Додаток 2
До Процедури розробки та періодичного перегляду освітніх програм

1. General Information	
Faculty	Faculty of Foreign Students
Programme	22 Healthcare, 226 Pharmacy, industrial pharmacy, second (master's) level of higher education, full-time
Academic year	2023-2024
Subject	Biological physics and physical methods of analysis, ОК-7 kaf_biophysics@meduniv.lviv.ua
Department	Biophysics Department 70010, Lviv, 3a Shymzeriv +38 (032) 2-75-58-76 Kaf_biophysics@meduniv.lviv.ua
Head of the Department	Roman Fafula, Professor, Doctor of Biological Science Kaf_biophysics@meduniv.lviv.ua
Year	I
Semester	I-II
Type of the Subject	Obligatory
Lecturer	Roman FAFULA, Prof., Doc.Biol. Sci.; fafula_roman@meduniv.lviv.ua Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology; Zoryana.Ivanytska@gmail.com Oksana MALANCHUK, Assoc. Prof., PhD in Phys. and Math Sci; oksana.malan@gmail.com
Erasmus	-
Responsible for Syllabus	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology; Zoryana.Ivanytska@gmail.com
Credits ECTS	4,5 credits
Hours	Lectures – 16 h Laboratory and practical classes – 50 h Individual student's work – 69 h
Language of Instruction	English
Consultations	According to the schedule
2. Brief review of the subject (Annotation)	

According to the curriculum, the discipline «Biological physics with physical methods of analysis» is one of the fundamental natural science disciplines that make up the theoretical basis of training highly qualified specialists for pharmacy.

Biological physics with physical methods of analysis studies physical mechanisms and physico-chemical processes in biological objects at various 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 determining role in biological processes occurring in living organisms both under normal conditions and during disease. The study of this discipline forms basic ideas about the most general properties and forms of movement of matter, about the most important physical laws that underlie mechanical, thermal, electrical, magnetic, spectral, optical, and other physical methods of drug research.

The proposed discipline is quite complex, and various forms of lecture, laboratory, practical classes and independent work of students are used to master it. The use of a theoretical basis for solving computational problems with medical and biological content, the interpretation of experimental results during laboratory work make it possible to learn scientific argumentation, and also develop the ability to think consistently and logically.

The proposed discipline ensures: compliance of the content with industry standards of higher education due to the direct connection of its content with the goals of higher education; compliance with licensing and accreditation conditions and requirements; compliance with the educational and professional program; the possibility of using the competences formed by biophysics as a foundation for the formation of the pharmacist's professional competences; unambiguity of the criteria for evaluating educational achievements.

3. Aim of the Subject

The aim the educational discipline "Biological physics with physical methods of analysis" is to deepen and improve knowledge, skills and practical understanding of biophysical processes in a living organism; physical methods of diagnosing diseases and researching biological systems; the impact of physical factors on the human body during its treatment; physical properties of materials used in medicine and pharmacy; physical properties and characteristics of the surrounding environment.

The main tasks of studying the discipline are:

- ✓ mastering the basic principles and theoretical provisions of biophysics;
- ✓ explanation of the relationship between the physical and biological aspects of the functioning of living systems;
- ✓ study of biological problems related to physical and physico-chemical mechanisms of interactions underlying biological processes;
- ✓ research of mechanisms of energy transformation in biological systems, electronic-conformational interactions in biomacromolecules, regulation and self-organization of complex biological systems.

Achieving these goals will allow future pharmacists to acquire physical and biophysical, physical-technical and mathematical knowledge and skills, which are necessary for the direct training of a pharmacist, and will also ensure the formation of general and special competencies and learning outcomes. Namely:

- ➢ ***general competencies:***

GC01. Ability to abstract thinking, analysis and synthesis
GC05. The ability to evaluate and ensure the quality of the work performed.
GC06. Ability to work in a team.
GC09. Ability to use information and communication technologies

- ➢ **Special (professional) competence*:***

PC01. Ability to integrate knowledge and solve complex pharmacy/industrial pharmacy problems in broad or multidisciplinary contexts.
PC03. Ability to solve pharmacy problems in new or unfamiliar environments in the presence of incomplete or limited information, taking into account aspects of social and ethical responsibility.
PC08. The ability to provide rational use and counseling regarding prescription and non-prescription drugs and other products of the pharmacy assortment, pharmaceutical care during the selection and sale of drugs by assessing the risk/benefit ratio, compatibility, taking into account their biopharmaceutical, pharmacokinetic, pharmacodynamic and physicochemical and chemical features, indications/contraindications for use, guided by data on the health status of a particular

patient.

PC20. The ability to develop and evaluate methods of quality control of medicinal products, including active pharmaceutical ingredients, medicinal plant raw materials and auxiliary substances using physical, chemical, physico-chemical, biological, microbiological and pharmaco-technological control methods.

