MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
EDUCATIONAL INSTITUTION
BELARUSIAN STATE MEDICAL UNIVERSITY

APPROVED
by First Vice-Rector, Professor
_____I.N.Moroz
27.06.2023
Reg. # UD-0911-01-07/2324edu.

MEDICAL AND BIOLOGICAL PHYSICS

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

7-07-0911-01 «General Medicine»

2023

Curriculum is based on the educational program «Medical and Biological Physics», approved 27.06.2023, registration # УД-0911-01-07/2324/уч.; on the educational plan in the specialty 7-07-0911-01 «General Medicine», approved 17.05.2023, registration # 7-07-0911-01/2324/mf.

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Medical and Biological Physics Department of the educational institution «Belarusian State Medical University»
(protocol # 11 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

«Medical and Biological Physics» is the academic discipline of Natural Science Module, which contains systematized scientific knowledge about physical laws and phenomena applied to medical problems solution, as well as about the arrangement of medical equipment and its safe operating practices.

The aim of the discipline «Medical and Biological Physics» is the formation of basic professional competence for the application of modern methods of diagnosis and treatment.

The objectives of the discipline «Medical and Biological Physics» are to form students' scientific knowledge about:

physical properties of biological tissues, physical and physico-chemical processes occurring in a living organism, modern methods of their study and description;

mechanisms of the physical factors influence on a human body, the physical basis of the modern medical equipment operation;

physical basis of modern diagnostic methods of the human body state;

skills and abilities necessary for:

experience foundation of the use of mathematical methods knowledge to solve scientific, practical, clinical and statistical problems and their application in medicine, as well as for knowledge deepening systemic and comparative analysis;

use of laboratory, diagnostic, therapeutic equipment and interpretation of the results of laboratory research methods;

safe work with medical equipment.

The knowledge, skills, and abilities acquired during the study of the academic discipline «Medical and Biological Physics» are necessary for successful mastering of the following academic disciplines: «Medical Biology and General Genetics», «Human Anatomy», «Radiation Medicine and Ecology», «Radiodiagnosis and Radiotherapy», Biomedical Module #1.

Studying the educational discipline «Medical and Biological Physics» should ensure the formation of students' basic professional competence:

BPC. Apply the basic biophysical patterns and knowledge concernig the general principles of medical equipment functioning to solve the problems of professional activity.

As a result of studying the discipline «Medical and Biological Physics» the student should

know:

the fundamental laws of physics and biophysics underlying the processes occurring in the human body;

the biorheological properties of biological tissues and fluids;

the characteristics of physical factors (therapeutic, climatic, industrial) that affect the human body and the biophysical mechanisms of such an impact;

the intent and the basics of the medical equipment, safety precautions when working with it;

physical methods for studying substances and natural phenomena;
methods of mathematical processing of biomedical data;

be able to:

apply physical methods for the study of substances;
use basic measuring instruments;
investigate the physical properties of substances and determine their physical characteristics;
treat the statistical processing of measurement results;
interpret results of the study of the physical characteristics of substances;
analyze the obtained experimental data;
draw the conclusions from obtained physical characteristics of the substances;

master:

skills of the practical use of instruments and equipment in the physical analysis of substances;
methods for determining various physical characteristics of biomedical objects;
methodology for estimating measurement error;
skills of the practical use of medical and diagnostic equipment.

Total number of hours for the study of the discipline is 216 academic hours. Classroom hours according to the types of studies: lectures - 16 hours (including 5 hours of supervised student independent work), laboratory classes - 43 hours, practical classes – 27, student independent work (self-study) – 130 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			ont-of-class self-studies	
				lectures (including supervised independent work)	snpervised stndent independent work	laboratory stndies (practical classes)		
7-07-0911-01 «General Medicine»	1	**108**	44	8	2,5	36	64	credit
	2	**108**	42	8	2,5	34	66	examination

