Додаток 2
До Процедури розробки та періодичного перегляду освітніх програм

1. General Information	
Faculty	Faculty of Foreign Students; Faculty of Medicine No. 2
Programme	22 Healthcare, 222 General Medicine, the 2nd (master) level of higher education, full-time
Academic year	2023-2024
Subject	Medical and Biological Physics OK-6 Kaf_biophysics@meduniv.lviv.ua
Department	Department of Biophysics 79010, Lviv, 3a Shymzeriv tel.: +38 (032) 275-58-76 Kaf_biophysics@meduniv.lviv.ua
Head of the Department	Roman Fafula, Dr.Sci., Professor, Kaf_biophysics@meduniv.lviv.ua
Year	I
Semester	I-II
Type of the Subject	obligatory
Professors	Roman Fafula, Dr.Sci., Professor, fafula_roman@meduniv.lviv.ua
Erasmus	–
Responsible for Syllabus	Roman Fafula, Dr.Sci., Professor, fafula_roman@meduniv.lviv.ua
Credits ECTS	4
Hours	In total – 120 h.: lectures — 16 h.; practical classes – 44 h.; individual work – 60 h.
Language of study	English
Consultations	According to the schedule

2. Brief review of the subject

According to the educational and professional program the discipline "Medical and Biological Physics" is one of the fundamental natural science disciplines that form the theoretical basis for the training of highly qualified specialists in medicine.

The subject of “Medical and Biological Physics” is physical processes occurring in biological media and the impact of external factors on living organism. Medical and biological physics studies the physical mechanisms and physicochemical processes in biological objects at different levels of their organization: molecular, cellular, tissue, organ, as well as at the level of the organism and population. Physical phenomena play an important and usually decisive role in biological processes occurring in living organisms both under normal conditions and in disease. The study of medical and biological physics forms in students a basic understanding of general properties and forms of motion of matter, about the most important physical laws that underlie the mechanical, thermal, electrical, magnetic, spectral, polarization and other physical methods of study of various properties of medications.

Medical and biological physics as a fundamental discipline is quite complex, and for its assimilation various forms of lectures, laboratory, practical classes and individual work of students are used. The use of a theoretical basis for solving computational problems with medical and biological

content, the interpretation of experimental results during laboratory work allow you to learn scientific reasoning, as well as develop the ability to think consistently and logically.

The proposed discipline provides: compliance of the content of industry standards of higher education through the direct connection of its content with the goals of higher education; compliance with licensing and accreditation conditions and requirements; compliance with "Standards and Guidelines for Quality Assurance in the European Higher Education Area"; the possibility of using the competencies formed by medical and biological physics as a foundation for the formation of professional competencies of the future specialist; unambiguity of criteria for assessing academic achievement.

3. Purpose and objectives of the course

The purpose of the subject "Medical and Biological Physics" is enhancement and improvement of knowledge, skills and practical understanding of biophysical processes in living organisms; physical methods for diagnosis of diseases and the study of biological systems; the impact of physical factors on the human body in treatment; physical properties of materials used in medicine and pharmacy; physical properties and characteristics of the environment.

The goals of training of “Medical and biological physics” are studying:

- ✓ the general physical and biophysical regularities that underlie human life;
- ✓ the physical bases and biophysical mechanisms of external factors (fields) effects on the human body systems;
- ✓ the physical phenomena underlying diagnostic and physiotherapy (curative) methods used in medical practice.

Achieving these goals will allow a medical students to master the physical, biophysical, technical and mathematical knowledge and skills which are necessary for training a doctor and for study of other theoretical and clinical disciplines in the higher medical educational establishments and ensure the formation of general and special competencies and learning outcomes.

Integral competence:

The ability to solve complex problems, including those of a research and innovation nature in the field of medicine. Ability to continue learning with a high degree of autonomy.

General competences*:*

GC 1	The ability for abstract thinking, analysis and synthesis.
GC 2	Ability to learn and master modern knowledge.
GC 3	The ability to apply knowledge in practical situations.
GC 4	Knowledge and understanding of the subject area and understanding of the professional activities.
GC 5	Ability to adapt and act in a new situation.
GC 6	Ability to make informed decisions.
GC 7	Ability to work in a team.
GC 8	Interpersonal skills.
GC 9	Ability to communicate in a foreign language.
GC 10	Skills in using information and communication technologies.
GC 11	Ability to search, process and analyze information from various sources.
GC 12	Definiteness and perseverance to the tasks and assumed responsibilities.

Special (professional) competences*:*

PC 2	Ability to determine the required list of laboratory and instrumental studies and evaluate their results.
PC 10	Ability to perform medical procedures.
PC 17	Ability to assess the impact of the environment, socio-economic and biological determinants on the health of the individual, family and population.

Integrative final program learning outcomes (PLO) of the discipline “Medical and Biological Physics” are:

PLO 1. Have thorough knowledge of the structure of professional activity. To be able to carry out professional activities that require updating and integration of knowledge. To take responsibility for professional development, the ability for further professional training with a high level of autonomy (GC1 – GC12, FC2, FC10, FC17).

PLO 2. Understanding and knowledge of fundamental and clinical biomedical sciences at a level sufficient for solving professional tasks in the field of health care (GC4, GC6, GC10 – GC12, FC2, FC10, FC17).

