**Додаток 2**
*До Процедури розробки та періодичного перегляду освітніх програм*

| 1. General Information | |
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| **Faculty** | Dentistry Faculty |
| **Programme** | 22 Healthcare, 221 Dentistry |
| **Academic year** | 2023-2024 |
| **Subject** | Medical and Biological Physics, OK-6<br>Kaf_biophysics@meduniv.lviv.ua |
| **Department** | Biophysics Department<br>70010, Lviv, 3a Shymzeriv<br>+38 (032) 2-75-58-76<br>Kaf_biophysics@meduniv.lviv.ua |
| **Head of the Department** | Roman FAFULA,<br>Professor, Doctor of Biological Science<br>Kaf_biophysics@meduniv.lviv.ua |
| **Year** | I |
| **Semester** | I-II |
| **Type of the Subject** | Obligatory |
| **Lecturer** | Roman FAFULA, Doctor of Biological Science, Professor<br>kaf_biophysics@meduniv.lviv.ua;<br>Oksana MALANCHUK, Ph.D. in Physical and Mathematical Science, Associate Professor,<br>oksana.malan@gmail.com;<br>Zoryana FEDOROVYCH, Ph.D. in Biology, Associate Professor,<br>zoryana.ivanytska@gmail.com;<br>Olga MESKALO, Ph.D. in Biology<br>meskalo.olga710@gmail.com; |
| Erasmus | - |
| **Responsible for Syllabus** | Roman FAFULA,<br>kaf_biophysics@meduniv.lviv.ua |
| **Credits ECTS** | 4.0 credits |
| **Hours** | 120 h (lectures – 8 h, laboratory and practical classes – 52 h, individual student's work – 60 h) |
| **Language of Instruction** | English |
| **Consultations** | Consultations take place according to the approved schedule |
| Address, telephone number and work schedule of the clinical base, office | - |

**2. Brief review of the subject (Annotation)**

Academic program of the discipline “Medical and biological physics” provides knowledge about physical processes and physicochemical phenomena in biological environments, the influence of external factors on the human body, the physical basis of diagnostic and physiotherapeutic methods used in modern dentistry.

According to the curriculum, the discipline “Medical and Biological Physics” is studied by the I year students. The program of the discipline is structured into 2 content modules as follows:

The content module 1. Biophysics of biological systems.

In the content module 1 thermodynamics of biological processes, biophysics of cellular processes and complex systems, in particular biological membranes, circulatory system, sensory systems, molecular mechanism of cellular processes are considered.

The content module 2. Physical bases of methods of medical imaging and therapy.

In the content module 2 the effects of environmental factors on the human body: mechanical waves, electromagnetic waves of different ranges and parameters, non-ionizing and ionizing radiation; methods of diagnosis and therapy, methods of qualitative and quantitative research of drugs; medical electronic equipment for medical imaging, registration and therapy are considered.

## 3. Aim of the Subject

1. The purpose of teaching the discipline "Medical and Biological Physics" is to deepen and improve knowledge, skills and practical understanding of biophysical processes in alive organisms; physical methods of disease diagnosis and research of biological systems; the impact of physical factors on the human body in its treatment; physical properties of materials used in dentistry; physical properties and characteristics of the environment.

2. The main tasks of studying the discipline "Medical and Biological Physics" are study:

- general physical and biophysical laws that underlie human life;
- physical bases and biophysical mechanisms of action of external factors (fields) on the systems of the human body;
- physical phenomena that underlie diagnostic and physiotherapeutic (therapeutic) methods used in medical practice.

3 **Competence and learning outcomes**, the formation of which is facilitated by discipline (the relationship with the normative content of higher education graduates' training, formulated in terms of learning outcomes of Higher Education Standard).