- **program results outcomes (PLO):**

PLO01. Considering modern scientific achievements possess specialized conceptual knowledge in the field of pharmacy and related fields, and be able to apply them in professional activities. (GC01, GC09, PC01, PC03, PC08)

PLO03. Possess specialized knowledge and abilities/skills for solving professional problems and tasks, including for the purpose of improving knowledge and procedures in the field of pharmacy. (GC01, PC01, PC03, PC08)

PLO06. Develop and make effective decisions to solve complex/complex problems of pharmacy personally and based on the results of joint discussion; formulate the goals of one's own activity and the activity of the team, taking into account public and industrial interests, the general strategy and existing limitations, determine the optimal ways to achieve goals. (GC01, GC06, PC01, PC03)

PLO07. Using professional literature, patents, databases and other sources, to analyze the necessary information on the development and production of medicinal products, systematize, analyze and evaluate it, in particular, using statistical analysis. (GC01, GC09, PC01, PC03, PC08)

PLO08. Develop and implement innovative projects in the field of pharmacy, as well as related interdisciplinary projects taking into account technical, social, economic, ethical, legal and environmental aspects. (GC01, GC09, PC01, PC03, PC08, PC20)

PLO09. Formulate, argue, understand and concretely convey to specialists and non-specialists, including those who have obtained higher education, based on their own knowledge and professional experience, the main trends in the development of world pharmacy and related industries. (GC01, GC06, PC01, PC03)

PLO13. Record cases of side effects when using medicinal products of natural and synthetic origin; evaluate factors that can affect the processes of absorption, distribution, deposition, metabolism and elimination of drugs and are determined by the condition and characteristics of a person and the pharmaceutical properties of drugs. (PC08)

PLO15. To predict and determine the influence of environmental factors on the quality and consumer characteristics of medicines and other products of the pharmacy assortment, to organize their storage in accordance with their physical and chemical properties and the rules of Good Storage Practices. (GC05, PC08)

PLO19. Develop technological documentation for the production of medicinal products, choose a rational technology, produce medicinal products in various dosage forms according to the prescriptions of doctors and the requirements (orders) of medical and preventive institutions, prepare them for release. (GC05, PC08)

PLO23. Determine the main chemical and pharmaceutical characteristics of medicinal products; choose and/or develop quality control methods for the purpose of their standardization with using physical, chemical, physico-chemical, biological, microbiological and pharmacotechnological methods in accordance with current requirements. (GK05, PC08)

4. Preliminary requirements

1. Knowledge of basic concepts, laws, the essence of phenomena, units of measurement for a school physics course.
2. Knowledge of human anatomy from a secondary school biology course.
3. Knowledge of the electronic structure of an atom and the nature of chemical bonds from a school chemistry course.
4. The ability to think abstractly, analyze and synthesize knowledge.
5. Ability to apply knowledge in practical activities.
6. Ability to search, process and analyze information from various sources.

5. Results of the Course

Results

Code	Results	Matrix of competencies

Kn -1	✓ general physical and biophysical the underlying patterns human activities;	*PLO 01, PRO 03, PLO 07, PLO 08, PLO 13, PLO 23.*
Kn -2	✓ physical bases of diagnostic and physiotherapeutic (treatment) methods, used in medical equipment;	*PLO 01,. PLO 03, PLO 12, PLO 15.*
Kn -3	physical foundations and biophysical mechanisms effects of external factors on systems the human body;	*PLO 01, PLO 03, PLO 06, PLO 08, PLO 13, PLO 23.*
Kn -4	✓ theoretical foundations of physical methods research of medicinal substances, principles structure and operation of the corresponding equipment.	*PLO 01, PLO 03, PLO 06, PLO 09, PLO 13, PLO 19, PLO 23.*
Sk -1	✓ analyze physical processes in the body, using physical laws and phenomena;	*PLO 01,PLO 07, PLO 08,PLO 13*
Sk -2	✓ choose appropriate physical methods research to solve specific problems of pharmaceutical analysis;	*PLO 01,. PLO 03, PLO 12, PLO 15.*
Sk -3	✓ use the equipment for conducting physical examinations of medicinal products;	*PLO 01, PLO 03, PLO 06, PLO 08, PLO 13, PLO 23.*
Sk -4	✓ interpret physical results experiments	*PLO 01, PLO 03, PLO 09, PLO 13, PLO 19, PLO 23.*
C -1	✓ ability to apply knowledge practical situations;	*PLO 01, PLO 03, PLO 06, PLO 07, PLO 08, PLO 09, PLO 13, PLO 15, PLO 19, PLO 23.*
C -2	✓ the ability to conduct research corresponding level.	
AR -1	✓ experience of an independent subject activities - educational and cognitive, analytical, the ability to synthesize knowledge;	*PLO 01, PLO 03, PLO 06, PLO 07, PLO 08, PLO 09, PLO 13, PLO 15, PLO 19, PLO 23.*
AR -2	✓ ability to self-study and continue professional development;	
AR -3	✓ ability to control, self-control learning outcomes.	

6. Course content

Course	Full-time form of education	
Classes	Hours	Groups
Lectures	**16**	
Practical	**50**	
Seminars	**-**	
Individual	**69**	

7. Course content

Code	Topic	Content	Code	Professors

L-1	Thermodynamics of open biological systems.	I and II principles of thermodynamics for open systems. The concept of bound and free energy. Thermal balance of the body, types of heat exchange. Temperature homeostasis, chemical and physical thermoregulation. Application of the second law of thermodynamics for living objects. Entropy change in open thermodynamic systems. Entropy production rate and dissipative function. Basic provisions of linear non-equilibrium thermodynamics.	*Kn* -1	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
L-2	Structure and physical properties of biological membranes. Passive and active transport of substances. Biopotentials.	Structure, functions and properties of membranes. Functions of membrane proteins. Conformational processes in membranes. Types and regularities of passive and active transport of substances. Diffusion, membrane and phase potentials. The nature of the membrane rest potential: equilibrium Nernst potential; diffusion potential; Donnan's potential; stationary Goldman-Hodgkin-Katz potential. The mechanism of generation and propagation of the action potential. The influence of medicinal substances on the value of the membrane potential.	*Kn* -1 *Kn* -3	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
L-3	Biophysics of sensory systems.	General principles of structure, properties and main functions of analyzers. Types of irritants. Weber-Fechner law. Physical and physiological sound characteristics, the relationship between them. Biophysics of hearing. Basics of physiological acoustics. Biophysics of vision.	*Kn*-1	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology

L-4	Quantum mechanical processes in biological media. Photobiological processes. The phenomenon of luminescence and its use in pharmacy.	Bohr's quantum theory. Quantum numbers. Pauli principle. Quantum theory of light. Energy levels of atoms and molecules. Absorption and emission of energy by atoms of matter. Luminescence. Types of luminescence. Bioluminescence. Chemiluminescence and its diagnostic significance. Quantum mechanisms of luminescence. Photoluminescence. Laws and characteristics of luminescence. Laws of thermal radiation. Thermal radiation of the human body.	*Kn*-1	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
L-5	Rheological properties of biological fluids. Physical foundations of hemodynamics.	Rheological properties of blood. Blood movement in the vascular system. Elements of heart biomechanics. Basic hemodynamic indicators.	*Kn*-1 *Kn*-2	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
L-6	Biological action of physical factors on a living organism.	Effect of ultrasound, IR and vibration on biological objects. Biophysical mechanism of action of laser radiation. Effect of ionizing radiation on a living organism. Mechanism of occurrence of bremsstrahlung X-ray radiation. Limiting wavelength. The nature of characteristic X-ray radiation. Moseley's Law.	*Kn*-1 *Kn*-3	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
L-7	Mechanical, electrical and optical methods for substances research. Their use in pharmaceutical analysis.	Mechanical methods. Methods of determining the density of liquid and solid substances. Optical methods (colorimetry, polarimetry, refractometry, nephelometry). Study of substances and their structure by methods of optical and electron microscopy.	*Kn*-4 *Sk*-2	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology

L-8	Physical basis of spectral analysis. Methods of radio spectroscopy. Their practical application in pharmacy.	Spectrophotometry. Spectrophotometers. Absorption spectra of substances. Types of spectra. Basic spectrophotometric quantities and methods of their representation. Optical, UV and IR spectrophotometry. Interpretation of UV and IR spectra of substances. EPR and NMR phenomena in pharmaceutical analysis.	*Kn*-3 *Kn*-4 *Sk*-2	Zoryana FEDOROVYCH, Assoc. Prof., PhD in Biology
LP-1	Mechanical properties of biological tissues. Study of the mechanism of muscle contraction.	The body as a biomechanical system. Mechanical models of biological objects. Functional and anatomical features of the musculoskeletal system of the human body. Mechanical properties of biological objects: muscles, bones, blood vessels, lung tissue. Biophysics of muscle contraction. Hill's equation. Heat production. Work and muscle power. Ergometry.	*Kn*-1 *Sk*-1 *Sk*-3	According to the schedule
P-2	Fundamentals of thermodynamics of open biological systems.	Features of the application of the first principles of thermodynamics for living systems. Using Hess's law to calculate the thermal effect of chemical processes. II principle of thermodynamics and its application to living systems. The concept of entropy. Physical and statistical content of entropy. Thermodynamic potentials.	*Kn*-1 *Sk* -1 AR-1	According to the schedule

P-3	Biophysics of membrane processes. Membrane transport.	Study of the structure, functions and physical properties of the cell membrane as a liquid crystal phase. Diffusion of uncharged particles through biological membranes. Fick's equation for passive transport of substances through membranes. Diffusion of charged particles through biomembranes. Nernst-Planck electrodiffusion equation. Filtration of substances through membranes. The role of osmotic pressure. Van't Hoff equation. Theorell equation. Physical meaning of electrochemical potential. Active transport of substances.	*Kn*-1 *Sk*-1	According to the schedule
P-4	Biopotentials. Resting membrane potential. Generation and propagation of action potential.	Resting membrane potential. Nernst's formula. Donnan equilibrium. Goldman-Hodgkin-Katz potential. Mechanism of action potential generation and propagation. Spread of AP propagation by nerve fiber.	*Kn*-1 *Sk*-1	According to the schedule
P-5	General characteristics and principles of functioning of the sensor system. Study of biophysical features of the sense of taste, smell and touch.	Structure, properties and main functions of analyzers Transmission and transformation of information in receptors. Types of irritants. Weber-Fechner law. Biophysics of taste, smell, touch.	*Kn*-1 *Sk*-1	According to the schedule
LP-6	Bioacoustics. Study of hearing biophysics.	Physical model of the organ of hearing. Thresholds of hearing and pain sensation. Acoustic impedance. Elastic properties of the tympanic membrane and basement membrane. Resonance phenomena in the structures of the ear. The phenomenon of damping in the ear. Transformation of acoustic energy into an electrical signal. Mechanisms of spatial location of sound. Basics of physiological acoustics.	*Kn*-1 *Sk*-1 *Sk*-3	According to the schedule