PLO 3. Specialized conceptual knowledge, which includes scientific achievements in the field of health care and is the basis for research, critical understanding of problems in the field of medicine and related interdisciplinary problems (GC1 – GC3, GC6, GC7, GC9 – CG12, FC2).

PLO 23. Assess the impact of the environment on the state of human health in order to estimate the morbidity pattern of the population (FC17).

PLO 24. Organize the necessary level of individual safety (own and persons cared for) in case of typical dangerous situations in the individual field of activity (CG6).

4. Preliminary requirements

1. Knowledge of basic concepts, laws, essence of phenomena, values of measurement in the course of high school physics.
2. Knowledge of human anatomy and physiology in the course of high school biology.
3. Knowledge of the electronic structure of the atom and the nature of chemical bonds in high school chemistry.
4. Be able to think abstractly, analyze and the ability to synthesize knowledge.
5. Be able to apply knowledge in practice.
6. Ability to search, process and analyze information from various sources.

5. Final program learning outcomes

Learning outcomes

Code	Outcomes	Matrix of competencies
ЗН-1	general physical and biophysical regularities that underlie human life;	*PLO 1, PLO 2, PLO 3*
ЗН-2	the physical bases and biophysical mechanisms of external factors (fields) effects on the human body systems;	*PLO 23, PLO 24*
ЗН-3	physical phenomena that underlie diagnostic and physiotherapeutic (therapeutic) methods used in medical practice;	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
УМ-1	analyze physical processes in the body, using physical laws and phenomena;	*PLO 1, PLO 2, PLO 3*
УМ-2	to analyze the mechanisms of interaction of physical factors of the external environment with the human body;	*PLO 23, PLO 24*
УМ-3	demonstrate the ability to choose the method of instrumental research according to the task;	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
УМ-4	demonstrate skills in working with medical equipment used for medical imaging and therapy, including ultrasound diagnostics, electrocardiography, rheography, audiometry, physiotherapy devices, optical and quantum-mechanical devices and systems, radiometric and dosimetric control devices;	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
УМ-5	explain the principle of operation of medical equipment.	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
К-1	ability to apply knowledge in practical situations;	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
К-2	ability to carry out research at the appropriate level.	

AB-1	experience of individual subject activity, educational-cognitive, analytical, ability to synthesis of knowledge;	*PLO 1, PLO 2, PLO 3, PLO 23, PLO 24*
AB-2	ability to self-study and continue professional development;	
AB-3	ability to control, self-control of learning outcomes.	

6. Course content

Course	full-time form of study	
Classes	**Hours**	**Number of groups**
Lectures (L)	16	1
Practical classes (PC)	44	1
Individual work (IW)	60	1

7. Course content

Code	**Topic**	**Content**	**Code**	**Professors**
L-1	Cell membranes. Structural and functional organization of membranes. Membrane transport.	Structure of biological membranes. Physical properties of biomembranes. Liquid crystalline state of biomembranes. Dynamic properties of membranes. Types of gradients. Passive transport of substances through membrane: diffusion, osmosis, filtration. Fick's equation. Membrane permeability coefficients for a certain substance. The Nernst-Planck equation. Electrochemical potential. Theorell equation. Primary and secondary active transport. Ion pumps and exchangers. Molecular organization of active transport on the example of Na^+/K^+ pump. Vesicular transport.	ЗН-1 УМ-1	Roman Fafula
L-2	Resting membrane potential. Mechanisms of action potential generation and propagation. Basic biophysical properties of ion channels.	Resting membrane potentials and action potential. The mechanism of resting membrane potential (equilibrium (Nernst) potential, diffusion potential, Donnan potential, stationary Goldman-Hodgkin-Katz potential). Action potential. Ionic mechanisms of action potential generation. Propagation of the action potential in nerve fibers. Local potentials. Cable theory. Equivalent electrical diagram of the excitable membrane. Phenomenological Hodgkin-Huxley equations. General principles of functioning of ion channels. Sodium channels. Potassium channels. Calcium channels. Anion channels. Voltage-gated ion channels. The concept of channelopathies.	ЗН-1 УМ-1	Roman Fafula
L-3	Elements of biomechanics. Biophysical foundations of rheology and hemodynamics.	Elements of biomechanics. Human musculoskeletal system. Dynamic and statistical work at various types of human activity. Ergometry. Methods and devices for measuring biomechanical characteristics. Mechanical properties of biological tissues. Hooke's law. Young's	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4 УМ-5	Roman Fafula