In accordance with the requirements of Higher Education Standard, discipline ensures students' acquisition of ***competences:***

**General competences (GC)**:

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| GC 1 | The ability for abstract thinking, analysis and synthesis. |
| GC 2 | Knowledge and understanding of the subject area and understanding of the professional activities. |
| GC 3 | The ability to apply knowledge in practical situations. |
| GC 4 | The ability to communicate in the official language both orally and in writing. |
| GC 5 | Ability to communicate in English. |
| GC 6 | Skills of information and communication technologies application. |
| GC 7 | The ability to search, work out and analyze information from various sources. |
| GC 9 | Ability to identify, pose and solve problems. |
| GC 11 | The ability to work as a team member |
| GC 12 | The desire to protect the environment. |

**Professional competences (PC)***:*

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|---|---|
| PC 2 | Ability to interpret the results of laboratory and instrumental research. |
| PC 4 | Ability to plan and implement measures for the prevention of diseases of organs and tissues of the oral cavity and maxillofacial region. |
| PC 13 | Ability to assess the impact of the environment on the health of the population (individual, family, population). |

Integrative **program results outcomes (PRO)** for the formation of which contributes to the academic discipline.

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|---|---|
| PRO 14 | Analyze and evaluate state, social and medical information using standard approaches and computer information technologies. |
| PRO 15 | Assess the impact of the environment on the health of the population in a medical institution by standard methods. |
| PRO 17 | Adhere to a healthy lifestyle, use the techniques of self-regulation and self-control. |
| PRO 20 | Organize the necessary level of individual safety (own and persons cared for) in case of typical dangerous situations in the individual field of activity. |

## 4. Preliminary requirements

To successfully master the subject «Medical and Biological Physics» the student must have the following knowledge and skills:

1. Knowledge of basic concepts, laws, the essence of phenomena, measurement values for the course of physics of secondary school.
2. Knowledge of functional concepts, methods and techniques of mathematical proofs, knowledge of basic geometric quantities for the course of mathematics of secondary school.
3. Knowledge of human anatomy from the course of biology of secondary school.
4. Knowledge of the electronic structure of the atom and the nature of chemical bonds in the chemistry course of secondary school.
5. Ability to think abstractly, analyze and the ability to synthesize knowledge.
6. Ability to apply knowledge in practice.
7. Ability to search, process and analyze information from various sources.

## 5. Results of the Course

**Results**

| Code | Results | Matrix of competencies |
|---|---|---|
| *Kn-1* | The impact of physical factors on the human body, standard methods of laboratory and instrumental studies. | *PRO 14, 15, 17, 20* |
| *Kn-2* | Biophysics of human organs, systems and physical characteristics of dental materials. | *PRO 14, 15, 17, 20* |
| *Kn-3* | Environmental factors that affect health negatively in the population. | *PRO 14, 15, 17, 20* |
| *Sk-1* | To analyse research results. | *PRO 14, 15, 17, 20* |
| *Sk -2* | To analyze the biophysical parameters of human organs, systems and determine the physical characteristics of dental materials. | *PRO 14, 15, 17, 20* |
| *Sk -3* | To evaluate the environment state and negative impacts on health. | *PRO 14, 15, 17, 20* |
| *C-1* | To apply knowledge in practical situations. | *PRO 14, 15, 17, 20* |
| *C-2* | To perform research at the appropriate level. | *PRO 14, 15, 17, 20* |
| *AR-1* | Experience of independent subject activity - educational-cognitive, analytical, ability to synthesis of knowledge; | *PRO 14, 15, 17, 20* |
| *AR-2* | Ability to self-study and continue professional development; | *PRO 14, 15, 17, 20* |
| *AR-3* | Ability to control, self-control of learning outcomes. | *PRO 14, 15, 17, 20* |

## 6. Course content

| Course | Full-time form of education | |
|---|---|---|
| Classes | Hours | Groups |
| Lectures | **8** | 19 |
| Practical | **52** | 19 |
| seminars | **-** | |
| Individual | **60** | 19 |