THEMATIC PLAN

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
1. Mathematical modelling of the biomedical process and medical data processing	-	-	**4**
1.1. Fundamentals of differential calculus. Study of the functional relationships. Determination of the rates of function change and gradient of function. Elements of the errors theory	-	-	2
1.2. Fundamentals of integral calculus. Methods of defining indefinite integrals. Calculation of definite integrals	-	-	2
2. Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods	**2**	**2**	**4**
2.1. Mechanical properties of biological tissues. Determining the elasticity modulus of materials	-	-	2
2.2. Mechanical oscillations. Fourier theorem for processing diagnostic data. Mechanical waves	1	1	-
2.3. Bioacoustics. Ultrasound and its properties. Acoustic methods of the examination and treatment in medicine	1	1	-
2.4. Biophysical basics of the acoustic sensation formation. Audiometry	-	-	2
3. Biorheology. Physical basics of hemodynamics. Elements of surface phenomena physics	**2**	**4**	**4**
3.1. Physical basis of hydrodynamics of ideal and viscous fluid	1	2	-
3.2. Biorheology and physical basis of hemodynamics	1	2	-
3.3. Viscometry	-	-	2
3.4. Liquid surface tension. Capillary phenomena	-	-	2
4. Transport phenomena and physical processes in biological membranes. Cell membrane potential	**2**	**6**	-
4.1. Structure and physical properties of biological membranes. Substance transport across biological membranes	1	2	-
4.2. Formation of cell membrane potentials at rest and during its excitation. Generation and propagation of action potential along axons	1	4	-

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
5. Electrical and magnetic phenomena in the human body, electrical actions and examination methods	**2**	**-**	**16**
5.1. Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography	1	-	2
5.2. The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basis of rheography	1	-	2
5.3. Principal physics of tissue and organ electrostimulation	-	-	2
5.4. Effect of high-frequency current and field on the human organism. Methods and equipment for high-frequency therapy	-	-	2
5.5. Obtaining and monitoring of biomedical information	-	-	4
5.6. Amplification of bioelectrical signals	-	-	4
6. Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules	**6**	**9**	**13**
6.1. Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity	1	-	2
6.2. Refractometry. Determination of the concentration of solutions using a refractometer. Principles of fiber optics. Fundamentals of endoscopy	-	-	2
6.3. Optical microscopy. Fundamentals of electron and scanning probe microscopy	-	-	2
6.4. Thermal radiation of bodies. Energy characteristics of thermal radiation. Infrared imagery and thermography in medicine	1	2	-
6.5. Laws of absorption and scattering of light. Fundamentals of photocolorimetry and spectrophotometry	-	-	2
6.6. Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra	-	-	2
6.7. Luminescence. Basic characteristics and laws of luminescence	2	1	1

Section (topic) name	Number of class hours		
	lectures	practical	laboratory
6.8. Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine	-	-	2
6.9. Biophysical foundations of vision	-	2	-
6.10.Bremsstrahlung and characteristic X-rays. Properties of X- rays and its use in medicine	2	4	-
7. Methods of nuclear physics in medicine	**2**	**6**	**2**
7.1. Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter	1	2	-
7.2. Radiation dosimetry. Registration methods of ionizing radiation	1	-	2
7.3. Magnetic resonance tomography. Radionuclide methods of diagnostics and radiotherapy. Positron-emission tomography	-	4	-
Total hours	**16**	**27**	**43**

CONTENT OF THE EDUCATIONAL MATERIAL

1. Mathematical modelling of the biomedical process and medical data processing

1.1. Fundamentals of differential calculus. Study of the functional relationships. Determination of the rates of function change and gradient of function. Elements of the error's theory

Function derivative as a measure of the process rate. Gradients. The use of derivatives to study an extremum of functions. Derivative and differential of a function, their geometric and physical meaning. Higher-order derivatives. Differential of one variable function. Partial derivatives and total differential of multivariable function. The overall health as a multivariable function. Medical data processing methods. Direct and indirect measurements. The accuracy evaluation of the result obtained in the experiments. Confidence level and confidence interval, the relative error. Processing of the results of direct and indirect measurements.

1.2. Fundamentals of integral calculus. Methods of defining indefinite integrals. Calculation of definite integrals

Antiderivative and indefinite integral. Definite integral, its application to calculate the areas of figures and work of a variable force. The use of integral calculus in probabilistic research methods in medicine. Methods for finding indefinite and definite integrals. Newton-Leibniz formula.

2. Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods

2.1. Mechanical properties of biological tissues. Determining the elasticity modulus of materials

Mechanical deformations. Hooke's law, modulus of elasticity. Determination of the elastic modulus of materials. Elastic, viscous and viscoelastic media, their mechanical characteristics and models. Mechanical properties of biological tissues: bone tissue, muscles, tendons, vessel walls.

2.2. Mechanical oscillations. Fourier theorem for processing diagnostic data. Mechanical waves

Mechanical oscillations. Harmonic oscillations. Energy of harmonic oscillations. Superposition of harmonic oscillations. Harmonic spectrum of complex oscillations. Fourier theorem for processing diagnostic data.

Mechanical waves. Energy characteristics of the wave: energy flux, intensity. Doppler effect.

2.3. Bioacoustics. Ultrasound and its properties. Acoustic methods of the examination and treatment in medicine

Sound classification. Physical characteristics of sound: frequency, intensity, harmonic spectrum. Characteristics of the acoustic sensation and their relationship to the physical characteristics of sound. Reflection and absorption of sound waves. Acoustic impedance.

Principles of ultrasound imaging of organs and tissues of the human body. Ultrasound diagnostics. Biophysical foundations of the ultrasound action on cells and tissues of the human body. Therapeutic and surgical applications of ultrasound. Application of the Doppler effect for non-invasive measurement of blood flow velocity.

Infrasound. Features of infrasound action on biological objects.

2.4. Biophysical basis of the acoustic sensation formation. Audiometry

Audition diagram. Weber-Fechner's Law. Sound intensity level and sound loudness level, relation between them, their units. Phonocardiography. Audiometry. Registration of the spectral characteristics of ear sensitivity at the threshold of hearing.

3. Biorheology. Physical basis of hemodynamics. Elements of surface phenomena physics

3.1. Physical basis of hydrodynamics of ideal and viscous fluids

Fundamental concepts of hydrodynamics. Continuity equation. Bernoulli's equation. Viscous fluid flow. Newton's formula. Poiseuille's law. Hydraulic resistance.

3.2 Biorheology and physical basis of hemodynamics

Laminar and turbulent flow. Reynolds number. Rheological properties of blood, non-Newtonian nature of its viscosity. Factors affecting blood viscosity in the human body. The role of vascular elasticity, pulse wave. Distribution of blood flow velocity and blood pressure in the systemic circulation. Application of the Bernoulli

equation for the study of blood flow in large arteries and aorta (blockage of the artery, arterial murmur, aneurysm behavior). Measuring methods of pressure and blood flow velocity.

Heart work and heard power.

3.3. Viscometry

Methods of viscosity measurements: Stokes, Ostwald, rotational method. Determination of the liquid viscosity with an Ostwald viscometer.

3.4. Liquid surface tension. Capillary phenomena

Physical fundamentals of the surface tension phenomenon. Coefficient of surface tension and methods for its determination. Pressure excess across a curved liquid interface, Laplace's formula. Wetting. Capillary phenomena, their significance in biological systems. Gas embolism.

4. Transport phenomena and physical processes in biological membranes. Cell membrane potentials

4.1. Structure and physical properties of biological membranes. Substance transport across biological membranes

Structure and physical properties of the biological membranes. Passive transport of substances across the biological membranes, its types. Mathematical description of passive transport of substances. Active transport of ions.

4.2. Formation of cell membrane potentials at rest and during its excitation. Generation and propagation of action potential along axons

Resting membrane potentials and their ionic nature. Nernst equation. The Goldman-Hodgkin- Katz equation for the resting potential of a cell. Action potential generation mechanism, its main phases. Refractory period. Propagation of the action potential along unmyelinated and myelinated axons.

5. Electrical and magnetic phenomena in the human body, electrical actions and examination methods

5.1. Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography

Electric field and its characteristics. Dipole field. Fundamentals of electrography of human organs. Electrocardiography, Einthoven's theory. Standard limb leads, augmented unipolar limb leads and chest leads. Formation of electrocardiogram waves, their connection with physiological processes in the myocardium. Determination of the amplitude and time parameters of the electrocardiogram

5.2. The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basis of rheography

Direct and alternating current. Ohm's law in differential form. Electrical conductivity of biological tissues. Galvanization and therapeutic electrophoresis. Alternating current, its characteristics. Ohmic resistance, inductance and capacitance in an alternating current circuit. Circuit impedance. Equivalent electrical circuit of living tissue. The impedance of living tissue, its dependence on the alternating

current frequency. Assessment of tissue viability. Physical basis of rheography as a diagnostic method.