		modulus and Poisson's ratio. Creep and stress relaxation. Biophysics of muscle contraction. Muscle contraction. Hill's equation. Power of single contraction. Smooth muscle biophysics. Biomechanics and energetics of heart muscle. Fundamentals of bioreology. Internal friction, viscosity. Newtonian friction law. Newtonian and non-Newtonian fluids. Methods and devices for measuring viscosity. Rheological properties of blood. Blood viscosity and its use in the diagnosis of diseases. Surface tension. Surface tension coefficient. Methods of its determination. Surface phenomena in the human body. Gas embolism. Laminar and turbulent fluid flow. Reynolds number. Basic concepts of hemodynamics. Stationary fluid flow. Continuity equation and Bernoulli's equation. Linear and volume flow rate. Flow of viscous fluids. Poiseuille's Formula and Hagen-Poiseuille formula. Hydraulic resistance. Biophysics of blood circulation. Work and power of the heart. Methods of measuring blood pressure and blood flow rate. Pulse wave. Basic hemodynamic parameters.		
L-4	Biophysics of sensory systems. Biophysics of hearing. Biophysics of visual reception.	General characteristics and principles of functioning of the sensory system. Research methods of sensor systems. Properties of sensory receptors. Types of receptors and sensations. Classification of sensory receptors and sense organs. Basic biophysical properties of sensory systems and receptors. Biophysical mechanisms of signal conversion in sensory receptors. Basic characteristics of mechanical vibrations and waves. Mechanism of propagation of acoustic waves. Objective and subjective sound characteristics. Intensity, intensity level, loudness, their units. Hearing threshold and pain threshold. Weber-Fechner law. Biophysics of sound perception. Auditory processes in the outer, middle and inner ear. Impedance matching. Coding of information in the auditory analyzer. Mechanotransduction in hair cells. Physical principles of audiometry. Audiogram and equal loudness curves. Laws of geometric optics. Basic photometric quantities. Optical power of the eye. Refractive surfaces of the eye.	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula

		Refractometry. Refraction of the eye in normal and pathological conditions. Accommodation. Aberration. Diffraction. Resolution of the eye. Angle of view. Day and twilight vision. Sensitivity of the eye. Visual defects and their correction. Perception of colors. Spatial vision. Molecular mechanism of visual reception. Transduction processes in retinal photoreceptors.		
L-5	Physical principles of electrocardiography and rheography. Influence of electric and magnetic field on a living organism.	The concept of electrography of organs and tissues. Physical and biophysical principles of electrocardiography. Einthoven's concept of ECG genesis. Electric and current dipole. Leads. Mechanisms of waves formation on ECG. Components of a normal electrocardiogram. Vector electrocardiography. Electric axis of the heart. Physical and biophysical principles of electroencephalography. Physical and biophysical principles of reography. The relation between the deformation of blood vessels and changes in their electrical resistance. Vector diagrams and impedance. Capacitive properties and equivalent electrical circuit of biological tissues. Specificity of vector diagrams and impedance of biological tissues. The impedance dispersion coefficient. Effect of electric field on biological tissues. Physical and biophysical processes occurring in biological tissues under the action of a constant and variable electric field (conduction current and displacement current, thermal effects). Healing factors and their use in medical techniques (galvanization, electrophoresis, franklinization, electrostimulation, electric impulsation, diathermy, electrotomy, electrocoagulation, etc.). The mechanism of action of impulse currents on biological tissues. Electrostimulation of organs and tissues. Cardiac pacemakers. Defibrillators. Magnetic field and its characteristics. Biot-Savart-Laplace-law. Magnetic properties of substances. Physical principles of magnetobiology. Electromagnetic waves and oscillations in biological media. Displacement current. Effect of permanent and variable magnetic field on biological objects. Primary mechanisms, induction currents, thermal effects. Healing factors and their use in medical methods	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula

		(magnetotherapy, inductothermy, etc.). Effects of electromagnetic fields on biological objects. Primary mechanisms, currents and thermal effects. Therapeutic factors and their application in medical techniques (UHF-therapy, SHF-therapy, microwave resonance therapy).		
L-6	Instrumental methods of analysis: optical, spectral and luminescent methods.	Elements of geometrical optics. Centered optical system. Optical microscopy. The main characteristics of the microscope. Techniques of optical microscopy. Light dispersion. Refractometry and fiber optics, their application in medicine. Concept of holography. Endoscopy. Light absorption. Burger' law. Light absorption by solutions. Burger-Lambert-Beer's law. Concentration colorimetry. Optical properties of biological tissues. Light scattering. Light scattering in dispersive media. Molecular scattering of light. Rayleigh law. Nephelometry. Light polarization. Ways to obtain polarized light. Birefringence. Nicholas prism. Malus' law. Optically active substances. Biot's law. Concentration polarimetry. Quantum-mechanical model of the hydrogen atom. Quantum numbers. Energy levels. The Pauli principle. The emission and absorption of light by atoms and molecules. Emission and absorption spectra. Spectrophotometry. Luminescence. Types of luminescence, basic laws and properties. Stokes' law. Bioluminescence. Chemiluminescence and its diagnostic value. Photoluminescence (fluorescence and phosphorescence). Phenomenon of photoeffect. External and internal photoelectric effects and their application in medicine.	ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
L-7	The effect of ionizing radiation on a living organism. Fundamentals of dosimetry. Physical principles of radiation diagnostics and radiation therapy.	X-rays. Spectrum and characteristics. Primary mechanisms of X-ray interaction with matter. X-ray attenuation and protection against X-rays. Interaction of X-rays with biological tissues. Biomedical application of X-rays (X-ray therapy, X-ray tomography, etc.). Radioactivity, its types and properties. Radioactive decay law. Lifetime. Activity, units of activity. Biological effect of ionizing radiation: primary physical and chemical processes. Direct and indirect action of ionizing radiation. Modification of radiobiological effects. Diagnostic and	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula

		therapeutic use of radionuclides. Protection against ionizing radiation. Radioprotectors and radiosensitizers. The physical and biophysical problems related to the Chernobyl disaster: remote effects. Natural background of radioactivity. Ionizing radiation dosimetry. Exposure and absorbed doses. Equivalent dose. Dose rate. Linear energy transfer. Relative biological efficiency of ionizing radiation. Detectors of ionizing radiation.		
L-8	Resonance methods of quantum mechanics. Nuclear magnetic resonance, electronic paramagnetic resonance, their application in medicine.	Quantum mechanical model of the hydrogen atom. Quantum numbers. Energy levels. Pauli principle. Resonance methods of quantum mechanics. Nuclear magnetic resonance, electronic paramagnetic resonance, their application in medicine. Magnetic resonance imaging.	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC-1	Thermodynamics of biological systems.	Thermodynamics of equilibrium states. Basic concepts of thermodynamics. The first law of thermodynamics. The main types of work that are carried out in a living organism. Enthalpy. Hess's law. Calorimetry. The second law of thermodynamics. Thermodynamic potentials. Change in standard free energy. Chemical potential. Electrochemical potential. Thermodynamics of biological processes. Temperature homeostasis, chemical and physical thermoregulation.	ЗН-1 УМ-1	Roman Fafula
PC-2	Elements of molecular biophysics. Separate biophysical research methods in medicine.	Diffusion. Osmotic and oncotic pressure. Basic biophysical research methods of biopolymers. Electrophoresis. Ultracentrifugation. X-ray structural analysis.	ЗН-1 УМ-1	Roman Fafula
PC-3	Fundamentals of biophysics of membrane processes. Membrane transport.	Structure of biological membranes. Physical properties of biomembranes. Liquid crystalline state of biomembranes. Dynamic properties of membranes. Types of gradients. Passive transport of substances through membrane: diffusion, osmosis, filtration. Fick's equation. Membrane permeability coefficients for a certain substance. The Nernst-Planck equation. Electrochemical potential. Theorell equation. Primary and secondary active transport. Ion pumps and exchangers. Molecular organization of active transport on the example of Na^+/K^+ pump. Vesicular transport.	ЗН-1 УМ-1	Roman Fafula
PC-4	Membrane potentials. Resting membrane potential. Action	Resting membrane potentials and action potential. The mechanism of resting membrane potential (equilibrium (Nernst)	ЗН-1 УМ-1	Roman Fafula

	potential. Propagation of the action potential in myelinated and non-myelinated nerve fibers.	potential, diffusion potential, Donnan potential, stationary Goldman-Hodgkin-Katz potential). Action potential. Ionic mechanisms of action potential generation. Propagation of the action potential in nerve fibers. Local potentials.		
PC -5	Fundamentals of biomechanics.	Elements of biomechanics. Human musculoskeletal system. Dynamic and statistical work at various types of human activity. Ergometry. Methods and devices for measuring biomechanical characteristics. Mechanical properties of biological tissues. Hooke's law. Young's modulus and Poisson's ratio. Creep and stress relaxation.	ЗН-1 УМ-1	Roman Fafula
PC -6	Biophysics of muscle contraction.	Biophysics of muscle contraction. Muscle contraction. Hill's equation. Power of single contraction.	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4	Roman Fafula
PC -7	Fundamentals of bioreology. Study of rheological properties of biological fluids.	Fundamentals of bioreology. Internal friction, viscosity. Newtonian friction law. Newtonian and non-Newtonian fluids. Methods and devices for measuring viscosity. Rheological properties of blood. Blood viscosity and its use in the diagnosis of diseases.	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4	Roman Fafula
PC -8	Surface tension of biological fluids.	Surface tension. Surface tension coefficient. Methods of its determination. Surface phenomena in the human body. Gas embolism.	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4	Roman Fafula
PC -9	Biophysics of the circulatory system.	Laminar and turbulent fluid flow. Reynolds number. Basic concepts of hemodynamics. Stationary fluid flow. Continuity equation and Bernoulli's equation. Linear and volume flow rate. Flow of viscous fluids. Poiseuille's Formula and Hagen-Poiseuille formula. Hydraulic resistance. Biophysics of blood circulation. Work and power of the heart. Methods of measuring blood pressure and blood flow rate. Pulse wave. Basic hemodynamic parameters.	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -10	Biophysics of breathing.	Biophysics of breathing. Biomechanics of inhalation and exhalation. Distension of the lungs. Breathing resistance. Work of breathing. Gas exchange. Spirometry. Pneumotachography.	ЗН-1 ЗН-3 УМ-1 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -11	Biophysics of hearing. Sound diagnostic methods.	Basic characteristics of mechanical vibrations and waves. Mechanism of propagation of acoustic waves. Objective and subjective sound characteristics.	ЗН-1 ЗН-2 ЗН-3 УМ-1	Roman Fafula