LP-7	Impact of mechanical waves on the body. Interaction of ultrasound with matter. Use of ultrasound in pharmacy.	Ultrasound. Ultrasound sources and receivers. Peculiarities of propagation of ultrasound waves. Cavitation. Echolocation. Interaction of ultrasound with matter. The use of ultrasound in medicine and pharmacy.	*Kn*-1 *Sk*-1 *Sk*-2 *Sk*-3	According to the schedule
LP-8	Biophysics of vision perception.	The optical system of the eye and some of its features. The structure of photoreceptor cells. Generation action potential in photoreceptors.	*Kn*-1 *Sk*-1	According to the schedule
P-9	Fundamentals of quantum biophysics. Study of photobiological processes.	Quantum mechanical features of the structure of biomolecules. Energy migration. Energy levels of atoms and molecules. Types of photobiological processes. General characteristics and physical basis of photobiological processes. Pigments of biological systems. Photosynthesis. Photo taxi. Photoperiodism.	*Kn*-1 *Sk*-1	According to the schedule
P-10	Luminescence of biosystems. Luminescence application in pharmacy.	Mechanism of excitation of luminescence. Luminescence types. Characteristics of fluorescent radiation. Laws of luminescence.	*Kn*-2	According to the schedule
P-11	Thermal radiation. Thermography.	Characteristics of thermal radiation. Absolutely black body. Laws of thermal radiation. Thermal radiation of alive body.	*Kn*-1 *Kn*-2 *Kn*-3 *Sk*-1	According to the schedule
LP-12	Study of rheological features of liquids.	Internal friction. Newton and non-Newtonian fluids. Rheological properties of blood, plasma, serum. Laminar and turbulent flows. Reynolds number. Flow of viscous liquids. Poiseuille's formula. Hydraulic resistance. Hematocrit index. Speed of erythrocytes sedimentation.	*Kn*-1 *Kn*-2 *Kn*-4 *Sk*-1	According to the schedule

LP-13	Physical bases of hemodynamics.	Steady flow of liquids. The equation of continuity of the stream. Linear and volumetric velocities. The basic equation of fluid dynamics. Basic hemodynamic indicators. General physical patterns of blood movement in vessels. Work and power of the heart. Pulse waves, the dependence of their propagation speed on vessel parameters.	*Kn*-1 *Kn*-2 *Sk*-1 *Sk*-3	According to the schedule
P-14	Electrical and magnetic properties of biological objects. Study of the features of electric fields in the body.	Electrical properties of cells and tissues. Conduction currents and bias currents. Electric dipole and characteristics of the electric field created by it. Electric fields created by organs and tissues. Magnetic properties of biological objects.	*Kn*-1 *Kn*-2 *Sk*-2 *Sk*-3	According to the schedule
LP-15	Study the effect of electric current on a living organism. Dispersion of electrical conductivity of biological tissues.	Electrical conductivity of cells and tissues at direct current. Passage of alternating current through biological objects. Physical characteristics of pulsed current. Impedance of tissues and organs. Dispersion of impedance. The polarization coefficient of the tissue. Rheography.	*Kn*-1 *Kn*-2 *Kn*-3 *Sk*-1	According to the schedule
LP-16	The mechanism of action of electromagnetic fields on biological objects and their application in medicine.	The influence of high-frequency and low-frequency electromagnetic fields on the human body. Healing factors and their use in medical methods (UHF therapy, microwave therapy, microwave resonance therapy). The use of high voltage constant electric field in medicine.	*Kn*-1 *Kn*-3 *Sk*-1 *Sk*-3	According to the schedule
LP-17	Study of the mechanism of laser radiation action on the biological objects.	Spontaneous and induced radiation. The main structural components of the laser and their purpose. Basic properties of laser radiation. Biophysical mechanism of action of laser radiation. Main directions of use of laser radiation in medicine.	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule

LP-18	X-ray radiation and its interaction with matter.	X-ray source. Mechanism of occurrence of bremsstrahlung X-ray radiation. Limiting wavelength. The nature of characteristic X-ray radiation. Moseley's Law. Coherent scattering, photo effect, Compton effect.	*Kn*-1 *Kn*-3	According to the schedule
LP-19	Radioactivity. Study of the biological action of ionizing radiation. Dosimetry of ionizing radiation.	Radioactivity. The main types of radioactive radiation. Half attenuation layer. Law of radioactive decay. Activity of a radioactive source. Half-life. Basic doses of ionizing radiation. Biological effect of ionizing radiation.	*Kn*-1 *Kn*-3 *Sk*-3	According to the schedule
LP-20	Mechanical methods of research of substances. Study of the biophysics of surface phenomena.	Capillary and rotational viscometry. Properties of the surface layer. Surface tension. Methods of determining the surface tension of liquids.	*Kn*-4 *Sk*-2 *Sk*-3 *Sk*-4	According to the schedule
LP-21	Optical methods for the research of substances. Optical microscopy and refractometry.	Methods of optical microscopy. Refractive index. The phenomenon of total internal reflection. Limit angle of refraction. Determining the concentration of a substance using a refractometer.	*Kn*-4 *Sk*-2 *Sk*-4	According to the schedule
LP-22	Optical methods of determining the concentration of substances. Colorimetry and polarimetry.	Mechanism of light absorption. The main characteristics of light absorption (intensity, absorption index, optical density of the medium, transmission coefficient, extinction). The principle of concentration colorimetry. Lambert-Booger-Behr law. Mechanism of light scattering. Rayleigh's law. Nephelometry. Polarization of light. Ways of obtaining polarized light. Double refraction. Nikola's prism. Optically active media. Bio's law. Polarimetry.	*Kn*-3 *Kn*-4 *Sk*-2 *Sk*-3	According to the schedule
LP-23	Spectral methods of substances research in the optical range.	Optical, UV and IR spectrophotometry. Interpretation of UV and IR spectra of substances. Application in research.	*Kn*-3 *Kn*-4 *Sk*-2 *Sk*-4	According to the schedule