5.3. Principal physics of tissue and organ electrostimulation

Impulse currents and their characteristics. Electroexcitability of tissues. Strength-duration curve, rheobase and chronaxy. Weiss–Lapicque law. Chronaximetry. Du Bois–Reymond law. Electrical stimulation of the heart.

Equipment for the electrical stimulation. Determination of the parameters of pulse currents (pulse duration, frequency, duty cycle). The study of the apparatus of amplipulse therapy.

5.4. Effect of high-frequency current and field on the human organism. Methods and equipment for high-frequency therapy

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

5.5. Obtaining and monitoring of biomedical information

Generalized circuit of detection, transfer and registration of biomedical information. General characteristics and classification of biomedical information sensors (measuring transducers). Temperature sensors. The dependence of metal and semiconductor resistance on temperature. Contact potential difference. Thermocouple, Thermoelectromotive force. Thermocouple, thermistor and wire thermistor calibration. Registration of biophysical parameters.

5.6. Amplification of bioelectrical signals

General principles of electrical signal amplification. Requirements for bioelectric signal amplifiers. Determination of the frequency (bandwidth) and amplitude (dynamic range) characteristics of the amplifier. Amplitude and frequency characteristics of the main bioelectrograms: electrocardiography, electromyography, electroencephalography. Differential amplifier, its application, features and method of connection to the patient.

6. Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules

6.1. Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity

General properties of electromagnetic waves. Electromagnetic spectrum. Wave properties of light. Natural and polarized light. Types of light polarization. Methods for obtaining polarized light based on the phenomena of Brewster, birefringence, absorption dichroism. Malus' law. Optical activity. Construction of polarization devices based on birefringence and absorption dichroism. Light passage through polarizers. Construction of a polarimeter. Determination of the optically active substance concentration with the polarimeter.

6.2. Refractometry. Determination of the concentration of solutions using a refractometer. Principles of fiber optics. Fundamentals of endoscopy

Laws of reflection and refraction of light. Construction of refractometer. Dependence of the refractive index of solutions on concentration. Determination of the solution concentration using a refractometer.

The phenomenon of total internal reflection of light, the principles of fiber optics, the design of modern endoscopes.

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

Optical microscope, ray tracings in the optical microscope. Magnification, resolution limit and resolution of optical microscopes. Abbe's formula. Fundamentals of an electron microscopy. Wave properties of electrons. De Broglie's wavelength. Resolution limit of the electron microscope. Physical principles of probe microscopy and its use in the study of biomedical objects.

Determination of the value of one eyepiece division (calibration value) and measurement of the size of microobjects with an optical microscope.

6.4. Thermal radiation of bodies. Energy characteristics of thermal radiation. Infrared imagery and thermography in medicine

The main characteristics of thermal radiation. Radiant emittance, emissivity, absorptivity. Blackbody, gray bodies and all other bodies. 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.

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

Light absorption. Laws of light absorption by matter. Linear decay constant of a substance, its dependence on the wavelength and the solution concentration. Transmittance and optical density, their dependence on wavelength and concentration. Construction of a photoelectrocolorimeter, determination of the solution concentration with the photoelectrocolorimeter. Determination of the substance absorption spectrum by a spectrophotometer. Light scattering, its types and laws. Rayleigh's law. Nephelometry.

6.6. Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra

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 and other solutions.

Photobiological processes, action spectrum.

6.7. Luminescence. Basic characteristics and laws of luminescence

Luminescence, its types and characteristics. Stokes and Vavilov laws. Luminescent analysis in medicine. Intrinsic luminescence of biological objects. Luminescent labels and probes.

Photodynamic therapy.

6.8. Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine

Stimulated emission and its properties. Amplification conditions. Laser construction. Functionality of the amplifying medium, the source of excitation energy, and the resonator in lasers. Laser components. Laser radiation properties, the use of lather in medicine. The use of laser radiation in therapy and surgery. Determining the laser wavelength and the small objects size from the diffraction pattern.

