MINISTRY OF HEALTHCARE OF UKRAINE
POLTAVA STATE MEDICAL UNIVERSITY

Department of Medical Informatics and Medical and Biological Physics

SYLLABUS

MEDICAL AND BIOLOGICAL PHYSICS

compulsory discipline

level of higher education	the second (master's) level of higher education
field of knowledge	22 «Healthcare»
specialty	222 «Medicine»
academic qualification	Master of Medicine
professional qualification	Doctor
academic and professional program	«Medicine»
mode of study	full-time
course(s) and semester(s) of study of the discipline	I year, I – II semester

Poltava – 2021

INFORMATION ABOUT TEACHERS TEACHING THE DISCIPLINE

Full name, patronymic of teachers, scientific degree, academic title	Isychko Lyudmyla Volodymyrivna - Ph.D. Korovina Lidia Dmitrivna - Ph.D. Makarenko Volodymyr Ivanovych - Ph.D. Makarenko Oleksandr Volodymyrovych - Ph.D., Associate Professor Samoilenko Serhiy Oleksandrovych - Ph.D., Associate Professor Bychko Marina Viktorivna – Ph.D. Stetsenko Sergey Anatolyevich
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MAIN CHARACTERISTICS OF THE ACADEMIC DISCIPLINE

The scope of the academic discipline

Number of credits / hours – **4/120**, of which:
Lectures (hours) – **18**
Practical (hours) – **50**
Independent work (hours) – **52**
Type of control: Final module control

The policy of the academic discipline

In order to successfully complete the course and take the test, it is necessary to study the educational material in full in accordance with the plan of practical classes and perform independent work.

To successfully acquire the material, the student should:

– come to class on time;
– attend all practical classes (in case of absence - work out);
– independently acquire the material of the missed lesson;
– honestly prepare for class;
– actively work in the classroom;
– turn off the phone in class (if there is no need to use it);
– to be tolerant and polite, open to constructive discussion;
– to prevent violations of academic virtue during project, individual and independent activities.

When organizing the educational process at PSMU, lecturers and students act in accordance with:

Regulation on the organization of the educational process at Poltava State Medical University;

Regulation on the academic integrity;

Internal code of order for students of Poltava State Medical University;

Documents are allocated on site: (https://www.umsa.edu.ua/n-process/department-npr/normativni-dokumenti**).**

Description of the discipline.

The discipline (elective course) "Medical and biological physics " provides students who are preparing for the second (master's) level of knowledge 22 "Healthcare", specialty 222 "Medicine" knowledge, skills and competencies on a) wildlife phenomena, occurring at all levels of its organization, from molecules and cells to the biosphere as a whole; b) the mechanisms of action of external fields on the human body, which underlie the functioning of modern electronic medical equipment and determine the main principles of its operation and use.

The main sections of the discipline "Medical and Biological Physics" for for applicants for higher education seeking to become masters in the field of knowledge 22 "Healthcare", specialty 222 "Medicine" are as follows: elements of mathematical processing of medical and biological information (basics of mathematical analysis, basics of probability theory and statistical processing of medical and biological data); biological physics (physical properties of biomembranes, ion transport through membrane structures, electrical membrane potentials of rest and action); medical physics (medical electronic equipment in diagnostics and therapy, medical application of basic physical laws together with hemodynamics and bioreology, optical and quantum-mechanical methods, the effect of ionizing radiation on humans, the basics of dosimetry of ionizing radiation, etc.).

The lecture course of the discipline "Medical and Biological Physics" is accompanied by a laboratory workshop, which provides additional competencies and practical skills to applicants for higher education, in particular when using modern electronic medical equipment, dosimetric radiation monitoring devices, other physical and biophysical methods in medicine.

The knowledge and skills acquired by applicants for higher education majoring in 222 "Medicine" at the Department of Medical and Biological Physics are a necessary components of the formation of professional competencies of specialists of the second (master's) level of higher education.

Prerequisites and postrequisites of the discipline (interdisciplinary links)

– It based on study of medical and general chemistry, medical biology, general physics.

– It lays the foundationsfor the study of disciplines: normal physiology, biological and bioorganic chemistry, biostatistics, histology, pathophysiology, radiology and radiation medicine, hygiene and ecology, ophthalmology, otorhinolaryngology.

The aim and tasks of the academic discipline:

– the purpose of teaching the discipline is to form in applicants for higher education a system of knowledge about the basic physical principles and approaches to the study of processes in wildlife, physical and technical principles of medical and technical devices used in practical medicine, the use of mathematical methods in biomedical research, which subject competencies in medical and biological physics and is an integral part of the professional competence of future doctors, health professionals, as well as the basis for the study of professionally oriented natural and clinical disciplines in medical institutions of higher education in Ukraine.

– the main objectives of the discipline are acquisition by applicants for higher education with practical-oriented professional competence: to interpret the general physical and

biophysical patterns that underlie the functioning of the human body, to explain the physical basis and biophysical mechanisms and effects of physical fields with the human body; explain the physical basis of operation and use of modern (electronic) medical devices; process the results of medical and biological research, prove the probability of conclusions using mathematical (statistical) methods.

Competences and learning outcomes in accordance with the academic and professional program, the formation of which is facilitated by the discipline (integral, general, special)

Integral competence:

- Ability to solve typical and complex specialized tasks and practical problems in professional activities in the field of health care in specialty "Medicine" or in the process of further training providing research and/or innovation, and characterising of complexity and ambiguity of conditions and requirements.