		Intensity, intensity level, loudness, their units. Hearing threshold and pain threshold. Weber-Fechner law. Biophysics of sound perception. Auditory processes in the outer, middle and inner ear. Impedance matching. Coding of information in the auditory analyzer. Mechanotransduction in hair cells. Physical principles of audiometry. Audiogram and equal loudness curves.	УМ-2 УМ-3 УМ-4 УМ-5	
PC -12	Biophysics of the vision. Biophysical bases of visual perception.	Laws of geometric optics. Basic photometric quantities. Optical power of the eye. Refractive surfaces of the eye. Refractometry. Refraction of the eye in normal and pathological conditions. Accommodation. Aberration. Diffraction. Resolution of the eye. Angle of view. Day and twilight vision. Sensitivity of the eye. Visual defects and their correction. Perception of colors. Spatial vision. Molecular mechanism of visual reception. Transduction processes in retinal photoreceptors.	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -13	Influence of mechanical factors on a living organism. Physical principles of ultrasound diagnostics.	Ultrasound and infrasound. Sources and detectors of ultrasound and infrasound. Peculiarities of propagation and biophysical mechanisms of action of ultrasound on biological tissues. Application of ultrasound in medicine. Lithotripsy. Physical principles of ultrasound diagnostics. Doppler effect. Dopplerography. Effect of infrasound and vibrations on the human body.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -14	Physical principles of electrography of tissues and organs. Electrocardiography.	The concept of electrography of organs and tissues. Physical and biophysical principles of electrocardiography. Einthoven's concept of ECG genesis. Electric and current dipole. Leads. Mechanisms of waves formation on ECG. Components of a normal electrocardiogram. Vector electrocardiography. Electric axis of the heart. Physical and biophysical principles of electroencephalography.	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -15	Electrical conductivity of cells and tissues. The effect of electric current on the human body. Physical principles of galvanization, electrophoresis and rheography.	Physical and biophysical principles of reography. The relation between the deformation of blood vessels and changes in their electrical resistance. Vector diagrams and impedance. Capacitive properties and equivalent electrical circuit of biological tissues. Specificity of vector diagrams and impedance of biological tissues. The impedance dispersion coefficient. Effect of electric field on biological tissues. Physical and biophysical processes	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula

		occurring in biological tissues under the action of a constant and variable electric field (conduction current and displacement current, thermal effects). Healing factors and their use in medical techniques (galvanization, electrophoresis, franklinization, electrostimulation, electric impulsation, diathermy, electrotomy, electrocoagulation, etc.). The mechanism of action of impulse currents on biological tissues. Electrostimulation of organs and tissues. Cardiac pacemakers. Defibrillators.		
PC -16	The effect of alternating electric and magnetic fields of high, ultrahigh and superhigh frequencies on biological objects.	Effects of electromagnetic fields on biological objects. Primary mechanisms, currents and thermal effects. Therapeutic factors and their application in medical techniques (UHF-therapy, SHF-therapy, microwave resonance therapy).	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -17	Absorption and scattering of light in biological media. Photocolorimetry and spectrophotometry.	Light absorption. Burger' law. Light absorption by solutions. Burger-Lambert-Beer's law. Concentration colorimetry. Optical properties of biological tissues. The emission and absorption of light by atoms and molecules. Emission and absorption spectra. Spectrophotometry.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -18	Polarization of light. Polarimetry. Polarization microscopy.	Light polarization. Ways to obtain polarized light. Birefringence. Nicholas prism. Malus' law. Optically active substances. Biot's law. Concentration polarimetry. Polarization microscopy.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -19	Thermal radiation. Thermography.	Thermal radiation of bodies, its characteristics. Kirchhoff's law. Laws of radiation of a black body: Planck's law, Stefan-Boltzmann law, Wiens displacement law. Thermal radiation the human body. Diagnostic techniques: thermoscopy, thermometry, thermography.	ЗН-1 ЗН-2 ЗН-3 УМ-1 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -20	Induced radiation. The effect of laser radiation on the living organism and its application in medicine.	Stimulated radiation. Equilibrium (Boltzmann) and inversion population of energy levels. Lasers, working principle and application in medicine. Interaction of laser radiation with biological tissues.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -21	X-rays. Methods of X-ray diagnostics and X-ray therapy in medicine.	X-rays. Spectrum and characteristics. Primary mechanisms of X-ray interaction with matter. X-ray attenuation and protection against X-rays. Interaction of X-rays with biological tissues. Biomedical application of X-rays (X-ray therapy, X-ray tomography, etc.).	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
PC -22	Radioactive radiation. The effect of ionizing	Radioactivity, its types and properties. Radioactive decay law. Lifetime. Activity,	ЗН-2 ЗН-3	Roman Fafula