6.9. Biophysical foundations of vision

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

6.10. Bremsstrahlung and characteristic X-rays. Properties of X- rays and its use in medicine

The origin of bremsstrahlung and characteristic X- **rays**, their characteristics and properties.

X-ray tube construction, bremsstrahlung spectrum and its adjustment. Characteristic X- rays. Moseley's law. Law of X- rays attenuation by matter, the half-value layer. Linear and mass attenuation coefficients, their dependence on radiation hardness and substance properties. Types of X-rays interaction with matter. Physical principles of X-ray diagnostics. The use of X-rays in radiation therapy. Fundamentals of X-ray computed tomography. Methods of X-ray protection.

7. Methods of nuclear physics in medicine

7.1. Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter

Radioactive decay and its types. Energy spectra of α- and β-particles, gamma radiation. Obtaining radionuclides. The fundamental law of radioactive decay. Half-life time.

Characteristics of the ionizing radiation interaction with matter: linear specific ionization, linear energy transfer, mean linear range. Features of the ionizing particles interaction with matter.

Activity of radionuclides, its units, relationship between them. Specific mass activity, specific volume activity, specific surface activity.

7.2. Radiation dosimetry. Registration methods of ionizing radiation

Exposure, absorbed and equivalent doses of ionizing radiation, the relationship between them and their units. Effective equivalent dose, its units, tissue weighting factor. Collective effective dose, its units. Dose rate.

Ionizing radiation detectors. The construction of dosimeters and radiometers. Determination of exposure rate. Biological and effective half-live times of radionuclides from the human body.

Background radiation.

7.3. Magnetic resonance tomography. Radionuclide methods of diagnostics and radiotherapy. Positron-emission tomography

Electron paramagnetic resonance. Paramagnetic properties of free radicals. Equipment scheme for electron paramagnetic resonance observation. Free radicals identification and determination of their concentration by the electron paramagnetic resonance methods.

Nuclei magnetic properties of chemical elements, chemical shift.

Principles of magnetic resonance tomography.

Principles of radionuclide diagnostic methods. Physical basis of radiotherapy.

Fundamentals of positron- emission tomography.

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		
	Semester 1						
1.	**Mathematical modelling of the biomedical process and medical data processing**	-	-	-	**4**	**20**	
1.1	Fundamentals of differential calculus. Study of the functional relationships Laboratory work (L.w.) «Determination of the rates of function change and gradient of function. Elements of the errors theory»	-	-	-	2	10	Interview, written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work
1.2	Fundamentals of integral calculus. Methods of defining indefinite integrals. L.w. «Calculation of definite integrals»	-	-	-	2	10	Interview, written classroom (home) practical exercises, accounts of home practical exercises with oral defense, written account of laboratory work
2.	**Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods**	**2**	**1**	**2**	**4**	**10**	
	Mechanical oscillations. Fourier theorem for processing diagnostic data. Mechanical waves. Bioacoustics.	2	1	-	-	2	

	Ultrasound and its properties. Acoustic methods of the examination and treatment in medicine						
2.1	Mechanical properties of biological tissues. L.w. «Determining the elasticity modulus of materials»	-	-	-	2	2	Interview, visual laboratory classes, control questioning, written account of laboratory work
2.2 2.3	Mechanical oscillations. Fouricr theorem for processing diagnostic data. Mechanical waves Bioacoustics. Ultrasound and its properties. Acoustic methods of the examination and treatment in medicine	-	-	2	-	4	Interview, written classroom (home) practical exercises, accounts of home practical exercises with oral defense, control questioning, test
2.4	Biophysical basis of the acoustic sensation formation. Audiometry L.w. «Registration of the spectral characteristics of ear sensitivity at the threshold of hearing»	-	-	-	2	2	Interview, electronic practicals, control questioning, written account of laboratory work
3.	**Biorheology. Physical basis of hemodynamics. Elements of surface phenomena physics**	**2**	**0,5**	**4**	**4**	**10**	
	Physical basis of hydrodynamics of an ideal and viscous fluids. Biorheology and physical basis of hemodynamics. Viscometry. Factors affecting blood viscosity in the human body. Distribution of blood pressure in the systemic circulation. Pulse wave. Heart work and heard power	2	0,5	-	-	-	
3.1	Physical basis of hydrodynamics of ideal and viscous fluids	-	-	2	-	2	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
3.2	Biorheology and physical basis of hemodynamics	-	-	2	-	2	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview,