LP-24	X-ray structural analysis in pharmacy.	Types of X-ray spectra. Methods and equipment for X-ray structural analysis. Interpretation of X-rays. Identification of crystalline substances.	*Kn*-3 *Kn*-4 *Sk*-2	According to the schedule
P-25	Radiospectroscopic methods of research of substances in pharmacy. Physical foundations of EPR and NMR spectroscopy methods.	Electronic paramagnetic resonance. EPR spectrometers. Nuclear magnetic resonance. NMR spectrometers. NMR spectra and their interpretation.	*Kn*-3 *Kn*-4 *Sk*-2 *Sk*-4	According to the schedule
ISW - 1	Mechanical models of biological objects.	Mechanical models biological objects.	*Kn*-1 *Sk*-1	According to the schedule
ISW - 2	Biophysics of respiration. The effect of coronavirus SARS-CoV-2 on the lungs.	Biomechanics of inhalation and exhalation. Lung distensibility. Breathing resistance. The work of breathing. Effect of the SARS-CoV-2 coronavirus on the lungs.	*Kn*-1 *Sk*-1 *Sk*-4	According to the schedule
ISW - 3	Sources of free energy in the body and the types of work performed in it.	Sources of free energy in the body and types of work in it are carried out	*Kn*-1 *Sk*-1	According to the schedule
ISW - 4	Ways of energy conversion in a living cell.	Metabolism and energy conversion. Energy expenditure of the body, basic metabolism.	*Kn*-1 *Sk*-1	According to the schedule
ISW - 5	Enthalpy. Hess's law. Calorimetry.	Enthalpy. Hess's law. Calorimetry.	*Kn*-1 *Sk*-1	According to the schedule
ISW - 6	Thermodynamics of irreversible processes	Onsager reciprocity ratio. Prigozhin's theorem. Thermodynamic equilibrium and steady state of the system. Criteria for achieving the stability of the biological stationary state systems	*Kn*-1 *Sk*-1	According to the schedule
ISW - 7	Models of biological membranes. Research methods biological membranes.	The role of physiological states of cytoplasm components in the performance of biological functions. X-ray structural analysis of membranes, method of destruction of cell membranes. Models of biological membranes/	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule

ISW - 8	Sodium, calcium, chlorine channels. Gate currents of potential-ion channels. Cable theory. Hodgkin-Huxley mathematical model. Relationship of membrane potentials with metabolism.	Sodium, calcium, chlorine channels. Gate currents of potential-controlled ion channels. Cable theory. Mathematical model of Hodgkin-Huxley. Connection of membrane potentials with exchange substances	*Kn*-1 *Sk*-1	According to the schedule
ISW - 9	Physical bases of sound research methods in clinic. Absorption and reflection of sound waves. Reverberation.	Auscultation, phonocardiography, percussion, audiometry, phonophoresis. Use of the Doppler effect in medicine. Absorption and reflection of sound waves. Reverberation.	*Kn*-1 *Sk*-1 *Sk*-2 *Sk*-3	According to the schedule
ISW - 10	Centralized optical system. Visual defects. Types of refractions.	Main characteristics of the centered optical system. Disadvantages of the optical system of the eye and their correction. Aberrations of the eye.	*Kn*-1 *Sk*-1	According to the schedule
ISW - 11	Photometric quantities in biology and medicine.	Optical microscope and its characteristics. Types of microscopes and their purpose. Determining the linear dimensions of a microobject using an optical microscope. Luminous flux, brightness, illumination, light pressure	*Kn*-1 *Sk*-1 *Sk*-2 *Sk*-3 *Sk*-4	According to the schedule
ISW - 12	Application of luminescence in medicine and pharmacy.	Luminophores. Resonant and sensitized fluorescence. Concentration extinction. Chemiluminescence and its diagnostic value. Luminescence analysis.	*Kn*-1 *Kn*-2 *Kn*-4 *Sk*-1 *Sk*-2	According to the schedule
ISW - 13	Physical bases of thermal imaging. Thermometry of an organism at various diseases.	Temperature distribution. Thermometry. Thermal imager. Thermometry of the body at various diseases	*Kn*-1 *Kn*-2 *Sk*-1	According to the schedule
ISW - 14	Methods of measuring rheological characteristics biological fluids.	Methods of determining the viscosity of liquids: capillary, rotational viscometry. Clinical method of blood viscosity determination. Stokes method.	*Kn*-2 *Kn*-4 *Sk*-2	According to the schedule

