PRIVATE HIGHER EDUCATIONAL INSTITUTION
"INTERNATIONAL ACADEMY OF ECOLOGY AND MEDICINE"
Department of Fundamental Disciplines

WORKING PROGRAM OF EDUCATIONAL DISCIPLINE

"MEDICAL AND BIOLOGICAL PHYSICS"

LEVEL OF HIGHER EDUCATION Second (master's) level
DEGREE OF HIGHER EDUCATION Master's degree
BRANCH OF KNOWLEDGE 22 Healthcare
SPECIALTY 222 Medicine

Reviewed and approved
at the meeting of the Academic Council
Protocol No. 1, dated August 01, 2016

Kiev 2016

Working program of education discipline Medical and Biological Physics for the preparation of students of higher education of the second (master's) level of higher education in specialty 222 Medicine.

Introduction

The program of the discipline "Medical and Biological Physics" is composed according to the educational-professional program for training specialists of the second (master's) level of specialty 222 Medicine, field of knowledge 22 Health care, the Law of Ukraine "On Higher Education" from 01.07.2014 № 1556-VII (Article 13, item 7), the provision "On the organization of the educational process in the PHEE" International Academy of Ecology and Medicine ", methodological recommendations approved by the Central Methodical Cabinet of Higher Medical Education of the Ministry of Health of Ukraine on curriculum development standards of higher education. The discipline " Medical and Biological Physics " belongs to the section of the General preparation of the curriculum for the preparation of higher education applicants of the second educational (master's) level.

Description of the discipline

<table>
<tr><td rowspan="2">The structure of educational discipline</td><td rowspan="2">Branch of knowledge, training direction, specialty, education level</td><td colspan="2">Characteristics of educational discipline</td></tr>
<tr><td colspan="2">Daily learning</td></tr>
<tr><td>Credits ECTS – 5,0</td><td>Field of knowledge:
22 Healthcare</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Modules – 2
Submodules – 3</td><td rowspan="3">Specialty:
222 Medicine</td><td colspan="2">Year of the education:</td></tr>
<tr><td colspan="2">1st</td></tr>
<tr><td rowspan="2">The amount of hours - 150</td><td colspan="2">Semester</td></tr>
<tr><td>1st</td><td>2nd</td></tr>
<tr><td rowspan="11"></td><td rowspan="11">Educational level:
master's degree</td><td colspan="2">Lectures</td></tr>
<tr><td>15 h.</td><td>15 h.</td></tr>
<tr><td colspan="2">Practical classes</td></tr>
<tr><td>40 h.</td><td>40 h.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Self-education (individual work)</td></tr>
<tr><td>20 h.</td><td>20 h.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Type of control: Current and final, exam</td></tr>
</table>

The subject of "Medical and Biological Physics" is studying physical processes occurring in biological media and the impact of external factors on living organism.

According to the curriculum a medical and biological physics is one the fundamental academic disciplines that forms the theoretical basis for training a highly qualified medical specialists. The studying of medical and biological physics forms in students a basic understanding of general properties and forms of motion of matter, about the most important physical laws that underlie the mechanical, thermal, electrical, magnetic, spectral, polarization and other physical methods of study of various properties of medications.

Interdisciplinary links:

Medical and Biological Physics as an academic discipline:

- integrates with disciplines such as medical chemistry, medical biology etc;
- lays the groundwork for the study of physiology, biochemistry, biostatistics, pathological physiology, radiation medicine, hygiene and ecology, ophthalmology, otorhinolaryngology etc.

PURPOSE AND GOALS OF THE DISCIPLINE.

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

1.2. The **goals** of training of "Medical and biological physics" are studying:

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

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

1.3. **Competencies and Learning Outcomes**

According to the requirements of Educational Standard of higher education the discipline provides obtaining **competencies** by students:

– *integrated:* ability to solve general and complex specialized tasks and practical problems in careers in health care or in learning, which provides research and/or implementation of innovation and characterized by complexity and uncertainty of the conditions and requirements.

– *general:* ability for abstract thinking, analysis and synthesis; ability to learn and acquire modern knowledge; ability to apply knowledge in practical situations; knowledge and understanding of the subject area and understanding of the profession; ability to make informed decisions; ability to use information and communication technologies; determination and persistence on tasks and responsibilities taken.

– *special (professional)*: ability to determine the list of necessary laboratory and instrumental studies and evaluating their results; skills to perform medical procedures; ability to assess the impact of environmental, social, economic and biological determinants of the health state of the individual, family and population.