							control questioning, essay, test
3.3	Viscometry L.w. «Determination of the liquid viscosity with an Ostwald viscometer»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
3.4	Liquid surface tension. Capillary phenomena L.w. «Determination of the surface tension by maximum bubble pressure method»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
4.	**Transport phenomena and physical processes in biological membranes. Cell membrane potentials**	**2**	**0,5**	**6**	**-**	**10**	
	Structure and physical properties of the biological membranes. Substance transport across biological membranes. Formation of cell membrane potentials at rest and during its excitation. Generation and propagation of action potential along axons	2	0,5	-	-	-	
4.1	Structure and physical properties of biological membranes. Substance transport across biological membranes	-	-	2	-	5	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
4.2	Formation of cell membrane potentials at rest and during its excitation. Generation and propagation of action potential along axons	-	-	2	-	5	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
	Final lesson on topics «Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods», «Biorheology. Physical basis of hemodynamics. Elements of	-	-	2	-	-	Colloquium. Electronic tests

	physics of surface phenomena», «Transport phenomena and physical processes in biological membranes. Cell membrane potentials»						
5.	**Electrical and magnetic phenomena in the human body, electrical actions and examination methods**	**2**	**0,5**	**-**	**16**	**18**	
	Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography. The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basis of rheography	2	0,5	-	-	-	
5.1	Physical basis of electrography of human tissues and organs. Fundamentals of electrocardiography L.w. «Physical basis of electrography of human tissues and organs»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.2	The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basis of rheography L.w. «Determination of the dependence of biological tissue impedance on current frequency»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.3	Principal physics of tissue and organ electrostimulation L.w. «The study of electrostimulation basis»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.4	Effect of high-frequency current and field on the human organism. Methods and equipment for high-frequency therapy L.w. «Physical principles of high-frequency electrotherapy»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
5.5	Obtaining and monitoring of biomedical information L.w. «Temperature sensors»	-	-	-	2	4	Visual laboratory classes, interview, control questioning, written account of laboratory work

	Final lesson on topics: «Mathematical modelling of the biomedical process and medical data processing», «Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods», «Biorheology. Physical basis of hemodynamics. Elements of surface phenomena physics», «Transport phenomena and physical processes in biological membranes. Cell membrane potentials», «Electrical and magnetic phenomena in the human body, electrical actions and examination methods»	-	-	-	2		Credit
	Semester 2						
5.6	Amplification of bioelectrical signals L.w. «The study of the properties of electrical signals amplifier»	-	-	-	2	2	Visual laboratory classes, interview, control questioning, written account of laboratory work
	Final lesson on topic «Electrical and magnetic phenomena in the human body, electrical actions and examination methods»	-	-	-	2		Colloquium. Electronic tests
6.	**Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules**	**4**	**1,5**	**9**	**13**	**30**	
	Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity. Thermal radiation of bodies. Energy characteristics of thermal radiation. Infrared imagery and thermography in medicine	2	0,5	-	-	-	
6.1	Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity L.w. «Polarimeter use to determine the concentration of optically active substances»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
6.2	Refractometry. Determination of the concentration of solutions using a refractometer. Principles of fiber optics.	-	-	-	2	3	Visual laboratory classes, interview, control

	Fundamentals of endoscopy L.w. «Determination of the liquid refractive index with a refractometer»						questioning, written account of laboratory work
6.3	Optical microscopy. Fundamentals of electron and scanning probe microscopy L.w. «Measuring the small objects size with a microscope»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
6.4	Thermal radiation of bodies. Energy characteristies of thermal radiation. Infrared imagery and thermography in medicine	-	-	2	-	3	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
6.5	Laws of absorption and scattering of light. Fundamentals of photocolorimetry and spectrophotometry L.w. «Absorption and scattering of light. Fundamentals of colorimetric analysis»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
6.6	Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra L.w. «Fundamentals of spectral analysis»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
	Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra. Luminescence. Basic characteristics and laws of luminescence. Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine	2	0,5	-	-	-	
6.7	Luminescence. Basic characteristics and laws of luminescence L.w. «Fundamentals of spectral analysis»	-	-	2		3	Written classroom (home) practical exercises, interview, control questioning, essay, test, written account of laboratory work