ISW - 15	Biophysics of blood circulation. Methods of determining the main hemodynamic parameters.	Bernoulli's law in medicine. Methods of determining blood flow velocity. Sphygmotonometer.	*Kn*-1 *Kn*-2 *Sk*-2 *Sk*-3	According to the schedule
ISW - 16	Application of the measuring electrical conductivity method in biological and medical research.	Effect of electric current on a living organism. Effect of pulsed electric current on a living organism. Electrosleep. Electrostimulators. Defibrillators. Galvanization. Electrophoresis.	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule
ISW - 17	Biomagnetism. Magnetotherapy.	Magnetic field characteristics. The effect of a magnetic field on a living organism. Magnetotherapy.	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule
ISW - 18	Application of ultrasound in medicine, pharmacy and biology.	Biological effect of ultrasound on a substance. Physical basis of using ultrasound. Doppler effect, its use for medical and biological research.	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule
ISW - 19	Effect of infrasound and vibrations on the living organism.	Infrasound, features of its distribution. Biophysical bases of IS action on biological objects. Noise. Vibrations, their physical characteristics.	*Kn*-1 *Kn*-3 *Sk*-1	According to the schedule
ISW - 20	The effect of X-rays on a living organism.	Properties of X-ray radiation. The essence of x-ray diagnostic methods and X-ray therapy.	*Kn*-1 *Kn*-2 *Kn*-3 *Sk*-1	According to the schedule
ISW - 21	Radionuclides, their appliation for visualization and their selection by physiological characteristics. Applying radiopharmaceuticals for therapeutic purposes.	Methods of radioisotope medicine. Basic methods of physical and chemical protection against radiation. Radiopharmaceuticals and their use.	*Kn*-2 *Kn*-4 *Sk*-2	According to the schedule
ISW - 22	Methods of measuring density, mass, viscosity coefficients. Centrifugation.	Methods of measuring density, mass and viscosity coefficients. Grouting centers.	*Kn*-4 *Sk*-2	According to the schedule
ISW - 23	Electric and magnetic methods. Electrophoresis. Types of electrophoresis. Application at drug research.	Methods of measuring electrical conductivity, dielectric permeability, loss tangent. Electrode potentials. Types of electrodes. Methods of conductometry. Electrophoresis and its application.	*Kn*-3 *Kn*-4 *Sk*-2	According to the schedule

ISW-24	Thermoanalytical methods of substances research in pharmacy.	Thermogravimetry and differential scanning calorimetry. Their use for quality control of medicinal products.	*Kn*-3 *Kn*-4 *Sk*-2 *Sk*-4	According to the schedule
ISW-25	Optical microscopy. Concentration interferometry. Methods of photocolorimetry.	Interference measurements. Methods of obtaining an interference pattern and its information parameters. The main types of measuring interferometers. Methods of photo colorimetry.	*Kn*-4 *Sk*-2 *Sk*-4	According to the schedule
ISW-26	Raman spectroscopy. The use of lasers in the methods of Raman scattering.	Physical foundations of the combination scattering method. Methods of obtaining Raman spectra. Spectrographs for recording Raman spectra. Advantages and disadvantages of the CSM method. Interpretation of Raman spectra. Using lasers in CSM methods.	*Kn*-3 *Kn*-4 *Sk*-2	According to the schedule
ISW-27	Methods and equipment for X-ray diffraction analysis. Identification of crystalline substances.	Interaction of X-ray radiation with electrons and nuclei of atoms. Diffraction of X-rays. Study of the structure of polycrystals by the Debye-Scherer method. Identification of crystalline substances.	*Kn*-3 *Kn*-4 *Sk*-2 *Sk*-4	According to the schedule
ISW-28	EPR, NMR spectroscopy application in pharmacy.	EPR spectra and their interpretation. The width and shape of the spectral bands. Ultrafine and superfine structure of high and low resolution NMR lines. Relaxation of the nucleus magnetic moment/ Chemical shift spectral lines. Split lines.	*Kn*-3 *Kn*-4 *Sk*-2	According to the schedule
ISW-29	Research of radiopharmaceuticals.	Technologies for obtaining radioactive pharmaceuticals. Measurement of radioactivity and specific activity. Radiometric verification drugs for identity, purity and effectiveness.	*Kn*-3 *Kn*-4 *Sk*-2	According to the schedule

The structure of the practical lesson includes preliminary control of students' knowledge and skills; formulation of the general problem and its discussion with the participation of students; if the equipment is available, performing laboratory work, solving problems with medical and biological content, and current control.
When conducting practical classes, a number of teaching methods are used: diagnosis (conversation, observation, testing); frontal laboratory work, informing (demonstration, counseling, story, problem statement, test control); independent work (research of scientific and information sources; creation of presentations); practical work (solving problems).
The following interactive learning technologies are used for their implementation: case method, team learning, analysis of situational problems with content close to professional activity, discussions, multimedia presentations.

8. Verification of results

Current control is carried out during training sessions and is aimed at checking students' assimilation of educational material (it is necessary to describe the forms of ongoing control during training sessions). Forms of assessment of current educational activities should be standardized and include control of theoretical and practical training. The final grade for the current educational activity is given on a 4-point (national) scale

Evaluation criteria

Evaluation on a 4-point scale	**Evaluation criteria for structured written work**	**Evaluation criteria for test control on the MISA platform** (10-15 questions with one correct answer)
«5»	*The student has mastered the theoretical material flawlessly, demonstrates deep and comprehensive knowledge of the relevant topic or academic discipline, the main provisions of scientific primary sources and recommended literature, thinks logically and constructs an answer, freely uses acquired theoretical knowledge at analysis of practical material, expresses your attitude to certain problems, demonstrates a high level of assimilation practical skills.*	*90-100 points*
«4»	*The student has mastered the theoretical material well, possesses the main aspects from primary sources and recommended literature, presents it in a reasoned way; owns practical skills, expresses his thoughts on certain problems, but assumes certain inaccuracies and errors in the logic of the presentation of the theoretical content or when performing practical skills.*	*70-89,9 points*
«3»	*student mainly mastered the theoretical knowledge of an educational topic or discipline,* *orients itself in primary sources and recommended literature, but answers unconvincingly, confuses concepts, additional questions arise from the student uncertainty or lack of stable knowledge; answering questions of a practical nature, reveals inaccuracies in knowledge, does not know how to evaluate facts and phenomena, relate them to future activities, execution errors are assumed* *practical skills.*	*50-69,9*
«2»	*The student has not mastered the study material* *topics (disciplines), does not know scientific facts,* *definitions, almost does not focus on primary sources and recommended literature, lack of scientific thinking, practical skills are not formed.*	*Less than 50 points*