## 7. Course content

| Code | Topic | Content | Code | Professors |
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| L-1 | Cell membranes. Membrane transport. Membrane potentials. The resting potential and the action potential. | Subject and methods of biophysics, connection with other sciences. Main chapters of biophysics. Structural elements of biological membranes. Physical properties of biomembranes. Type of gradients. Passive transport of substances through membrane structures: diffusion, osmosis, filtration Active transport, main types. Molecular organization of active transport using the example of the $Na^+$-$K^+$ pump. Secondary active transport. Resting and action membrane potentials. The nature of resting membrane potential. | *Kn-1*, *Kn-2*, *Kn-3* | DSc, Professor Roman Fafula |
| L-2 | Mechanical properties of living tissues. Fundamentals of bioreology. Biophysical foundations of hemodynamics. | Mechanical properties of living tissues. Deformation properties of biological tissues. Hooke's law. Young's modulus and Poisson's ratio. Fluidity and stress relaxation. Internal friction, viscosity. Newton's formula for the force of internal friction. Types of fluids: Newtonian and non-Newtonian. Laminar and turbulent fluid flow. Reynolds number. Basic concepts of hemodynamics. Steady flow of liquids. Continuity equation and Bernoulli's equation. Linear and volume velocities. The basic equation of fluid dynamics. Flow of viscous liquids. Poiseuille and Hagen-Poiseuille formulas. Hydraulic resistance. Biophysics of blood circulation. Work and power of the heart. Pulse wave. | *Kn-1*, *Kn-2*, *Kn-3* | DSc, Professor Roman Fafula |
| L-3 | Biophysics of sensory systems. Biophysics of hearing. Biophysics of the visual analyzer. | General characteristics and principles of functioning of the sensory system. Research methods of sensor systems. Properties of sensory receptors. Types of human receptors and sensations. Classification of sensory | *Kn-1*, *Kn-2*, *Kn-3* | DSc, Professor Roman Fafula |

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| | | receptors and sense organs. Basic biophysical properties of sensory systems and receptors.<br>Basics of bioacoustics. Biophysics of the organ of hearing. Biophysical basis of auditory sensation. Coding of information in the auditory analyzer.<br>Biophysical bacics of vision. Molecular mechanism of visual reception. Photoisomerization of rhodopsin. Circular vision. | | |
| L-4 | Biological action of ionizing radiation. Dosimetry of ionizing radiation. Applications of ionizing radiation in dentistry. | The phenomenon of radioactivity. Types of ionizing radiation. Law of radioactive decay. Activity of a radioactive preparation. Doses and doses of ionizing radiation. Linear energy transfer. Interaction of charged particles and electromagnetic radiation with matter. Mechanism of perturbation and ionization of substance molecules. Radiation-chemical damage to proteins, nucleic acids, lipids. Radiolysis of water. Reactions of cells to irradiation. Human radiation damage. Quantitative assessment of radio damage. Dose-effect curve. Modification of radio-biological effects. Ionizing radiation in medicine. | *Kn-1*, *Kn-2*, *Kn-3* | DSc, Professor Roman Fafula |
| P-1 | Thermodynamics of equilibrium states. | Subject and methods of biophysics, connection with other sciences. Main chapters of biophysics.<br>Thermodynamics of equilibrium states. Basic concepts of thermodynamics. The first law of thermodynamics. Enthalpy. Hess's law. Calorimetry. The second law of thermodynamics.<br>Thermodynamic potentials. Change in standard free energy. Chemical potential. Electrochemical potential. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-2*, *Sk-3*, *C-1*, *AR-1*, *AR-2*, *AR-3* | According to the schedule |