6.8	Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine L.w. «The principle of lasers operation, their properties and applications»	-	-	-	2	3	Visual laboratory classes, interview, control questioning, written account of laboratory work
6.9	Biophysical foundations of vision	-	-	2	-	3	Written classroom (home) practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
	Final lesson on topic «Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules»	-	-	2	-	-	Colloquium. Electronic tests
6.10	Bremsstrahlung and characteristic X-rays. Properties of X- rays and its use in medicine	-	-	2	-	3	Written home practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
	Bremsstrahlung and characteristic X-rays. Properties of X- rays. X-rays interaction with matter. Physical principles of X-ray diagnostics. The use of X-rays in radiation therapy. Fundamentals of X-ray computed tomography. Methods of X-ray protection	2	0,5	-	-	-	
7.	**Methods of nuclear physics in medicine**	**2**	**1**	**6**	**2**	**32**	
	Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter. Radiation dosimetry. Registration methods of ionizing radiation	2	1	-	-	-	
7.1	Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter	-	-	2	-	10	Written home practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test

7.2	Radiation dosimetry. Registration methods of ionizing radiation L.w. «Determination of the specific mass activity of food and building materials using a radiometer»	-	-	-	2	10	Written home practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test, written account of laboratory work
7.3	Magnetic resonance tomography. Radionuclide methods of diagnostics and radiotherapy. Positron-emission tomography	-	-	2	-	12	Written home practical exercises, accounts of home practical exercises with oral defense, interview, control questioning, essay, test
	Final lesson on topics «Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules», «Methods of nuclear physics in medicine»	-	-	2	-		Colloquium. Electronic tests. Exam
		16	**5**	**27**	**43**	**130**	

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. – 260p.

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

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

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

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;
written classroom (home) practical exercises;
written accounts of laboratory work;
essays.

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

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);
Team-Based Learning (TBL);
Research-Based Learning (RBL).

LIST OF PRACTICAL SKILLS

1. The use of physical methods for substance research technique.
2. Measurement of substance physical parameters.
3. Statistical processing of the measurements.
4. Measurement of blood pressure.
5. Pulse rate determination on radial artery.
6. Biomedical object research by the optical microscopy.
7. Carrying out high-frequency electrotherapy.
8. Solution concentrations determination by refractometry.
9. Solution concentrations determination by photocolorimetric analysis.
10. Determination of the optically active substance concentrations by polarimetry.
11. Hearing threshold curve monitoring.
12. Carrying out electrical stimulation.
13. Electrocardiogram recording.
14. Radiation dose monitoring.
15. Calculation of the internal exposure dose.

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. Fourier theorem for processing diagnostic data. Mechanical waves. Bioacoustics. Biophysical basics of the acoustic sensation formation. Audiometry. Ultrasound and its properties. Acoustic methods of the investigations and treatments in medicine.

Lecture 2. Physical basis of the hydrodynamics of ideal and viscous fluids. Biorheology and physical basis of hemodynamics. Viscometry. Factors affecting the blood viscosity in the body. Distribution of blood pressure in the cardiovascular system. Pulse wave. Heart work and heard power.

Lecture 3. Structure and physical properties of the biological membranes. Transport of substances through the biological membranes. Formation of the resting membrane potentials and generation of the action potential. Generation and propagation of the action potential along axons.

Lecture 4. Physical basics of the electrography of tissues and organs of the human body. Fundamentals of electrocardiography. The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basics of rheography.

2 Semester

Lecture 1. Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity. Thermal radiation of bodies. Energy characteristics of thermal radiation. Infrared imagery and thermography in medicine.

Lecture 2. Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra. Luminescence. Basic characteristics and laws of luminescence. Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine.

Lecture 3. Bremsstrahlung and characteristic X-rays. Properties of X- rays. X-rays interaction with matter. Physical principles of X-ray diagnostics. The use of X-rays in radiation therapy. Fundamentals of X-ray computed tomography. Methods of X-ray protection.

Lecture 4. Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter. Radiation dosimetry. Registration methods of ionizing radiation.