General competencies:

− ability to abstract thinking, analysis and synthesis, the ability to learn and acquire modern knowledge.
− ability to apply knowledge of medical and biological physics in practical situations.
− knowledge and understanding in the field of sciences that form the foundations of biomedical physics and understanding of professional activity.
− ability to adapt and act in a new situation.
− ability to communicate in the state language both orally and in writing; ability to communicate in a foreign language, ability to use international Greco-Latin terms, abbreviations and clichés in professional oral and written speech.
− ability to use information and communication technology.

Special (professional) competencies:

− ability to determine the necessary list of laboratory and instrumental studies and evaluate their results.
− skills of performing medical manipulations.
− ability to assess the impact of the environment, socio-economic and biological determinants on the health of the individual, family, population.

Program learning outcomes, the formation of which is facilitated by the discipline:

− prescribe and analyze additional (mandatory and optional) examination methods (laboratory, radiological, functional and/or instrumental), evaluate information for the purpose of differential diagnosis of diseases, using knowledge about the human, his organs and systems, based on the results of laboratory and instrumental research, by making an informed decision and using standard techniques adhering to the relevant ethical and legal norms.
− perform medical manipulations (according to list 5) in a health care facility, at home or at work on the basis of a previous clinical diagnosis and / or indicators of the patient's condition, using knowledge about the person, his organs and systems, adhering to relevant ethical and legal norms, by making an informed decision and using standard techniques.
− assess the impact of the environment, socio-economic and biological determinants on the health of the individual, family, population; to analyze the incidence of the population, identifying risk groups, risk areas, time and risk factors in the health care facility, using statistical and laboratory methods.
− adhere to the requirements of ethics, bioethics and deontology in their professional

activities.

− provide the necessary level of individual safety (own and caregivers) in the event of typical dangerous situations in the individual field of activity.

Learning outcomes for the discipline:

upon completion of the study, applicants for higher education should:

to know:

general physical and biophysical patterns that underlie the processes occurring in the human body; characteristics of physical external factors affecting the human body and biophysical mechanisms of these influences; purpose and principles of electronic medical equipment, safety precautions when working with it.

to be able to:

use medical equipment used in diagnostics, electrical stimulation and physiotherapy (in particular, in electrocardiography, rheography, impedance plethysmography, audiometry, optical and quantum mechanical devices and systems, radiometric and dosimetric control devices).

Thematic plan of lectures (by modules), specifying the basic issues, which are considered at the lecture

No	Topic name	Hours
	Module 1. Medical and biological physics. *Content module 2. Biological physics*	
1	Fundamentals of biomechanics and bioacoustics. - Types of bone connections in the skeleton. - Degrees of freedom. - Types of levers. Lever rule. - Muscles classification. - Skeletal muscle structure. - Mechanism of muscle contraction. - Oscillations, their types, parameters. - Transverse and longitudinal waves. - Sound waves. - Objective and subjective characteristics of sound. - Sound perception area, volume scale. - The structure of the ear. - The mechanism of functioning of the ear. - Sound methods of research of a human body. - Ultrasound in medicine. - The effect of infrasound on the body.	2
2	Fundamentals of bioreology and hemodynamics. – Laminar and turbulent flow. – Bernoulli’s law. – Viscosity of liquids. – Surface tension of liquids. – Circulatory system. – Pulse wave. – Blood pressure. Methods of measuring blood pressure.	2

3	Fundamentals of membrane biophysics. – Membrane models. – Structure of biological membranes. – Functions of biological membranes. –Passive transport of substances across cell membranes. – Diffusion: simple diffusion, facilitated diffusion, exchange diffusion. – Filtration. – Osmosis, electroosmosis, abnormal osmosis. – Compatible transfer of substances across cell membranes, its types. – Active transport of substances across cell membranes, its types.	2
Content module 3. Medical physics		
4	Physical basis of electrography. – Electric charge, Coulomb's law. – Electric field; intensity, electric field potential. – Electric dipole, electric dipole moment – History of the discovery of biopotentials, Einthoven's theory. – Other types of electrography (EEG, EMG, etc.) – Membrane theory of potentials. – Rest potential. – Action potential. – Phases of transmembrane action potential of myocardial cells. – Depolarization and repolarization of the heart muscle. – Practical electrocardiography	2
5	Electrical properties of biological objects. Rheography. – Electric current, types of conductivity. – Elements of electrical circuits. – Wheatstone Bridge. – The concept of impedance. – The equivalent circuit diagram of tissue. – Electrophysiotherapy. – UHF therapy. – Physical processes in tissues under the action of electromagnetic fields. – Polarization in an alternating electric field. – Inductothermy. – Impedance plethysmography.	2

6	Physical principles of optical research methods. – Geometric optics. Light beam. – The law of light reflection – The law of light refraction – Refraction and reflection in wave optics. – The phenomenon of complete internal reflection. – Fiber optics. – Lenses. – Optical microscope. – Diffraction – Polarization. – The structure of the eye. – Accommodation of the eye. Visual acuity. – Nerve optical pathways. – Adaptation of the eye	2
7	Fundamentals of quantum mechanics. – Prerequisites Quantum Mechanics – Radiation of a completely black body. – Wien's displacement law. – Stefan-Boltzmann law. – Bouguer-Lambert-Beer law. – Planck's hypothesis – Laws of the photo effect – Einstein's theory – Compton effect – Corpuscular-wave dualism – De Broglie's hypothesis – The structure of the atom. Rutherford's experiment – Planetary model of atomic structure – Bohr's postulates – De Broglie's theory – Spectrum. Spectroscopy.	2
8	X-rays. Interaction of ionizing radiation with biological tissues. – Ionizing radiation. – Cathode rays. – The structure of the X-ray tube. – Braking and characteristic X-radiation. – Interaction of X-rays with matter. – Coherent scattering. – Photo effect. – Incoherent scattering. – Shadow projections. – Computed tomography.	2