COMPETENCY MATRIX

No	Competence	Knowledge	Ability	Communication	Autonomy and responsibility
	Integral competence				
	The ability to solve general and complex specialized tasks and practical problems in careers in healt h care or in learning, which provides research and / or implementation of innovatio n and characterized by complexity and uncertainty of the conditions and requirements.				
	General competences				
1	Ability for abstract thinking, analysis and synthesis, ability to learn and be trained simultaneously.	To know: methods of analysis, synthesis and further modern training.	Be able to: analyze information, make informed decisions, acquire modern knowledge.	Establish appropriate relationships to achieve goals.	To take responsibility for the timely acquisition of modern knowledge.
2	Ability to apply knowledge in practical situations.	To know: specialized conceptual knowledge.	Be able to: solve complex problems and issues that arise in professional activities.	Clear and unequivocal reports of their findings, knowledge and explanations that justify them to specialists and nonspecialists.	To take responsibility for making decisions in difficult conditions.
3	Knowledge and understanding of the subject area and understanding of professional activity.	To know: the structure of professional activity.	Be able to: carry out professional activity that needs updating and integration of knowledge.	Ability to form effective communication strategy in professional activities.	To take responsibility for professional development, ability to further professional training with a high level of autonomy.
4	The ability to make informed decisions; to work in team; skills of interpersonal interaction.	To know: tactics and strategies of communication, laws and methods of communicative behavior.	Be able to: make informed decisions, choose methods and strategies of communication to ensure effective teamwork	Use communication strategies and skills of interpersonal interaction	To take responsibility for the choice of tactics and methods of communication.

5	Skills of using information and communication technologies.	To know: information and communication technologies used in professional activities.	Be able to: use information and communication technologies in the professional field that needs updating and integration of knowledge.	Use information and communication technologies in professional activity.	To take responsibility for the development of professional knowledge and skills.
6	Certainty and persistence on tasks and responsibilities taken.	To know: responsibilities and ways to perform the tasks.	Be able to: define goals and objectives, be persistent and diligent in the performance of duties.	Set interpersonal communication for effective implementation of tasks and responsibilities.	To take responsibility for qualitative performance of tasks.
	Special (prof essional) competences				
1	The ability to determine the list of necessary laboratory and instrumental studies and to evaluate their results.	To know: the impact of physical factors on the human body, standard methods of laboratory and instrumental studies.	Be able to: analyze research results.	Select and evaluate research results.	To take responsibility for the decisions on the evaluation of research results.
2	Skills of performing medical procedures.	To know: biophysics of human organs and systems.	Be able to: analyze the biophysical parameters of human organs and systems.	Form and bring the conclusions to patients and professionals about the need for a health care manipulation.	Responsibility, independence.
3	Ability to evaluate the impact of environmental, social, economic and biological determinants on the health of the individual, family and population.	To know: • environmental factors that affect health negatively in the population; • statistical analysis methods for the evaluation of environmental factors and methods for determination of relation between them.	Be able to: evaluate the • environment state and negative impacts on health. • know methods of statistical analysis.	Make conclusions about the health of the population on the basis of the relationship with environmental factors.	To take responsibility for the correct conclusions regarding the negative impact of environmental factors.

L earning outcomes:

Integrative final learning outcomes of syllabus are:

- to evaluate information on the diagnosis using the standard procedure based on the results of laboratory and instrumental studies;
- to perform medical procedures;
- to identify the negative environmental factors; to analyze the health state of certain contingent; to determine the relation between the environment and the health state of certain contingent; to develop preventive measures on the basis of the relationship between the environment and the health state of certain contingent. To provide analysis of morbidity, groups of risk, areas of risk, time of risk and risk factors. To evaluate the impact of social, economical and biological determinants of the health of the individual, family and population.
- to organize the necessary level of individual security in the case of typical dangerous situations in the individual field activity.

As a result of learning of "Medical and Biological Physics" student have to

know:

- ✓ physical bases and biophysical mechanisms of external factors effects on the human body systems;
- ✓ fundamental physical and biophysical laws that underlie the human life;
- ✓ physical bases of diagnostics and physiotherapy (curative) methods used in medical equipment.
- ✓ knows and understands the physical laws describing the flow of fluids and the factors affecting the vascular resistance of blood flow;
- ✓ knows and understands natural and artificial sources of ionizing radiation and its interaction with matter;
- ✓ knows and understands the physicochemical and molecular basis of sensory organs;
- ✓ knows and understands the physical basis of non-invasive imaging methods;
- ✓ knows the physical basis of selected therapeutic techniques, including ultrasound and irradiation;
- ✓ knows and understands the basics of excitation and conduction in the nervous system and higher nervous functions, as well as striated and smooth muscle physiology and blood functions;
- ✓ knows and understands the effects of oxidative stress on cells and its importance in the pathogenesis of diseases and in aging processes

able to:

- ✓ perform a statistical analysis of experimental results;
- ✓ is able to use knowledge of the laws of physics to explain the effects of external factors such as temperature, acceleration, pressure, electromagnetic fields and ionizing radiation on the body and its components;
- ✓ can assess the harmfulness of the dose of ionizing radiation and apply the principles of radiological protection;
- ✓ is able to describe changes in the functioning of the organism in a situation of disruption of homeostasis, in particular, determine its integrated response to

physical exertion, exposure to high and low temperature, loss of blood or water, sudden verticalization, transition from sleep to wakeful state;

- ✓ can operate simple measuring instruments and assess the accuracy of the measurements taken;
- ✓ model a simple biological systems; analyze the physical processes in the body using physical laws and phenomena.