Learning outcome code	Code of the type of classes	Method of verification of learning outcomes	Enrollment criteria
Kn -1 *Sk -1* *Sk -3* *Sk -4*	LP-1 LP-6 ISW -1 ISW -2	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1Sk-1AR -1	P-2 P-5 P-9 ISW -3 ISW -4 ISW -5 ISW -6	*written control, which includes extensive theoretical questions and problems with medical and biological content*	evaluation according to the established criteria on a traditional 4-point scale
Kn -1Kn -3 Sk -1	P-3,4 ISW -7,8	*written control, which includes extensive theoretical questions and problems with medical and biological content*	evaluation according to the established criteria on a traditional 4-point scale
Kn -1Sk -1Sk -2 Sk -3	LP-7 ISW -9	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1 *Sk -1* *Sk -2* *Sk -3* *Sk -4*	LP-8 ISW -10 ISW -11	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1; *Kn -2* *Kn -4* *Sk -1* *Sk -2*	P-10 LP-12 ISW -12 ISW -14	*written control, including extensive theoretical questions and problems with medical and biological content*	evaluation according to the established criteria on a traditional 4-point scale
Kn -1; Kn -2 *Kn -3* *Sk -1* *Sk -2*	P-11 ISW -13	*written control, including extensive theoretical questions and problems with medical and biological content*	evaluation according to the established criteria on a traditional 4-point scale
Kn -1, Kn -2 *Sk -1* *Sk -2* *Sk -3*	LP-13 ISW -15	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1, Kn -2 *Sk -2* *Sk -3*	P-14	*written test control that includes theoretical questions and computational problems with medical biological content*	evaluation according to the established criteria on a traditional 4-point scale

Kn -1 *Kn -2Kn -3 Sk -1*	LP-15 ISW -16	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1 *Kn -3* *Sk -1* *Sk -3*	LP-16 ISW -17	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1Kn -3 Sk -1 *Sk -3*	LP-17 ISW-18 ISW -19	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn-1, Kn -2 *Kn -3 Sk -1*	LP-18 ISW -20	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -1, Kn -2 *Kn -3, Kn -4* *Sk -2* *Sk -3*	LP-19 ISW -21	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -3; Kn -4 *Sk -2 Sk -3 Sk -4*	LP-20 ISW -22 ISW -23 ISW -24	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -4Sk -2Sk -4	LP-21 ISW -25	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -3 *Kn -4* *Sk -2* *Sk -3*	LP-22	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -3, Kn -4 *Sk -2* *Sk -4*	LP-23 ISW -26	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale

Kn -3, Kn -4, Sk -2Sk -4	LP-24 ISW -27	*- report on the completed laboratory work;* *- written control, which includes theoretical questions and calculations problems with medical and biological content*	pass/failed evaluation according to the established criteria on a traditional 4-point scale
Kn -3, Kn -4,Sk - 2 Sk 4	P-25, ISW-28, ISW -29	*written test control, which includes theoretical questions and calculation problems from medical and biological content*	evaluation according to the established criteria on a traditional 4-point scale
The final test			
General evaluation system	Scores of the current tests for I and II semesters / the differential test – 60% / 40% in 200-points scale		
Scales	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 72 points for I and II semesters		
Type of a final examination	**Verification**		**Criteria**
Exam	An exam is a form of final control of a student's assimilation of theoretical and practical material from an educational discipline. The exam is conducted in written form based on examination tickets prepared in accordance with the program of the academic discipline. Ticket structure and evaluation criteria for each type of task: 1) written answers to 40 standard test questions, each question has five choices, with one correct answer (format A). 40 minutes are allotted for writing the test control (based on 1 test per 1 minute). (40 points – 1 point for each test task); 2) written standardized answers to five open descriptive questions (1 - 5 tasks, 30 points - 6 points for each question) and two calculated problems with professional (medical and biological) content (6 - 7 tasks, 10 points - for 5 points for each problem). Duration – 95 minutes. Total - 80 points. The list of exam questions is open throughout the entire course.		**Evaluation criteria for test tasks**: correct answer to 1 test - 1 point. Evaluation criteria for theoretical questions: 6 points – the student fully possesses the educational material, explains it in a reasoned way, deeply and comprehensively reveals the content of theoretical questions; 5 points – the student has sufficient knowledge of the educational material in its entirety, teaches it reasonably, but insignificant inaccuracies are allowed during teaching; 4 points – the student has a sufficiently complete command of the educational material, but does not teach it in a sufficiently justified way or mistakes are made; 3 points – the student does not answer the question fully enough, did not sufficiently justify his answer, the sequence of presentation of the material is violated, he made a mistake 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; insufficiently correct wording; 1 point – the student has a partial command of the educational material, has not revealed the content of the question, shows unsatisfactory knowledge of the conceptual apparatus; 0 points - the student does not know the educational material and is unable to explain it, gives the wrong answer to the question or does not answer anything at all. **Evaluation criteria for computational problems with professional (medical-biological) content:** 5 points - the correct answer is received. All the key points of the solution are substantiated; 4 points – a logically correct solution sequence is given. Some of the key points of the solution are reasonably insufficient. 1–2 minor mistakes in calculations and transformations are possible, which do not affect the correctness of further solving. The answer received may be incorrect or incomplete; 3 points – a logically correct solution sequence 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 further solving. The answer received may be incorrect, or incomplete, or only a part of the task is solved correctly; 2 points - some steps are missed in the correct sequence of solving. The key points of the solution are not substantiated. Possible errors in calculations or transformations that affect further solving. The answer received is incomplete or incorrect; 1 point - There are only a few solving steps in the solving sequence. The key points of the solution are not substantiated. The answer received is incorrect or the