	radiation on a living organism. Dosimetry of ionizing radiation.	units of activity. Biological effect of ionizing radiation: primary physical and chemical processes. Direct and indirect action of ionizing radiation. Diagnostic and therapeutic use of radionuclides. Natural background of radioactivity. Ionizing radiation dosimetry. Exposure and absorbed doses. Equivalent dose. Dose rate. Linear energy transfer. Relative biological efficiency of ionizing radiation. Detectors of ionizing radiation. Modification of radiobiological effects.	УМ-2 УМ-3 УМ-4 УМ-5	
IW-1	Thermodynamics of irreversible processes.	Thermodynamics of irreversible processes (linear law for the fluxes and thermodynamic forces, cross transfer processes, Onsager reciprocal relations, entropy production, conjugation of flows, steady state, Prigogine theorem).	ЗН-1 УМ-1	Roman Fafula
IW-2	Elements of molecular biophysics. Intermolecular interaction in biopolymers. Biophysics of proteins. Enzyme catalysis. Biophysics of nucleic acids.	Intermolecular interaction in biopolymers (covalent interaction, electrostatic and dispersion interaction, hydrophobic interaction, hydrogen bond). Biophysics of proteins. Enzyme catalysis. Biophysics of nucleic acids.	ЗН-1 УМ-1	Roman Fafula
IW-3	General principles of functioning of ion channels. The concept of channelopathies.	General principles of functioning of ion channels. Sodium channels. Potassium channels. Calcium channels. Anion channels. Voltage-gated ion channels. The concept of channelopathie.	ЗН-1 УМ-1	Roman Fafula
IW-4	Ionic currents n the membrane. Hodgkin-Huxley model. Equivalent electrical circuit of the biomembrane. The influence of medicinal substances on the membrane potential.	Cable theory. Equivalent electrical diagram of the excitable membrane. Phenomenological Hodgkin-Huxley equations.	ЗН-1 УМ-1	Roman Fafula
IW-5	Statics. Human locomotor system.	Human musculoskeletal system. Dynamic and statistical work at various types of human activity. Ergometry. Methods and devices for measuring biomechanical characteristics.	ЗН-1 ЗН-3 УМ-1 УМ-4 УМ-5	Roman Fafula
IW-6	Biophysics of smooth muscles. Biomechanics and energetics of heart muscle.	Smooth muscle biophysics. Biomechanics and energetics of heart muscle.	ЗН-1 УМ-1	Roman Fafula
IW-7	Biophysics of voice.	Biophysics of voice.	ЗН-1 УМ-1	Roman Fafula

IW-8	Basic biophysical properties of sensory systems and receptors. Biophysics of perception of smell, taste and touch.	Biophysics of perception of smell, taste and touch. Structure of receptor molecules. Mechanism of transduction in olfactory neurons and hair cells.	ЗН-1 УМ-1	Roman Fafula
IW-9	Basics of medical equipment.	General characteristics and classification of electronic medical devices. Application of electronic medical equipment in diagnostics and therapy. Electrodes and sensors. Signal amplification and generation. Safety rules when working with electronic medical equipment.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-10	Biomagnetism. Physical foundations of the use of magnetic fields in medicine.	Magnetic field and its characteristics. Biot-Savart-Laplace-law. Magnetic properties of substances. Physical principles of magnetobiology. Electromagnetic waves and oscillations in biological media. Displacement current. Effect of permanent and variable magnetic field on biological objects. Primary mechanisms, induction currents, thermal effects. Healing factors and their use in medical methods (magnetotherapy, inductothermy, etc.).	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-11	Laws of geometric optics. Refractometry.	Elements of geometrical optics. Refractometry and fiber optics, their application in medicine. Concept of holography. Endoscopy.	ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-12	Optical microscopy, types of microscopes and their characteristics.	Centered optical system. Optical microscopy. The main characteristics of the microscope. Techniques of optical microscopy.	ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-13	Electron microscopy.	Electron microscopy.	ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-14	Photobiological processes. Photomedicine.	Elements of photobiology. The main types and stages of photobiological processes. Electronic transitions in atoms and molecules. Photochemical reactions. The mechanism of biological action of electromagnetic radiation of ultraviolet, visible and infrared ranges on a living organism. Use of non-ionizing radiation in medicine. Photomedicine.	ЗН-2 ЗН-3 УМ-2 УМ-3 УМ-4 УМ-5	Roman Fafula
IW-15	Phenomenon of photoeffect and luminescence. Application of luminescence in medicine.	Phenomenon of photoeffect. External and internal photoelectric effects and their application in medicine. Luminescence. Types of luminescence, basic laws and properties. Stokes' law. Bioluminescence. Chemiluminescence and its diagnostic value. Photoluminescence (fluorescence and phosphorescence).	ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula

IW -16	Laser devices: rules of safe operation. Biological effects of laser radiation on body tissues.	Laser devices: rules of safe operation. Biological effects of laser radiation on body tissues.	ЗН-2 ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW -17	Resonance methods of quantum mechanics. NMR tomography.	Resonance methods of quantum mechanics. Nuclear magnetic resonance, electron paramagnetic resonance, their application in medicine. Nuclear magnetic tomography.	ЗН-2 ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW -18	X-ray imaging, sources of X-ray radiation. Radiography. Mammography. Angiography. Computed tomography. Storage formats and image analysis tools.	Biomedical application of X-rays (X-ray therapy, X-ray tomography, etc.). X-ray imaging, sources of X-ray radiation. Radiography. Mammography. Angiography. Computed tomography. Storage formats and image analysis tools.	ЗН-2 ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW -19	Methods of radioisotope medicine. Radionuclide diagnostics. Positron emission tomography.	Diagnostic and therapeutic use of radionuclides. Positron emission tomography.	ЗН-2 ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula
IW -20	Nuclear safety. Protection against ionizing radiation.	Protection against ionizing radiation. Radioprotectors and radiosensitizers. The physical and biophysical problems related to the Chernobyl disaster: remote effects.	ЗН-2 ЗН-3 УМ-3 УМ-4 УМ-5	Roman Fafula

The following *teaching methods are used during practical classes*: verbal methods (lecture, discussion); visual methods (illustration, demonstration, frontal experiment); practical methods (laboratory work and solving of problems with professional content); individual work of students with comprehension and learning of material; use of control and training computer software in the discipline; use of project method for interdisciplinary integration.

8. Verification of results

Current control is realized on the basis of the control of theoretical knowledge, skills and abilities. Forms of current control: oral survey (frontal, individual, combined survey), practical test of formed professional skills, test control (open and closed tests).