9	Radioactivity. The use of ionizing radiation in medicine. – Discovery of radioactivity. – Types of radioactive radiation. Isotopes. – Penetrating power of radioactive radiation. – The nature of radioactive radiation. – Nuclear binding energy. Stable and unstable nuclei. – Alpha, beta, and gamma decay. – Radioactive series. – Law of radioactive decay. – The half-life – Dosimetry. – Equivalent and effective equivalent dose. – Biological action of radioactive radiation. – Radioisotope research methods.	2
Total		**18**

Thematic plan of seminar classes by modules and content modules, specifying the basic issues, which are considered at the seminar class

– seminar classes are not provided by programme.

Thematic plan of practical classes by module and content modules, specifying the basic issues, which are considered at the practical class

No	**Title of the topic**	**Number of hours**
Module 1. Medical and biological physics *Content module 1*. Fundamentals of mathematical processing of medical and biological data		
1.	Medico-biological quantities. Functions. Derivative and differential function. – Medico-biological quantities and dimensions. – Functions and their properties. – Derivative and differential function. – Application of differential to solve problems in biology and medicine.	2
2.	Indefinite and definite integrals. – Antiderivative function. – Indefinite and definite integral. – Basic properties of integrals. – Basic methods of integration. – Application of integration to solve problems in biology and medicine.	2

3.	Fundamentals of probability theory. – The concept of trials and events. – The concept of probable, impossible and accidental (random) event. – The concept of compatible, incompatible and opposite events. – Dependent and independent events. – The concept of probability. – Theorems of addition and multiplication of probabilities. – Bernoulli's formula. – The formula of total probability. – Bayesian formula.	2
4.	Fundamentals of mathematical statistics. – Basic concepts of mathematical statistics. – Calculation of basic statistical characteristics. – Student's criterion. – Assessment of the reliability of direct measurements. – Assess the statistical significance of difference of two independent sample populations. – Correlation analysis in medicine. – Assessment of the statistical significance of the correlation dependence. – Solving problems of biology and medicine with the use of mathematical statistics.	2
Content module 2. Biological physics		
5.	Mechanical properties of biological tissues. Determination of the Young's modulus of bone. – The concept of deformation. Types of deformation. – Absolute and relative elongation, mechanical stress. Hooke's law. – Deformation diagram, its main areas; characteristic points. – Young's modulus , methods of its definition. – Deformation properties of biological tissues (bones, skin, lungs, etc.).	2
6.	Biophysics of muscle contractions. Dynamometry. Ergometry. – Muscle structure. – Mechanism of muscle contraction. – Muscle contraction modes. – Muscle force and energy characteristics. Hill's equation. – Determination of muscle force and work (dynamometry, ergometry.)	2

7.	Oscillations and waves. Sound, infrasound and ultrasound. Acoustic methods in medicine. Biophysics of the hearing organ. Audiometry. – Basic physical characteristics of oscillations – Mechanical waves, their classification – Infrasound, The effect of infrasound on biological tissues and human organs. – Ultrasound. The effect of ultrasound on biological tissues and human organs. – Application of ultrasound and infrasound in medicine. – Sound, its physical and physiological characteristics. Sound (acoustic) pressure. – Use of sound for diagnostics. – Structures of the human sound analyzer. – The mechanism of sound sensation. – Audibility threshold and pain threshold. – Characteristics of auditory sensation. Weber-Fechner law. – Audiometry.	2
8.	Surface phenomena. Determination of surface tension coefficient. Gas embolism. – Superficial phenomena. Surface tension, wetting phenomenon, capillary phenomena. – Surface tension coefficient. – Methods for surface tension coefficient determining. – Determination of the surface tension of the liquid by the method of the drop separation. – The mechanism of gas, fat and thromboembolism.	2
9.	Viscosity of liquids. Methods for determining the viscosity of liquids. – Stationary fluid flow. The condition of continuity of the stream. Linear and volumetric velocities. Bernoulli's equation. – Internal friction (viscosity). Newton's formula for internal friction. – Newtonian and non-Newtonian fluids. – Laminar and turbulent flow. Reynolds number. Poiseuille's formula. Hydraulic resistance. – Methods for measuring the viscosity of liquids. – Blood viscosity, methods for its determination. – Viscosity measurement with a capillary viscometer.	2
10.	Biophysics of blood circulation. Analysis of the heart work. Methods of measuring blood pressure. – The structure of the human cardiovascular system. – The structure and principle of the heart. – Determination of heart work. – Distribution of blood velocity and pressure in blood vessels. – Systolic (maximal), diastolic (minimal) and pulse pressure. – Methods of measuring blood pressure. – Measurement of blood pressure by the method of Korotkov.	2