LIST OF LABORATORY STUDIES

1 Semester

1. Fundamentals of differential calculus. Study of the functional relationships

L.w. «Determination of the rates of function change and gradient of function. Elements of the errors theory».

2. Fundamentals of integral calculus. Methods of defining indefinite integrals.

L.w. «Calculation of definite integrals».

3. Mechanical properties of biological tissues.

L.w, «Determining the elasticity modulus of materials».

1. Biophysical basis of the acoustic sensation formation. Audiometry.

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

2. Viscometry.

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

3. Liquid surface tension. Capillary phenomena.

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

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

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

8. The use of direct and alternating current in medicine. Equivalent electrical circuit of living tissue. Physical basis of rheography.

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

9. Biophysical basis of tissue and organ electrostimulation.

L.w. «The study of electrostimulation basis».

10. Effect of high-frequency current and field on the human organism. Methods and equipment for high-frequency therapy.

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

11. Obtaining and monitoring of biomedical information.

L.w. «Temperature sensors»

12. Final lesson on topics: «Mathematical modelling of the biomedical process and medical data processing», «Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods», «Biorheology. Physical basis of hemodynamics. Elements of surface phenomena physics», «Transport phenomena and physical processes in biological membranes. Cell membrane potentials», «Electrical and magnetic phenomena in the human body, electrical actions and examination methods».

2 Semester

1. Amplification of bioelectrical signals.

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

2. Electromagnetic waves, their properties. Methods for obtaining polarized light. The use of polarization methods for the study of biological objects. Optical activity.

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

3. Refractometry. Determination of the concentration of solutions using a refractometer. Principles of fiber optics. Fundamentals of endoscopy.

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

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

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

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

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

6. Emission and absorption of energy by atoms and molecules. Fundamentals of spectral analysis. Emission and absorption spectra.

L.w. «Fundamentals of spectral analysis».

7. Luminescence. Basic characteristics and laws of luminescence.

L.w. «Fundamentals of spectral analysis».

8. Stimulated emission. Lasers. Properties of laser radiation. The use of lasers in medicine.

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

9. Radiation dosimetry. Registration methods of ionizing radiation.

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

LIST OF PRACTICAL STUDIES

1 Semester

1. Mechanical oscillations. Fourier theorem for processing diagnostic data. Mechanical waves. Bioacoustics. Ultrasound and its properties. Acoustic methods of the examination and treatment in medicine.
2. Physical basis of hydrodynamics of an ideal and viscous fluids.
3. Biorheology and physical basis of hemodynamics.
4. Structure and physical properties of the biological membranes. Substance transport across biological membranes. Formation of cell membrane potentials at rest and during its excitation. Generation and propagation of action potential along axons.
5. Structure and physical properties of the biological membranes. Substance transport across biological membranes.
6. Final lesson on topics «Fundamentals of biomechanics. Biomechanics of hearing. Acoustic research methods», «Biorheology.Physical basis of hemodynamics. Elements of physics of surface phenomena «, «Transport phenomena and physical processes in biological membranes. Cell membrane potentials».

2 Semester

1. Thermal radiation of bodies. Energy characteristics of thermal radiation. Infrared imagery and thermography in medicine.
2. Luminescence. Basic characteristics and laws of luminescence.
3. Biophysical foundations of vision.
4. Final lesson on topic «Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules».
5. Bremsstrahlung and characteristic X-rays. Properties of X- rays and its use in medicine.
6. Radioactivity. Artificial and natural radioactivity. Interaction of ionizing radiation with matter.
7. Magnetic resonance tomography. Radionuclide methods of diagnostics and radiotherapy. Positron-emission tomography.

8. Final lesson on topics «Electromagnetic radiation, its use in medicine. Elements of the physics of atoms and molecules», «Methods of nuclear physics in medicine».

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 Radiation and Ecological Medicine	Radiation Medicine and Ecology	No amendments	Protocol # 11 of 18.05.2023
2. Radiation Diagnosis and Radiation Therapy	Radiation Diagnosis and Radiation Therapy	No amendments	Protocol # 11 of 18.05.2023

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Associate Professor of the Medical and Biological Physics Department of the educational institution «Belarusian State Medical University», Ph.D., Associate Professor _____ O.N.Belaya

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