and calculation of the correlation coefficient».

6. Final lesson on mathematical modeling of biomedical and pharmaceutical processes, elements of probability theory and fundamentals of mathematical statistics.

7. Modern methods used to measure the linear and angular quantities.

L.w. «The study of measuring instruments». Methods of body mass measurement.

L.w. «Body weight measurement».

8. Acoustics. Biophysical basics of the acoustic sensation formation. Sound, ultrasound, infrasound. Ultrasound. Acoustic and ultrasound methods of the examination and treatment in medicine.

L.w. «Registration of the spectral characteristics of ear sensitivity at the threshold of hearing».

9. General properties and features of the molecular structure of liquids. Molecular motion in liquids. The phenomenon of transport in liquids. Physical basis of hydrodynamics of ideal and viscous fluid. Methods of liquid viscosity determination.

L.w. «Determination of the liquid viscosity with an Ostwald viscometer».

10. Surface tension.

L.w. «Determination of the surface tension by maximum bubble pressure method».

11. Elastic bodies. Elastic properties of solids. Determination of the elasticity modulus of materials.

L.w. «Determining the elasticity modulus of the bone by bending deformation».

12. Physical properties of biological membranes. Substance transport across biological membranes. Resting biopotentials and their ionic nature. Formation of cell membrane potentials during its excitation.

13. Generation and propagation of action potential.

14. Modeling of biological processes as a method of cognition. Final lesson on topics «Introduction to the discipline «Biomedical Physics». Mathematical modeling of biomedical and pharmaceutical processes. Mechanics», «Molecular physics», «Cell biophysics. Modeling of biological processes".

15. Final lesson on topics «Mechanics», «Molecular physics», «Cell biophysics. Biological processes modeling»

15. Physical basis of electrography of human tissues and organs.

L.w. «Physical basis of electrography of human tissues and organs».

16. Methods of biomedical information monitoring. Sensors.

L.w. «Temperature sensors».

17. Amplification of bioelectrical signals.

L.w. «The study of the properties of electrical signals amplifier».

2 Semester

1. Methods of biomedical information monitoring. Sensors.

L.w. «Temperature sensors».

2. Alternating current. Various loads in the AC circuit. Living tissue impedance to alternating current. Physical basis of rheography.

L.w. «Determination of the dependence of biological tissue impedance on current frequency».

3. Effect of high-frequency current and field on the human organism. The use of UHF oscillations in medicine. Study of the methods and equipment for high-frequency therapy.

L.w. «Physical principles of high-frequency electrotherapy».

4. Physical basis of electrography of human tissues and organs.

L.w. «Physical basis of electrography of human tissues and organs». Amplification of bioelectrical signals.

L.w. «The study of the properties of electrical signals amplifier».

5. Final lesson on topic « Electricity and magnetism»

6. Electromagnetic oscillations and waves.

L.w. «Polarimeter use to determine the concentration of optically active substances».

7. Refraction and refractometry.

L.w. «Determination of the liquid refractive index with a refractometer».

8. Optical microscopy. Fundamentals of electron and scanning probe microscopy.

L.w. «Measuring the small objects size with a microscope».

Optical system of the eye. Biophysical foundations of vision.

9. Laws of light absorption and light scattering. Fundamentals of photocolorimetry and spectrophotometry.

L.w. «Absorption and scattering of light. Fundamentals of colorimetric analysis».

10. Atomic and molecular spectra. Emission and absorption spectra. Spectral instruments.

L.w. «Fundamentals of spectral analysis».

Luminescence. Types and basic characteristics of luminescence. Photoluminescence. Quantum yield, the delay time. Stokes and Vavilov laws. Luminescence of biological systems. Luminescent analysis.

11. Stimulated emission. Lasers. The effect of laser radiation on biological tissues.

L.w. «The principle of lasers operation, their properties and applications».

12. Final lesson on topic « Optics»

13. Bremsstrahlung and characteristic X-rays. Interaction of X-rays with matter. X-ray diffraction analysis. The use of X-rays in diagnostics and radiotherapy. Fundamentals of X-ray computed tomography (CT).

14. Radioactivity. The main types of radioactive decay. The fundamental law of radioactive decay. Half life time. Activity, its units. Drug activity change with time. Interaction of ionizing radiation with matter. Radionuclide methods of diagnostics and radiation therapy.

15. Radiation dosimetry.

L.w. «Determination of the specific mass activity of food and building materials using a radiometer».

Radioactivity. Radiation dosimetry. Final lesson on topic «Nuclear physics»

PROTOCOL OF THE CURRICULUM APPROVAL BY OTHER DEPARTMENTS

Title of the discipline requiring approval	Department	Amendments to the curriculum in the academic discipline	Decision of the department, which designed the curriculum (date, protocol #)
1 Analytical Chemistry	Pharmaceutical Chemistry	No amendments	Protocol #10 of 18.05.2023
2. Physical and colloid chemistry	General Chemistry	No amendments	Protocol #10 of 18.05.2023
3.Pharmaceutical Chemistry	Pharmaceutical Chemistry	No amendments	Protocol #10 of 18.05.2023

COMPILERS/AUTHORS:

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Curriculum content, composition and the accompanying documents comply with the established requirements.

Dean of the Medical Faculty for International Students of the educational institution «Belarusian State Medical University» _____ O.S.Ishutin
26.06. 2023

Methodologist of the educational institution «Belarusian State Medical University» _____ S.V.Zaturanova
26.06. 2023