11.	Structure and functions of biological membranes. Active and passive transport. Study of permeability of biological membranes. - The main structural components of biological membranes. - Physical properties of biomembranes. Liquid crystal state of biomembranes. - Functions of the biological membrane. – Passive transport of substances through membrane structures. – Fick's equation. Diffusion rate. Nernst-Planck equation. Electrochemical gradient and potential. – Methods of studying the permeability of biological membranes. – Active transport, main types. – Secondary active transport. – Molecular organization of active transport on the example of K+-Na+ -pump. – The nature of the rest membrane potential. – Nernst equilibrium potential. – Diffusion equilibrium potential. – Donnan's potential. – Stationary Goldman-Hodgkin-Katz potential. – Nernst-Planck electrodiffusion equation. – Action potential. Hypothesis of origin. – Propagation of the action potential of pomyelin and non-myelin nerve fibers. – The speed of the nerve impulse.	2
	Content module 3. Medical physics	
12.	Fundamentals of electrodynamics. Medical equipment. Analysis of the work of the Wheatstone bridge. – Basic concepts of electrodynamics. – Current, voltage, electrical resistance. Ohm's law. – The structure and principle of operation of the Wheatstone Bridge. – Method of measuring electrical resistance using the Wheatstone bridge. – Bridge circuits in medical equipment. – General characteristics and classification of electronic medical devices. Use of electronic medical equipment in diagnostics, electrical stimulation and physiotherapy. – The concept of electrodes and their classification. – The concept of sensors and their classification .	2

13.	Physical bases of electrocardiography (ECG). – Electric field; electric field potential. – Electric dipole, electric moment of the dipole. – Einthoven's theory. – ECG model as a confirmation of Einthoven's concept of ECG genesis. – Phases of the transmembrane action potential of the myocardial cell. Depolarization and repolarization of the heart muscle. – Practical electrocardiography. – Structure and principle of operation of the electrocardiograph. – ECG recording technique in standard leads.	2
14.	Physical basics of rheography. – Electrical characteristics of biological tissues. Tissues conductivity. – Impedance of biological tissues. Equivalent electrical circuit. Impedance dispersion. – Physical basics of rheography. – Structure and principle of operation of the rheograph. – Methods of measuring the impedance of biological tissues and the rheogram registration. Rheogram analysis.	2
15.	Electrokinetic phenomena. Electrophoresis. – Direct electrokinetic phenomena. – Inverse electrokinetic phenomena. – Double electric layer and its nature. The nature of electrokinetic phenomena. Zeta potential (electrokinetic potential). – Medical electrophoresis. Advantages of electrophoresis – Electrokinetic phenomena in the body. – The use of electrokinetic phenomena in biomedical research. – Determination of ion mobility by electrophoresis on paper.	2
16.	Basics of UHF therapy and inductothermy. – The effect of an alternating ultra-high frequency electromagnetic field on biological objects. – Primary mechanisms, currents and thermal effects, specific action. – Therapeutic factors and their use in medical methods (UHF therapy, inductothermy).	2
17.	Refractometry. Determination of the refractive index of liquids. – Geometric optics: basic concepts, laws. – Fiber optics. – Structure and principle of operation of the Abbe refractometer. Methods of refractometry. – Determination of the refractive index of a liquid using a refractometer	2
18.	Biophysics of vision. – Eye structure. Defects of vision and vision correction. – Determination of acuity and viewfield.	2

19.	Optical microscopy. Techniques of microscopy. – Structure and principle of operation of an optical microscope – Techniques of optical microscopy. – Method of determining the size of micro-objects using an optical microscope.	2
20.	Thermal radiation of bodies, its characteristics. The concept of thermography. – Thermal radiation. Emissivity and absorption. – Absolutely black body and gray body. – Kirchhoff's law. Laws of thermal radiation of an absolutely black body. – Use of infrared rays for diagnostic purposes (thermometry, thermography, thermal vision). – Structure and principle of operation of the thermograph	2
21.	Interaction of light with substance (dispersion, absorption, scattering, photo effect). Photometry. – Interaction of light with substance (dispersion, absorption, scattering, photo effect). – Photometry. Basic photometric quantities. The law of illumination. – Structure and principle of operation of the luxmeter. – Checking the law of illumination. – Spectrophotometry. Colorimetry. Nephelometry	2
22.	Stimulated radiation. Determination of erythrocyte size. – Induced radiation. – Structure and principle of operation of the laser. – Properties of laser radiation. – Lasers and their use in medicine. – Method of determining the size of erythrocytes using a laser.	2
23.	X-rays. – The nature of X-rays. – Braking and characteristic radiation. – X-ray tube. – X-ray spectrum. – Interaction of X-rays with substance and body tissues. – Bouguer's law. – X-ray diagnostics and X-ray therapy.	2
24.	Radioactivity. The use of ionizing radiation in medicine. Dosimetry of ionizing radiation. – Radioactivity. Radionuclides. – Interaction of ionizing radiation with substance and body tissues. – Protection against ionizing radiation. – Dosimetry (dosimetric values, dosimeters).	2
25.	**Final modular control**	2
Total		**50**

Self-directed work

No.	Title of the topic	Number of hours
1.	Preparation for practical training is theoretical preparation and practical skills development	44
2.	Preparation for the final modular control	8
3.	Studying the topics that are not included in the classroom plan	0

Individual tasks – the program does not provide.

The list of theoretical questions for applicants' preparation for the final module control and semester final attestation

Module 1. Medical and biological physics.