Individual work of students is evaluated on practical classes and is part of the final grade of the student. The final grade for the current educational activity is set on a 4-point (traditional) scale.

Criteria of evaluation

- ✓ grade 5/"excellent" – the student has mastered the theory flawlessly, demonstrates deep and comprehensive knowledge of the certain topic or academic discipline, the main theses of scientific papers and recommended literature, thinks logically and gives an answer, freely uses the acquired theoretical knowledge when analyzing practical material, expresses his attitude to certain problems, demonstrates a high level of mastery of practical skills;
- ✓ grade 4/"good" – the student has mastered the theoretical material well, knows the main aspects from primary sources and recommended literature, presents it in a reasoned way; has practical skills, expresses his thoughts on certain issues, but certain inaccuracies and errors are assumed in the logic of the presentation of theoretical content or in the performance of practical skills;
- ✓ grade 3/"satisfactory" – the student has basically mastered the theoretical knowledge of the topic or discipline, orients himself in primary sources and recommended literature, but answers

unconvincingly, confuses concepts, additional questions cause the student uncertainty or lack of stable knowledge; when answering questions of a practical nature, reveals inaccuracies in knowledge, does not know how to evaluate facts and phenomena, relate them with future activities, makes mistakes when performing practical skills;

- ✓ grade 2/"unsatisfactory" – the student has not mastered the material of the topic (discipline), does not know scientific facts, definitions, hardly orients himself in primary sources and recommended literature, lacks scientific thinking, practical skills are not formed.

Code	Code	Verification	Criteria
ЗН-1 – ЗН-3, УМ-1 – УМ-5, К-1 – К-2 АВ-1 – АВ-2	L-1-8, PC-1-22, IW-1-20.	Test control on the MISA platform (10-15 test tasks with one correct answer); Oral survey and/or written control – theoretical questions (including questions on individual work) and tasks of medical and biological content Practical skills / report on laboratory work.	**Test control**: 50-69% – satisfactory; 70-89% – good; 90-100% – excellent. **Oral survey and/or written control:** evaluation according to evaluation criteria . **Practical skills / report on laboratory work**: passed / failed

The final test		
General evaluation system	Scores of the current tests for semesters / exam – 60% / 40% in 200-points scale	
Scales	Traditional 4-point scale, 200-points scale, ECTS	
The conditions of access to the differential test	The student attended all practical (laboratory) classes and received at least 120 points for current educational activity.	
Type of a final examination	**Verification**	**Criteria**
Criteria of evaluation for the exam		
Exam	**Examination (exam)** is a form of final control of the student's mastery of theoretical and practical material on the academic discipline. The exam takes place in written form by examination papers in accordance with the academic program. The exam is written and includes both theoretical and practical training. **The structure of the examination papers**: 1) 40 standard test tasks, each of which has one correct answer out of five offered (format A). 40 minutes are allotted for writing the test. (40 points – 1 point for each test task); 2) five open descriptive questions (1 - 5 tasks, 30 points - 6 points for each question) and two problems with professional (medical and biological) content (6 - 7 tasks, 10 points - 5 points	**Evaluation criteria for test tasks:** correct answer to one test - 1 point. **Evaluation criteria of theoretical questions:** **6 points –** the student sufficiently fully knows the educational material, explains it in a reasoned way, deeply and comprehensively reveals the content of theoretical questions; **5 points –** the student enough fully knows the educational material, explains it in a reasoned way, however permits insignificant inaccuracies during answering; **4 points –** the student enough fully knows the educational material, however does not reproduce it sufficiently justified or mistakes are made; **3 points –** the student does not

	for each task). Duration – 95 minutes. In total - 80 points The list of exam questions is open throughout the entire course. **Maximum score points** which a student can score in exam is 80. **Minimum score points** required for passing is not less than 50	answer the question fully enough, does not sufficiently justify his/her answer, the sequence of presentation of the material is incorrect, he/she makes mistakes in the use of conceptual apparatus or formulas; **2 points –** the student understands the material only in a general way, the answer is incomplete and shallow; the formulation is not correct enough; **1 point –** the student partially knows the educational material, does not reveal the content of the question, shows unsatisfactory knowledge of the conceptual apparatus; **0 points –** the student does not know the educational material and is not able to explain it, gives the wrong answer to the question or does not answer anything at all. **Evaluation criteria of practical skills - computational problems with professional (medical-biological) content:** **5 points** – the logically correct solution is given; all the key points of the solution are substantiated; correct answer is received; **4 points** – the logically correct solution is given; some of the key points of the solution are insufficient. 1–2 minor mistakes in calculations and transformations are possible, which do not affect the correctness of solution; the received answer may be incorrect or incomplete; **3 points** – the logically correct solution is given; some of the key points are insufficiently substantiated or not substantiated. 1–2 errors or typos in calculations or transformations are possible, which slightly affect the correctness of solutions; the received answer may be incorrect, or incomplete, or only a part of the task is solved correctly; **2 points** – some steps are omitted in the correct solution; the key points of the solution are not substantiated; errors in calculations or transformations that affect solution

		are possible; the received answer is incomplete or incorrect; **1 point** – there are only a few solution steps in the solution; the key points of the solution are not substantiated; the received answer is incorrect or the task is not completely solved; **0 points** – the sotution to the task is not started or the solution is completely incorrect.