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| | | Thermodynamics of biological processes. | | |
| P-2 | Fundamentals of biophysics of membrane processes. Membrane transport. | Fick's equation. Membrane permeability coefficients for a certain substance. Change in the potential energy during the penetration of ions into the biomembrane. Nernst-Planck electrodiffusion equation. The Nernst equation. Electrochemical potential. Theorell equation. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-2*, *Sk-3*, *C-1*, *AR-1*, *AR-2*, *AR-3* | According to the schedule |
| P-3 | Membrane potentials. The resting potential. The action potential. Propagation of the action potential in myelinated and non-myelinated nerve fibers. | Resting membrane potential: equilibrium Nernst potential, diffusion potential, donnan potential, stationary membrane potential and Goldman-Hodgkin-Katz stationary potential equation. Change in the value of the membrane potential during the generation of the action potential and with distance. Differences in propagation of action potentials in myelinated and unmyelinated nerve fibers. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-2*, *Sk-3*, *C-1*, *AR-1*, *AR-2*, *AR-3* | According to the schedule |
| P-4 | Fundamentals of biomechanics. | Basic concepts and laws of mechanics used in biomechanics. Methods and devices for measuring biomechanical characteristics. Ergometry. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-2*, *Sk-3*, *C-1*, *AR-1*, *AR-2*, *AR-3* | According to the schedule |
| P-5 | Biophysics of muscle contraction. | Placement of contractile proteins in muscle cells. Biophysics of muscle contraction. Power and speed of a single contraction. Hill's equation. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-2*, *Sk-3*, *C-1*, *AR-1*, *AR-2*, *AR-3* | According to the schedule |
| P-6 | Fundamentals of bioreology. Study of rheological properties of biological fluids. | Methods and devices for measuring the viscosity of biological fluids. Determination of the viscosity of liquids by a capillary viscometer. | *Kn-1*, *Kn-2*, *Kn-3*, *Sk-1*, *C-1*, *C-2*, *AR-1*, *AR-2*, | According to the schedule |

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| | | | *AR-3* | |
| P-7 | Biophysics of the circulatory system. | The main hemodynamic indicators in different parts of the vascular bed: blood pressure and velocity.<br>Speed of blood movement: linear, volumetric.<br>Blood pressure and its components: hydrodynamic, static, hydrostatic.<br>Determination of blood pressure distribution in the vascular system according to the Poiseuille equation.<br>Hemodynamic resistance for series and parallel connection of vessels.<br>The speed of pulse wave propagation.<br>Metabolism processes between blood and tissues in capillaries.<br>Measurement of pressure in the circulatory system. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-8 | Surface tension of biological fluids. | Surface tension.<br>Coefficient of surface tension.<br>Methods of its determination.<br>Surfactants.<br>Gas embolism. | *Kn -1, Kn -2, Kn -3, Sk-1, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |
| P-9 | Biophysics of hearing. Sound diagnostic methods. | Objective and subjective sound characteristics. Intensity, level of intensity, loudness, their units. Hearing threshold and pain threshold. Weber-Fechner law. Structure and functioning of the auditory system.<br>Physical basics of audiometry. Audiogram and curves of the same loudness. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-10 | Biophysics of the vision organ. Biophysical bases of visual reception. Devices for research and correction of human vision. | 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. Day and twilight vision. Sensitivity of the eye. Defects of the eye and their correction. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |

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| P-11 | Physical bases of ultrasound application in dentistry: echoosteometry, Doppler ultrasonography. | Sources and detectors of ultrasound and infrasound. Parameters of ultrasonic waves. Peculiarities of propagation and biophysical bases of the effect of ultrasound and infrasound on biological tissues.<br>Ultrasound research methods in dentistry. | *Kn -1, Kn -2, Kn -3, Sk-1, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |
| P-12 | Physical bases of electrography of tissues and organs. | Physical and biophysical bases of electrocardiography. Einthoven's first concept of the genesis of the ECG (the heart is an electric dipole, the potential of an electric dipole, the lead system). Ohm's law, electrical conductivity of biological tissues. The second concept of ECG (heart is a current dipole, current dipole potential). | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-13 | Direct electric current. Electrical conductivity of cells and tissues. Physical bases of methods of galvanization, electrophoresis. | Basic characteristics of direct electric current.<br>Action of constant electric current in electrolytes.<br>Electrical conductivity of electrolytes in a constant electric field.<br>Ohm's law for electrolytes.<br>Conductivity of cells and biological tissues in a constant electric field.<br>Polarization. Types of polarization.<br>Application of direct current in medicine: electrophoresis, galvanization. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-14 | Alternating electric current. Physical bases of rheography. Rheographic methods in dentistry: rheodentography and rheoparodontography. | Physical and biophysical bases of rheography.<br>The relationship between the deformation of blood vessels and the change in their electrical resistance.<br>Vector diagrams and impedance.<br>Capacitive properties and equivalent electrical circuits of biological tissues.<br>Specificity of vector diagrams and impedance of biological tissues.<br>Impedance dispersion coefficient. | *Kn -1, Kn -2, Kn -3, Sk-1, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |

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| | | Rheographic methods in dentistry. | | |
| P-15 | The effect of alternating electric and magnetic fields of high, ultrahigh and ultrahigh frequencies on biological objects. UHF therapy in dentistry. | Physical and biophysical processes occurring in biological tissues under the influence of an alternating electric and magnetic field (conduction and displacement currents, thermal effects) of high, ultrahigh and ultrahigh frequencies.<br>Healing factors and their use in medical methods:<br>UHF therapy, microwave therapy. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-16 | Optical microscopy. Optical microscopy methods in the study of tissue and microorganisms preparations: light microscopy using immersion lenses, dark field, phase contrast, luminescent and other methods of microscopy. | Optical microscopy.<br>The main characteristics of the microscope.<br>Techniques of optical microscopy.<br>Methods of optical microscopy in the study of tissue preparations and microorganisms | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, K-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-17 | Absorption and scattering of light in biological media. | Absorption of light. Bouguer's law. Absorption of light by solutions, Bouguer-Lambert-Behr law. Concentration colorimetry. | *Kn -1, Kn -2, Kn -3, Sk-1, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |
| P-18 | Polarization of light. Polarimetry. | Methods employed to polarize light. Double refraction. Nikola's prism. Malus' law. Optically active substances. Law of Bio. Concentration polarimetry. | *Kn -1, Kn -2, Kn -3, Sk-1, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |
| P-19 | Thermal radiation. Thermography. | Thermal radiation of bodies, its characteristics. Kirchhoff's law. Absolute blackbody radiation laws: Planck's radiation law, Stefan- | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3,* | According to the schedule |

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| | | Boltzmann law, Wien's displacement law. Thermal radiation of the human body. | *C-1,* *AR-1,* *AR-2,* *AR-3* | |
| P-20 | Basics applications non-ionizing radiation of ultraviolet, visible and infrared ranges for diagnostics, prevention and treatment in medicine and dentistry. | The effect of non-ionizing radiation on a living organism. Mechanism of biological action of electromagnetic radiation of ultraviolet, visible and infrared ranges. Electronic transitions in atoms and molecules. Photochemical reactions. | *Kn -1,* *Kn -2,* *Kn -3,* *Sk-2,* *Sk-3,* *C-1,* *AR-1,* *AR-2,* *AR-3* | According to the schedule |
| P-21 | Luminescence. Mechanisms of luminescence. Laws and characteristics of luminescence. Applications in diagnostics. | Luminescence. Luminophores. Types of luminescence. Mechanisms of luminescence: resonant fluorescence, spontaneous illumination, sensitized luminescence. Stokes radiation. Anti-Stokes radiation. Stokes' law. Quantum output of luminescence. Vavlov's law. Energy output. Concentration extinction. Application of the phenomenon of luminescence in stomatology. | *Kn -1,* *Kn -2,* *Kn -3,* *Sk-2,* *Sk-3,* *C-1,* *AR-1,* *AR-2,* *AR-3* | According to the schedule |
| P-22 | Laser and it applications in dentistry. | Difference between spontaneous and induced radiation. Equilibrium (Boltzmannian) and inverse population of energy levels. Classification of lasers. The principle of operation of a quantum-optical generator. Properties of laser radiation. Processes occurring under the influence of laser radiation in biological tissue. Use of lasers in dentistry. | *Kn -1,* *Kn -2,* *Kn -3,* *Sk-1,* *C-1,* *C-2,* *AR-1,* *AR-2,* *AR-3* | According to the schedule |
| P-23 | X-rays. Methods of X-ray diagnostics and X-ray therapy in medicine and dentistry. | The range of wavelengths of X-ray radiation. Moseley's Law. X-ray energy. Penetration depth. Intensity of X-ray radiation. Mass absorption coefficient and linear absorption coefficient. The flow of X-ray radiation. | *Kn -1,* *Kn -2,* *Kn -3,* *Sk-2,* *Sk-3,* *C-1,* *AR-1,* *AR-2,* *AR-3* | According to the schedule |