1. Deformations, their types. Elasticity and plasticity. Absolute and relative deformation. Mechanical stress. Hooke's law. Joung's module (of bones).

2. Surface tension. The mechanism of occurrence. The phenomenon of wetting, unwetting. Surface tension coefficient and methods of its determination. Embolism, its types, mechanisms of formation.

3. Internal friction. Viscosity. Newton's formula for internal friction. Newtonian and non-Newtonian fluids. Blood viscosity. Methods of determining the viscosity of liquids.

4. Stationary fluid flow. Continuity equation. Linear and volumetric velocities. Laminar and turbulent flow. Reynolds number.

5. The concept of an ideal fluid. Bernoulli's equation. Flow of viscous liquids. Poiseuille's formula. Hydraulic resistance.

6. Biophysics of blood circulation. Heart work and power. Distribution of speed and pressure in blood vessels. Methods of blood pressure measurement (invasive, non-invasive). Korotkov's method, the nature of Korotkov's tones.

7. Structure, functions of biological membranes. Physical properties of biomembranes. Liquid crystal state of biomembranes. Functions of proteins.

8. Passive transport of substances through membrane structures. Fick's equation. Diffusion rate. Electrochemical gradient and potential. Osmosis and filtration.

9. Active transport, it main types. Molecular organization of active transport on the example of K-Na-pump activity. Secondary active transport.

10. The nature of the rest membrane potential. The mechanism of rest potential formation. Action potential (AP). Origin and development of AP.

11. Mechanical waves. Types and characteristics of mechanical waves. Oscillations, them types. Self-oscillation. Resonance. Sound waves, their types. Physical characteristics of sound, their connection with physiological characteristics. Weber-Fechner law.

12. Audiometry. Audiogram. Intensity scale and volume scale, units. Threshold of audibility and pain threshold. Infrasound, physical characteristics of infrasound. The effect of infrasound on biological tissues and human organs.

13. Ultrasound. Basic properties and features of ultrasound propagation. The effect of ultrasound on biological tissues and human organs. Use in medicine.

14. The human hearing system. Role and functions of the middle, outer, inner ear. Physics of hearing, characteristics of auditory sensation.

15. Biomechanics. Muscles. Dynamic and static work of human muscles in different

types of its activities. Types of contractions. Muscle strength, work, power. Methods of their measurements. Ergography.

16. Degrees of freedom of the material point, material body and joints. Levers. Classification of levers. Moment of force. Lever rule (equilibrium condition).

17. Deformation properties of biological tissues (bones, muscles, vessels, skin). Mechanical stress. Deformation diagram.

18. Electrical characteristics of biological tissues. Ohm's law in differential form. Conductivity of biological tissues. Capacitive properties. Equivalent electrical circuit.

19. Biophysical bases of electrography. The concept of an equivalent electric generator. Einthoven's concept of the genesis of the ECG (integral electrical vector of the heart, dipole potential, lead system).

20. Heart as a current electric dipole (current dipole and its characteristics, dipole potential of the heart).

21. Impedance of biological tissues. Impedance dispersion. Physical bases of rheography.

22. Physical processes in biological objects under the action of electric and magnetic fields (polarization, conduction currents, inductive and bias).

23. Physical bases of therapeutic methods (galvanization, franklinization, diathermy, inductothermy, darsonvalization, UHF and microwave therapy, microwave resonance therapy). Thermal and specific action.

24. Elements of geometric optics. Centered optical system. Optical microscopy. Characteristics of the microscope.

25. Light absorption. Bouguer's law. Absorption of light by solutions. Bouguer-Lambert-Beer law. Concentration colorimetry.

26. Light scattering in dispersed media. Molecular scattering of light.

27. Basic ideas of quantum mechanics: wave properties of microparticles, de Broglie's formula. The concept of the electron microscope.

28. Thermal radiation of bodies, its characteristics. Absolutely black and gray bodies. Kirchhoff's law. Thermal radiation of the human body. The concept of thermography.

29. The law of radiation of an absolutely black body: Planck's law of radiation, Stefan-Boltzmann's law, Wien's displacement law.

30. Photo effect and its applications. Intrinsic and extrinsic photo effects. Photoelectric devices in medicine.

31. Luminescence: types, basic regularities and properties. Stokes' law. Application of luminescence in medicine.

32. Stimulated radiation. Equilibrium and inverse population of energy levels. Lasers, principle of action and application in medicine.

33. X-rays, spectrum and characteristics, applications in medicine. Interaction of X-rays with substance. The law of attenuation of X-rays.

34. Radioactivity. Types of radioactivity. The basic law of radioactive decay. Half-life. Activity, units of activity.

35. Ionizing radiation and its types. Interaction of ionizing radiation with substance. Protection against ionizing radiation. Biophysical bases of interaction of ionizing radiation with biological tissues.

36. Dosimetry of ionizing radiation. Exposure and absorbed doses. Biological action of radiation, biologically equivalent dose. Dose rate. Dose units and dose rates.

The list of practical skills required for the final module control and semester final assessment

Module 1. Medical and biological physics.