The highest possible score points which a student can collect for the current educational activity for admission to the exam (pass-fail test) is 120 points.

Minimal number of score points which a student must collect for current educational activity for admission to the exam (pass-fail test) is 72 points.

Calculation of the points number is based on grades received by student by the traditional scale (by calculation of the arithmetic mean (AM) rounded to two decimal places). The resulting value is converted into points by multi-points scale as follows:

$$x = \frac{AM \times 120}{5}$$

For convenience, the table of recalculation on a 200-point scale is given:

Conversion of the average grade for current educational activity to the point scale for discipline which is finished with exam

4-grading scale	200-grading scale	4-grading scale	200-grading scale	4-grading scale	200-grading scale	4-grading scale	200-grading scale
5	120	4.45	107	3.91	94	3.37	81
4.95	119	4.41	106	3.87	93	3.33	80
4.91	118	4.37	105	3.83	92	3.29	79
4.87	117	4.33	104	3.79	91	3.25	78
4.83	116	4.29	103	3.74	90	3.2	77
4.79	115	4.25	102	3.7	89	3.16	76
4.75	114	4.2	101	3.66	88	3.12	75
4.7	113	4.16	100	3.62	87	3.08	74
4.66	112	4.12	99	3.58	86	3.04	73
4.62	111	4.08	98	3.54	85	3	72
4.58	110	4.04	97	3.49	84	Less than 3	Insufficiently
4.54	109	3.99	96	3.45	83		
4.5	108	3.95	95	3.41	82		

Grade on discipline is defined as the sum of points for current educational activity (at least 72 points) and points for the exam (at least 50 points).

Points on discipline are converted regardless both in ECTS scale and a 4-point scale. Scores of ECTS scale can not be converted into 4-point scale and vice versa. Scores of students taking into account the number of points on the discipline are ranked on a ECTS scale so that:

Grade in ECTS	**Statistical index**
A	Top 10% of students
B	The next 25% of students
C	The next 30% of students
D	The next 25% of students
E	The last 10% of students

Ranking with assigning grades of "A", "B", "C", "D", "E" is held for the students of one course, studying one specialty and successfully completed the academic discipline. Students who have received grades FX, F ("2") are not recorded to the list of students for ranking. Students who have received grade FX after repassing automatically get grade "E".

For students who completed the program successfully the points on discipline are converted into a traditional 4-point scale by absolute criteria, which are listed in the table below:

Points on discipline	Grade in 4-point scale
From170 to 200 points	**5**
From 140 to 169 points	**4**
From 122 to 139 points	**3**
Lower than minimum number of points that a student must score	**2**

9. Course policy

Student attendance is required.
The missed practical class are making up according to an appropriate schedule agreed on the department.
The policy of academic integrity.
Use any material or aid (including cell phone etc) during the period of test/exam is prohibited.

The policy of academic discipline is based on the principles of academic integrity. The student is obliged to fully master the knowledge, skills, practical skills and competencies of this discipline.
Policy on compliance with the principles of academic integrity of students of higher education:

- ✓ individual performance of educational tasks of current and final controls without using external sources of information, except for cases permitted by the teacher;
- ✓ cheating during control is prohibited (including using mobile devices).

Educational policy:

- ✓ attendance at all classes is mandatory for the purpose of current and final assessment of knowledge (except for respectable reason);
- ✓ missed classes are reworked according to the approved schedule;
- ✓ repass the topic for which the student received a negative grade is carried out at a time convenient for the teacher and the student;
- ✓ it is not allowed to repass the topic in order to impove the grade during the current and final control.

10. Books

Main sources:

1. Chalyi A.V., Tsekhmister Ya.V., Agapov B.T. Medical and Biological Physics: textbook for the students of higher medical institutions of the IV accreditation level. – Vinnytsia, Nova Knyha, 2010. – 480 p.
2. Davidovits P. Physics in biology and medicine. 5th ed. – Amsterdam: Elsevier Academic Press, 2019. – 377 p.
3. Herman I.P. Physics of the Human Body. Springer, 2008. – 860 p.
4. Hobie R.K., Roth B.J. Intermediate Physics for Medicine and Biology. Springer, 2007. – 616 p.
5. Medical and Biological Physics: Laboratory Manual for students of higher medical institutions of the IV accreditation level // Lychkovsky E., Fafula R., Fedorovych Z., Makar N., Odnorih L. – Lviv, Danylo Halytsky Lviv National Medical University, 2014. – 300 p.
6. Newman J. Physics of the Life Sciences. Springer, 2008. – 718 p.

Additional sources:

1. Cotterill R. Biophysics. An introduction. J. Wiley & Sons, 2002. – 396 p.
2. Glaser R., Biophysics, Springer, 2004.
3. Hendee W., Ritenour R. Medical imaging physics. J.Wiley&Sons, 2002.

11. Equipment, and software of the discipline / subject

- ✓ academic program of the discipline;
- ✓ lecture notes on discipline (thesis);
- ✓ lecture presentations;

- ✓ video content of lectures on the distance learning platform;
- ✓ guidelines for lecturers/instructors;
- ✓ guidelines for practical classes for students;
- ✓ guidelines for individual students' work;
- ✓ test and control tasks for practical classes;
- ✓ questions and tasks for the final control (exam).

12. Additional information

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