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| P-24 | Radioactivity. Ionizing radiation and its effect on the body. Physical bases of radiodiagnostics and radiotherapy. | The main types of radioactive decay. Particle flow. Surface density of particles. The surface density of the particle flow. Particle energy flow. Surface energy density. Surface energy flow density. Linear stopping power of a substance. Average linear distance of a particle. Average mass distance of a particle. Linear ionization density. Linear energy transfer. Steering wheel The law of decreasing ionizing particle flux density. The law of decreasing intensity of γ-radiation. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-25 | Dosimetry of ionizing radiation. The effect of ionizing radiation on the body. Quantitative assessment of radio damage. Modification of radiobiological effects. | Dosimetric values and their measurement units. Dosimeters. | *Kn -1, Kn -2, Kn -3, Sk-2, Sk-3, C-1, AR-1, AR-2, AR-3* | According to the schedule |
| P-26 | Radiation threats and security under martial law. Test credit | Radiation damage. Irradiation for non-medical and medical purposes. Pollution levels. Household dosimetric devices. Medical consequences of a large-scale radiation accident. Measures to protect against radiation exposure in different ways of spreading radioactive substances. Differentiated class | *Kn -1, Kn -2, Kn -3, Sk-1, Sk-2, Sk-3, C-1, C-2, AR-1, AR-2, AR-3* | According to the schedule |
| ISW-1 | Thermodynamics of irreversible processes. | Thermodynamics of irreversible processes (linear law for flows and thermodynamic forces, cross transfer processes, Onsager's relation, entropy production, conjugation of flows, steady state, Prigozhin's theorem). | *Kn-1, Kn-2, Kn-3* | According to the schedule |
| ISW-2 | Physical properties of biological membranes. Liquid crystalline | Liquid crystalline state of biomembranes. Dynamic properties of membranes. | *Kn-1, Kn-2, Kn-3* | According to the schedule |

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| | state of biomembranes. Dynamic properties of membranes. | | | |
| ISW-3 | Ion channels of cell membranes. Ionic currents in the axon and methods of their study. Influence of drugs on the value of membrane potential. | Cable theory. Equivalent electrical diagram of the excitable membrane section. Phenomenological equations of Hodgkin-Huxley. The concept of gate ion currents of potential-controlled ion channels. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-4 | Statics. Human musculoskeletal system. | Basic concepts of the mechanics of translational and rotational movements. Equations of motion, conservation laws. Human musculoskeletal system. Dynamic and statistical work of a person in various types of his activity. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-5 | Smooth muscle biophysics. Biomechanics and energy of the heart muscle. | Biophysics of smooth muscles. Biomechanics and energetics of heart muscle. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-6 | Models of studying blood circulation. Measurement of blood flow velocity. | Blood circulation study models: linear model with distributed parameters; electrical model for studying hydrodynamic phenomena in the vascular system; mechanical model of vascular systems.<br>Ultrasonic method of measuring the speed of blood flow. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-7 | Blood rheology: parameters, effect on blood flow. | Hemorheological indicators of blood.<br>Factors affecting blood viscosity: hematocrit, plasma properties, aggregation and deformability of cellular elements.<br>Physical properties of erythrocyte aggregates in blood vessels.<br>Methods of determining blood viscosity.<br>Blood viscosity and the use of its value in the diagnosis of | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |

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| | | diseases. | | |
| ISW-8 | Biomechanics of respiration. | Biophysics of respiration. Biomechanics of inhalation and exhalation. Distension of the lungs. Breathing resistance. The work of breathing. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-9 | Basic kinematic and dynamic characteristics of mechanical oscillations and waves. | Basic kinematic and dynamic characteristics of mechanical vibrations and waves. Mechanism of acoustic waves propagation. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-10 | Laws of geometric optics. Refractometry. | Laws of geometric optics. Basic photometric quantities. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-11 | The effect of mechanical waves on the body. Principles of ultrasonic imaging. Ultrasonography. | Ultrasound application in medicine for diagnosis and therapy. Ultrasound research methods in medicine. Effect of vibrations on the human body. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-12 | Electrography in dentistry. | Electrography in dentistry and medicine. Electromyography and its role in dentistry. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-13 | Methods of electrotherapy in dentistry. | Therapeutic effect of constant and alternating electric and magnetic fields and their applyig in dentistry. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-14 | Methods of optical microscopy in dentistry. | Techniques of optical microscopy. Dental microscope. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-15 | Investigation of optical properties of biological tissues. Spectroscopy. | Optical properties of biological tissues. Methods of studying the optical properties of biological tissues. Physical basis of the spectroscopy method. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-16 | The wave nature of light. Polarizing microscope. | The principle of operation of a polarizing microscope. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |

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| ISW-17 | Temperature topography of the human body. | Constancy of body temperature.<br>Physical factors that influence the formation of a thermographic picture: convection, evaporation, radiation.<br>Physiological factors of formation of body temperature field.<br>Registration of the temperature relief of the surface of the human body. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-18 | Chemiluminescence. Application of chemiluminescence in diagnosis. | Mitogenetic glow.<br>Bioluminescence.<br>Ultra-weak glow.<br>Luminescent analysis.<br>The method of fluorescent probes. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-19 | Laser devices: rules of safe operation.<br>Biological effects of laser radiation on the tissues. | Types of lasers.<br>Rules for working with an optical quantum generator.<br>Effect of laser radiation on biological tissues.<br>The difference in the use of high and low intensity laser radiation. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-20 | Resonant methods of quantum mechanics. NMR tomography. | The Zeeman effect.<br>Conditions under which nuclear magnetic resonance occurs.<br>NMR tomography. NMR-tomogram. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-21 | X-ray imaging, sources of X-rays. Radiography. Mammography. Angiography. Computed tomography. Save formats and image analysis tools. | X-ray tube Application of X-ray radiation in medicine.<br>Methods of obtaining images of internal human organs for diagnostic purposes: fluorographic, stomatological, mammographic, CT, angiographic. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-22 | Physical principles of radiation therapy. | The difference between the use of ionizing radiation for diagnosis and for therapy.<br>Types of radiation therapy: gamma therapy, X-ray therapy, linear accelerator therapy, brachytherapy. | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |
| ISW-23 | Nuclear radiation used in medicine. | Classification and characteristics of radioactive elements. The use of radionuclides in diagnostics | *Kn-1*, *Kn-2*, *Kn-3* | According to the schedule |

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|---|---|---|---|---|
| | | and therapy: the method of labeled atoms, autoradiography. Cobalt, rhodon therapy. Physical and biophysical problems associated with the accident at the Chernobyl NPP. | | |

The following teaching methods are used during practical classes: verbal methods (lecture, conversation); visual methods (illustration, demonstration, frontal experiment); practical methods (laboratory work and solving problems with professional content); individual work of students on comprehension and mastering of material (research of scientific and information sources; creation of presentations); use of the project method to ensure interdisciplinary integration (solving problems with medical and biological content).