1. Interpret the concept of derivative.
2. Explain the mathematical basis of methods for integrating indefinite and definite integrals.
3. Interpret the concept of probability of a random event.
4. Apply the theorems of addition and multiplication of probabilities to solve problems.
5. Interpret the concepts of mathematical expectation, variance and standard deviation.
6. Apply the laws of distribution of random variables.
7. Analyze the relationship between the resulting characteristics of the organism using the correlation coefficient.
8. Classify mechanical oscillations and waves.
9. Interpret the basic physical concepts and laws of biomechanics, bioacoustics, bioreology and hemodynamics.
10. Explain the physical foundations of audiometry as a method of hearing research.
11. Demonstrate skills in work with an audiometer.
12. To interpret the biophysical mechanisms of action of ultrasound and infrasound on the human body and to explain the mechanisms underlying the use of ultrasound in medicine.
13. Interpret mechanical models of viscoelastic properties of biological tissues.
14. Determine the Young's modulus of biological tissues.
15. Explain the phenomena of surface tension and viscosity of liquids.
16. Interpret gas embolism as a physical phenomenon.
17. Demonstrate skills in measuring the coefficients of surface tension and viscosity of liquids.
18. Explain the physical basis of methods for measuring blood viscosity and methods for measuring blood pressure and blood flow velocity.
19. Analyze the structural elements of biological membranes, their physical and dynamic properties.
20. Explain the mechanisms of passive and active transport of substances through the membrane structures of cells.
21. Interpret the Fick equation, membrane permeability coefficient, diffusion rate, Nernst-Planck equation, electrochemical potential, Theorell's equation.
22. Analyze the molecular organization of active transport on the example of the Na^+-K^+-pump.
23. Explain the ionic nature of the resting membrane potential (Nernst equilibrium potential, diffusion potential, Donnan potential, stationary Goldman-Hodgkin-Katz potential).
24. To interpret the mechanism of action potential, speed and features of its propagation in axons.
25. To interpret the genesis of the electrocardiogram on the basis of the analysis of the basic concepts of electrocardiography.
26. Explain the physical basis of the action of direct and alternating electric fields on the human body and distinguish physiotherapeutic (therapeutic) techniques that use them.
27. Analyze the equivalent electrical circuits of biological tissues and blood, the impedance dispersion of biological tissues in norm and pathology.

28. Classify electronic medical equipment used in diagnostics, electrical stimulation and physiotherapy.
29. Explain the mechanism of action of magnetic (constant and alternating) field on biological objects, based on the analysis of physical and biophysical processes occurring in biological tissues under the action of physical fields in the human body.
30. Determine the optical characteristics of the eye and the microscope as a centered optical system.
31. Interpret the physical mechanisms underlying refractometry and concentration polarimetry.
32. Demonstrate skills in working with a refractometer.
33. Explain the physical basis of the phenomena of absorption, scattering and dispersion of light.
34. Explain the methods of concentration colorimetry.
35. Explain the basic laws of thermal radiation of bodies.
36. Interpret the thermal radiation of the human body and the physical basis of the method of thermography.
37. Interpret the basic concepts of quantum mechanics.
38. Compare the corresponding characteristics of optical and electron microscopes.
39. Explain the quantum-mechanical model of the hydrogen atom (energy states, quantum numbers, Pauli principle).
40. Interpret the main types, properties and applications of luminescence.
41. Explain the physical basis of the laser and the principle of its operation.
42. Classify lasers and distinguish areas of use of lasers in medicine.
43. Explain the basics of quantum-mechanical resonance methods in medicine.
44. Explain the primary mechanisms of interaction of X-rays with substance and distinguish areas of application of X-rays in medicine.
45. Analyze the main types, properties and doses of radioactive radiation.
46. Explain the main mechanisms of interaction of ionizing radiation with biological objects, draw conclusions about ways to protect against the effects of ionizing radiation.

The form of final control of academic performance

Final module control.

The system of continuous and final control

At each practical lesson the current control of knowledge according to the concrete purposes of a subject is carried out. Theoretical, practical training and independent work of the applicant for higher education as preparation for classroom classes are estimated at practical classes.

Assessment of success is integrated (all types of applicants for higher education work are evaluated both in preparation for the lesson and during the lesson) according to the criteria that are communicated to students at the beginning of the study of the discipline.

Criteria for assessing students' knowledge of the discipline are determined according to standardized generalized criteria for assessing the knowledge of higher education students in PSMU (table 1).

Table 1.

Standardized generalized criteria for assessing the knowledge

of applicants for higher education in PSMU

For 4-point scale	Score in ECTS	Evaluation criteria
5 (excellent)	A	The applicant for higher education shows special creative abilities, is able to acquire knowledge independently, without the help of the teacher finds and processes the necessary information, is able to use the acquired knowledge and skills of decision-making in unusual situations, convincingly argues answers, independently reveals own talents and inclinations, possesses not less than 90 % of knowledge on the topic both during the survey and all types of control.
4 (good)	B	The applicant for higher education is fluent in the studied amount of material, applies it in practice, freely solves exercises and problems in standardized situations, independently corrects errors, the number of which is insignificant, has at least 85% knowledge of the topic as during the survey, and all types of control.
	C	The applicant for higher education is able to compare, summarize, systematize information under the guidance of a researcher, generally apply it in practice, monitor their own activities, correct errors, among which there are significant, select arguments to confirm opinions, has at least 75% knowledge of topics both during the survey and all types of control.
3 (satisfactorily)	D	The applicant for higher education reproduces a significant part of theoretical material, shows knowledge and understanding of the basic provisions with the help of a researcher can analyze educational material, correct errors, among which there are a significant number of significant, has at least 65% knowledge of the topic, and during the survey, and all types of control.
	E	The applicant for higher education has educational material at a level higher than the initial, a significant part of it is reproduced at the reproductive level, has at least 60% knowledge of the topic as during the survey, and all types of control.
2 (unsatisfac-torily)	FX	The applicant for higher education has the material at the level of individual fragments that make up a small part of the material, has less than 60% knowledge of the topic as at the time of the survey, and all types of control.
	F	The applicant for higher education has the material at the level of elementary recognition and reproduction of individual facts, elements, has less than 60% knowledge of the topic as during the survey, and all types of control.