		task is not completely solved; 0 points - the student did not start solving the task or the solution to the task is completely incorrect. The maximum number of points that a student can score when taking the exam is 80. The minimum number of points when passing the exam is not less than 50.
Exam in online form	The final control is carried out with using the platform MISA, according to the schedule. The duration of the exam is 2 academic hours (90 minutes). The procedure for conducting the exam in remote form includes: 1) test control, which contains 40 standard test questions, each question has five choices, with one correct answer (format A). 2) test control, which contains 40 test questions, each question has five choices, with more than one correct answer	**Evaluation criteria for test tasks:** Correct answer to 1 test with one correct answer - 1 point. Incorrect answer - 0 points. Each test with several correct answers are evaluated according to the formula m/n points, where n is the number of correct answers in the test, m is the number of correct answers given by the student. The maximum number of points that a student can score when taking the exam is 80. The minimum number of points when passing the exam is not less than 50

Maximum quantity of points, which student can collect for the current educational activity for admission to the exam (differentiated credit) makes 120 points.

Minimum quantity of points, which student can collect for the current educational activity for admission to the exam (differentiated credit) makes 72 points.

The calculation of the number of points is made on the basis of the collected student's marks on the traditional scale during the discipline study, by calculating the arithmetic mean (AM or average), rounded to two decimal places. The obtained value is converted into points according to the scoring scale as follows:

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

For convenience, a calculation table is given on a 200-point scale:

Recalculation of the average grade for the current activity into a multi-point scale for disciplines ending with an exam

4- points scale	200-points scale	4-points scale	200-points scale	4-points scale	200-points scale	4-points scale	200-points 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	Less3	Not enough
4.54	109	3.99	96	3.45	83		
4.5	108	3.95	95	3.41	82		

The grade for the discipline*, which ends with the exam, is defined as the sum of the points for the current educational activity (at least 72) and the points for the exam (at least 50).*
Points from the discipline are independently converted both to the ECTS scale and to the 4-point scale. Points from the ECTS scale are not converted into a 4-point scale and vice versa. Students' points, taking into account the number of points obtained from the discipline, are ranked on the ECTS scale as follows

ECTS	Statistical indicator
A	**The best 10 % students**
B	**The following 25 % students**
C	**The following 30 % students**
D	**The following 25 % students**
E	**The last ones 10 % students**

Ranking with the assignment of grades "A", "B", "C", "D", "E" is carried out for students of this course who are studying in one specialty and have successfully completed the study of the discipline. Students who receive grades of FX, F ("2") are not listed as ranked students. Students with an FX grade automatically receive an "E" grade after retaking.

Discipline points for students who have successfully completed the program are converted to a traditional 4-point scale according to the absolute criteria, which are listed below in the table:

Discipline points	Evaluation on a 4-point scale
From 170 to 200 points	**5**
From 140 to 169 points	**4**
From 122 to 139 points	**3**
Below the minimum number of points that the student must score	**2**

9. Course policy

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:

• independent performance of educational tasks of current and final controls without using external sources of information, except for cases permitted by the teacher;

• writing off during knowledge 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 good reason);

• missed classes are made up according to the approved schedule;

• revision of the topic of the lesson for which the student received a negative grade is carried out at a time convenient for the teacher and the student outside of classes;

• it is not allowed to rewrite the topic during the current training and final control in order to increase the grade.

10. Literature

1. Basic:

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. / A.V. Chalyi, Ya.V. Tsekhmister, B.T. Agapov – Vinnytsia, Nova Knyha, 2010. – 480 p.
2. Hobie R.K., Roth B.J. Intermediate Physics for Medicine and Biology. / R.K. Hobie, B.J. Roth. – Springer, 2007. – 616 p.
3. 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.
4. Cotterill R. Biophysics. An introduction. J. Wiley & Sons, 2002. – 396 p.

5. Davidovits P. Physics in biology and medicine. 5-th ed. – Amsterdam: Elsevier Academic Press, 2019. – 377 p.

2. Additional:

1. Medical and biological physics. Practicum for students studying the subject in English / V. M. Trusova et al. - Kharkiv: V. N. Karazin Kharkiv nat. univ., 2018. - 123 p.
2. Newman J. Physics of the Life Sciences. – Springer, 2008. – 718 p.
3. Herman I.P. Physics of the Human Body. – Springer, 2008. – 860 p.
4. Glaser R. Biophysics an introduction. 2-nd ed. – Berlin: Springer, 2012. - 407 p.
5. Hille B. Ionic Channels of Excitable Membranes. Sinauer Associates inc. Sunderland, 2004 - 816 p.

11. Equipment, hardware and software resources of the discipline/ course

- Curriculum of the discipline.
- Abstracts of lectures on the discipline.
- Multimedia presentations of lectures.
- Video content of lectures posted on the distance learning platform.
- Methodical recommendations and developments for the teacher.
- Methodical recommendations for practical classes for students.
- Methodical recommendations for students' independent work.
- Test and control tasks for practical classes.
- Questions and tasks for the final control (exam).

12. Information Resources

Docent Oksana Malanchuk is responsible for the educational process at the department
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A student scientific circle works at the department. The head of the scientific circle is Maianna PAYKUSH, Assoc. Prof., Doc. Pedagog. Sci.;marianna.gron@gmail.com

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