**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

| **Learning outcome code** | **Code of the type of classes** | **Method of verification of learning outcomes** | **Enrollment criteria** |
|---|---|---|---|
| Kn-1, Kn-2, Kn-3<br>Sk-1,Sk-3,<br>C-1 – C-2<br>AR-1 – AR-3 | L-1 – 4,<br>P-1 – 26,<br>ISW-1 – 23 | Test control on MISA platform (10-15 test tasks with one correct answer);<br><br>Oral interview and/or written control containing theoretical questions (including questions from independent work) and tasks of medical and biological content.<br><br>Practical experience / performance report laboratory work. | **Test control:**<br>50-69% – satisfactory;<br>70-89% – good;<br>90-100% - excellent.<br><br>**Oral interview and/or written control**: evaluation according to evaluation criteria.<br><br>**Practical skills / report on completed laboratory work**: pass / fail |

| **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 current performance. | |
| Type of a final examination | Verification | Criteria |

| **Criteria of evaluation for the differential test** | | |
|---|---|---|
| **The differential test** | Differentiated test is a form of final control, which consists in evaluating the student's assimilation of educational material from the academic discipline based on the average score of the results of the current control and points for the performance of individual control tasks in the final lesson. | **Evaluation criteria for test tasks**: correct answer to 1 test - 2 point.<br>Maximum quantity of points, which the student can collect on the differentiated credit is 80 points. |

| | | |
|---|---|---|
| | Differentiated test is carried out in writing according to standardized versions of control tasks compiled in accordance with the curriculum of the academic discipline.<br><br>The structure of the control task and the criteria for evaluating each type of tasks of differentiated test: 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 – 2 point for each test task). | Minimum quantity of points on the differentiated credit 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 table of conversion into 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-grade scale | 200-grade scale | 4-grade scale | 200-grade scale | 4-grade scale | 200-grade scale | 4-grade scale | 200-grade 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** | **Insuffi-ciently** |
| **4.54** | **109** | **3.99** | **96** | **3.45** | **83** | | |
| **4.5** | **108** | **3.95** | **95** | **3.41** | **82** | | |

**Point of the discipline,** which is completed with an exam is defined as the sum of points for current educational activity (at least 72) and points for the exam (at least 50).

The scores from discipline are converted to the ECTS scale and to the 4-point scale independently. The ECTS scale points are not converted to the 4-point scale and vice versa. Amount of points which is charged to students, from the discipline is converted in scale ECTS thus:

| Estimation ECTS | Statistics |
|---|---|
| A | The best 10 % of students |

| | |
|---|---|
| B | The following 25 % of students |
| C | The following 30 % of students |
| D | The following 25 % of students |
| E | The last10 % of students |

"A", "B", "C", "D", "E" ranking is made for students studying at one of the specialties and who have successfully completed study course.

Students who receive grades FX, F ("2") are not included in the list of students ranked. Students with an FX grade automatically receive an "E" score after retaking.

Points of discipline for students who have successfully completed the program are converted into traditional 4-point scale by absolute criteria, which are listed in the following table:

| **Points from discipline Estimation on 4-point scale** | **Points from discipline Estimation on 4-point scale** |
|---|---|
| From170 to 200 points | 5 |
| From140 to 169 points | 4 |
| From 139 points to the minimum number of points that student must scores | 3 |
| Less than minimal quantity of points, which student must collect | 2 |

## 9. Course policy

The policy of the 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 control and final control 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 (unless there is a valid reason);

• missed classes are reworking according to the approved schedule;

• revision of the lesson's topic for which the student received a negative grade is carried out at a time convenient for the teacher and the student and differe than time for class given in schedule;

• 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**

Methodical instructions for students and teachers, workbooks, tables, diagrams, devices are necessary for conducting laboratory classes for students of higher education.
Additional methodological recommendations posted on the misa platform.

**12. Information Resources**

Associated professor Oksana Malanchuk is responsible for the educational process at the department
A student's scientific circle works at the department.
Practical classes are held in the classrooms of the department at the address of st. Shimzeriv, 3a. Theoretical building, II floor
Web page of the department: https://new.meduniv.lviv.ua/kafedry/kafedra-biofizyky/
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