Conversion of the current grade, set on the traditional 4-point scale, to multi-point in

each lesson is not carried out.

Conversion of the grade on the traditional 4-point scale into multi-point (maximum 120 points) is carried out only after the current lesson, which precedes the final module control. The conversion is performed according to the following algorithm:

– calculates the average student's grade on the traditional 4-point scale, obtained during the current classes belonging to this module (to the nearest hundredth point);

– the average score of the current performance is calculated on the total number of classes in the module, and not on the actual number of students attended;

– to obtain a convertible multi-point total score of the current performance per module, the calculated average score per module obtained on the traditional 4-point scale multiplied by a factor of 24 is used. The exception is when the average score on a traditional 4-point scale is 2 points. In this case, the student receives 0 points on a multi-point scale, or to obtain a convertible multi-point total assessment of current performance for the module using table 2.

The minimum convertible sum of current performance points for all modules is 72 points.

Table 2

Unified table of correspondence of scores for current performance, scores for FMC, and traditional four-point score

Average score for current performance (A)	Points for current success in the module (A * 24)	Points for FMC from the module (A * 16)	Points for the module and / or exam (A *24 +A* 16)	Category ECTS	For 4-point scale
2	48	32	80	F FX	2 (unsatisfactorily)
2,1	50	34	84		
2,15	52	34	86		
2,2	53	35	88		
2,25	54	36	90		
2,3	55	37	92		
2,35	56	38	94		
2,4	58	38	96		
2,45	59	39	98		
2,5	60	40	100		
2,55	61	41	102		
2,6	62	42	104		
2,65	64	42	106		
2,7	65	43	108		
2,75	66	44	110		
2,8	67	45	112		
2,85	68	46	114		
2,9	70	46	116		
2,95	71	47	118		
3	72	50	122	E	3 (satisfactorily)
3,05	73	50	123		
3,1	74	50	124		
3,15	76	50	126		

3,2	77	51	128		
3,25	78	52	130		
3,3	79	53	132		
3,35	80	54	134	**Б**	
3,4	82	54	136		
3,45	83	55	138		
3,5	84	56	140		
3,55	85	57	142		
3,6	86	58	144		
3,65	88	58	146		
3,7	89	59	148		
3,75	90	60	150	**C**	
3,8	91	61	152		
3,85	92	62	154		
3,9	94	62	156		
3,95	95	63	158		
4	96	64	160		**4 (good)**
4,05	97	65	162		
4,1	98	66	164		
4,15	100	66	166		
4,2	101	67	168		
4,25	102	68	170	**B**	
4,3	103	69	172		
4,35	104	70	174		
4,4	106	70	176		
4,45	107	71	178		
4,5	108	72	180		
4,55	109	73	182		
4,6	110	74	184		
4,65	112	74	186		
4,7	113	75	188		
4,75	114	76	190	**A**	**5 (excellent)**
4,8	115	77	192		
4,85	116	78	194		
4,9	118	78	196		
4,95	119	79	198		
5	120	80	200		

The final control of mastering the module occurs upon completion of the study of the block of relevant content modules by testing and tasks performing.

Applicants for higher education who have attended all lectures and practical classes (or completed missed classes in the prescribed manner), fulfilled all the requirements of the curriculum and scored a convertible amount of points not less than the minimum – 72 points are allowed to the final module control. If according to the results of the current success the student scored 72 points, he is allowed to take the final module control (FMC).

The presence of a grade of "2" for current performance does not deprive the applicant for higher education of the right to admission to the final modular control with a

minimum number of points for current performance.

The applicant for higher education is not entitled to retake the current grades "2" if he has the minimum amount of points for admission to control measures. Current scores of "3" or "4" do not add up. The applicant for higher education is required to retake "2" if the average grade point average for the module does not reach the minimum (3.0 points). Permission to practice the current grade "2" is granted by the head of the department only in order for the student to achieve the minimum number of points for admission to the final control.

Applicants for higher education who have an average grade point average of 4.5 to 5.0 during their studies in medical informatics are exempted from compiling the FMC and (with consent) receive a final grade automatically in accordance with Table 3.

Table 3

Criteria for compliance of the average score of the current performance with the results of the final module control

Average score of current performance	Compliance with final module control scores
4,5	72
4,55	73
4,6	74
4,65	74
4,7	75
4,75	76
4,8	77
4,85	78
4,9	78
4,95	79
5	80

Assessment of knowledge during the FMC takes place in two stages.

The first – passing a test control, which contains only theoretical questions in accordance with the program of the discipline. The total number of questions in the test control is – 25 items. For each question the student has an opportunity to receive 2 points. If the number of points received by the student for the test control is more than 20 points, the test is considered passed. Otherwise, the test is considered failed and a general unsatisfactory score is given for FMC, which is equal to the number of points of correct answers.

The next stage is to solve typical problems. For a comprehensive solution of which the student can receive a maximum of 30 points.

Therefore, in case of successful passing of the test the total estimation on FMC is made according to the scheme:

The overall assessment of the FMC is set in accordance with the following provisions.

FMC = points for test control + score for the task

71-80 points are awarded to a applicants for higher education who has completed test tasks and has shown comprehensive, systematic and in-depth knowledge, the ability to independently perform the tasks provided by the program, acquainted with the main and

additional literature recommended by the program. The student's knowledge is strong, generalized; the student is able to apply knowledge creatively, his educational activity is marked by the ability to independently assess various situations, phenomena, facts, to identify and defend a personal position.

61-70 points are awarded to a applicants for higher education who has completed test tasks and mastered the curriculum in full, successfully completes the tasks provided by the program, worked out the basic literature recommended by the program. That is, the student knows the essential features of concepts, phenomena, patterns, relationships between them, as well as independently applies knowledge in standard situations, has mental operations, is able to draw conclusions, correct mistakes. The answer is complete, correct, logical, reasonable.

50-60 points are awarded to a applicants for higher education who has completed test tasks and demonstrated knowledge of basic educational material in the amount necessary for further study and future work in the profession, able to perform basic tasks on the model provided by the program, familiar with the basic literature recommended by the program. As a rule, the student's response to the reproduction of educational material is concise, due to the initial ideas about the subject of study. The student reproduces the basic educational material and has basic skills of educational activity.

0-49 points are awarded to a applicants for higher education who did not complete the test tasks and whose knowledge has gaps, who made fundamental mistakes in performing the tasks provided by the program, ie a student who is unable to describe the phenomena, does not show knowledge and understanding of the main topics.

The result of the final module control is evaluated in points (traditional 4-point evaluation is not given). The maximum number of points of the final modular control is 80 points. The minimum number of points of the final module control, for which the control is considered to be passed, is 50 points. **The maximum number of points per module is 200 points.**

The grade in the discipline is set by the department on a traditional (national) 4-point scale based on the average number of points for the two modules provided by the program of the discipline.

The scale of translation of the average number of points for the modules provided by the program in the discipline, in the traditional assessment on a 4-point scale of disciplines is presented in table 4.

Table 4

Conversion of the average number of points for all modules provided by the program in the discipline, in the traditional score on a 4-point scale

The average number of points for all modules of the discipline	Traditional score on a 4-point scale
122 – 139,99	3
140 – 179,99	4
180 – 200	5

The grade from the discipline is given only if the applicants for higher education has all the booked modules.

Teaching methods

The learning process uses a wide range of traditional and innovative teaching methods. Based on the dominant in modern didactics classification of teaching methods by type of cognitive activity, it is recommended to use the following methods:

– explanatory-illustrative (information-receptive) method
– reproductive
– method of problem statement
– partial search (heuristic) method
– research method
– interactive method

Control methods

– oral examination (individual and frontal);
– written survey;
– combined (condensed) survey;
– control of practical skills and abilities;
– self-control;
– control over the performance of individual tasks;
– test control.

Methodological support

1. Working curriculum
2. Methodical elaboration of lectures
3. Methodical instructions for independent work of students during preparation for a practical lesson and in class
4. List of recommended reading
5. Materials for control of knowledge, skills and abilities of students: tests of different levels of difficulty, situational tasks, computer control programs.
6. Multimedia presentations

Recommended reading

Basic

1. Korovina L.D. Biophysics with beginnings of mathematical analysis and statistics. Extended course of lectures. Vol.1. Bases of mathematical analysis, probability theory and mathematical statistics. Biomechanics. Second supplemented edition. – Poltava, 2018. – 127 p.

2. Korovina L.D. Biophysics with beginnings of mathematical analysis and statistics. Extended course of lectures. – Vol.2. Basis of thermodynamics. Biomembranes. Electricity and magnetism. – Poltava, 2018. – 117 p.

3. Korovina L.D. Biophysics with beginnings of mathematical analysis and statistics. Extendedc ourse of lectures. Vol.3. Optics. Quantum phenomena. – Poltava, 2018.– 128 p.

4. Medical and biological physics: texbook for the students of higher medical establishments of the IV accred. level / Edited by Alexander V. Chalyi. – Third edition. – Vinnytsia : Nova Knyga, 2017. – 480 p.

5. Medical and biological physics: texbook for the students of higher medical establishments of the IV accred. level / Chalyi A. V., Tsekhmister Ya. V., Agapov B.T., [et al.]. – Vinnytsia, Nova Knyha, 2010. – 480 p.p.

Supplementary

1. Compendium of Medical Physics, Medical Technology and Biophysics for students, physicians and researchers. Nico A.M. Schellart. – Department of Biomedical Engineering and Physics Academic Medical Center University of Amsterdam. – Amsterdam. – 2009 (electronic book).

2. Roland Glaser. Biophysics: An Introduction. – 2010.

3. Philip Nelson. Biological Physics (Updated Edition). – 2007.

4. Paul Davidovits. Physics in Biology and Medicine, Third Edition (Complementary Science). – 2007.

5. Bengt Nölting. Methods in Modern Biophysics. – 2009.

6. Biological thermodynamics. Donald T. Haynie (Cambridge University Press, 2001)

Information resources

1. Biophysical Society . Access: https://www.biophysics.org/
2. https://www.biophysics.org/education-resources
3. Institute of Applied Problems of Physics and Biophysics. Access: http://www.nas.gov.ua/UA/Org/Pages/default.aspx?OrgID=0000292

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