Is ready to:

- ✓ perceive and recognize their own limitations and make self-assessment of deficits and educational needs.

2. INFORMATION SCOPE OF ACADEMIC DISCIPLINE

150 hours of 5.0 ECTS credits are for the study of the academic discipline, incl. lectures 30 hours, practical (seminars) 80 hours, independent work 40 hours. Normative discipline.

The syllabus is structured into 2 thematic modules and 3 submodules.

Module 1. Fundamentals of higher mathematics and biological physics.

Submodule1. Fundamentals of mathematical processing of medical and biological data.

Submodule 2. Biological physics.

Module 2. Fundamentals of medical physics.

Submodule 3. Medical physics.

Module 1. Fundamentals of higher mathematics and biological physics.

Submodule1. Fundamentals of mathematical processing of medical and biological data.

Specific objectives:

- To explain the concept of differential, partial derivatives and total differential;
- To use differentials in approximate calculations;
- To explain the mathematical bases of integration methods for indefinite and definite integrals;
- To interpret the concept of differential equations;
- To explain the methods of solving the first and the second order differential equations;
- To apply the theory of differential equations for modeling of biomedical processes;
- To explain the concept of probability of random events;
- To apply the theorems of addition and multiplication of probabilities for solving problems;
- To explain the concept of mathematical expectation, variance and standard deviation;
- To apply the laws of distribution of random variables;

- To interpret the correlation dependence between random variables;
- To analyze the relationships between the characteristics of the body by means of correlation coefficient.

Topic 1. Medical and biological quantities. Functions. Derivative and differential function.

Fundamentals of differential calculation.
Differential function of one variable. Partial derivatives and differentials of a function of two or more variables. Full differential.
The concept of differential equations.
First-order differential equations with separable variables. Linear, homogeneous differential equations of the second order with constant coefficients. Methods for solving differential equations.

Topic 2. Indefinite and definite integrals.

Fundamentals of integrated computing.
Indefinite and definite integrals. Integration by the method of variable replacement and parts.

Topic 3. Fundamentals of probability theory.

Elements of probability theory. Theorems of addition and multiplication of probabilities.

Topic 4-5. Fundamentals of mathematical statistics.

Elements of mathematical statistics. Mathematical expectation, variance, standard deviation. Laws of distribution of random variables. Confidence probabilities and confidence intervals. Functional and correlation. Regression equation. Correlation coefficient.

Submodule 2. Biological physics.

Specific objectives:
- To interpret the basic physical concepts and laws of biomechanics.
- To interpret mechanical models of viscoelastic properties of biological tissues;
- To classify mechanical oscillations and waves;
- To interpret the basic physical concepts and laws of biomechanics, bioacoustics, bioreology and hemodynamics;
- To interpret mechanical models of viscoelastic properties of biological tissues;
- To determine the Young's modulus of biological tissues;
- To explain the physical foundations of audiometry as a method of hearing research;
- To demonstrate skills in working with an audiometer;
- To interpret the biophysical mechanisms of action of ultrasound and infrasound on the human body and explain the mechanisms underlying the use of ultrasound in medicine;
- To explain the physical foundations of audiometry as a method of hearing research;
- To demonstrate skills in working with an audiometer;

- To explain the phenomena of surface tension and viscosity of liquids;
- To interpret gas embolism as a physical phenomenon;
- To demonstrate skills in measuring the coefficients of surface tension and viscosity of liquids;
- To interpret the basic physical concepts and laws of bioreology and hemodynamics.
- To explain the phenomena of surface tension and viscosity of liquids;
- To explain the physical basis of methods for measuring blood viscosity and methods for measuring blood pressure and blood flow velocity;
- To analyze the structural elements of biological membranes, their physical and dynamic properties;
- To explain the mechanisms of passive and active transport of substances through the membrane structures of cells;
- To interpret the Fick equation, membrane permeability, diffusion rate, Nernst-Planck equation, electrochemical potential, Theorell equation;
- To explain the ionic nature of the resting membrane potential (Nernst equilibrium potential, diffusion potential, Donnan potential, stationary Goldman-Hodgkin-Katz potential);
- To interpret the mechanism of occurrence of action potential, speed and features of its distribution in axons.

Topic 6. Mechanical properties of biological tissues. Determination of the Young's modulus of bone.

Subject and methods of biophysics, connection with other sciences. The main sections of biophysics.

Basic concepts of mechanics of translational and rotational motions. Equations of motion, conservation laws. Elements of biomechanics. The musculoskeletal system of man. Young's modulus and Poisson's ratio. Fluidity and relaxation of tension.

Topic 7. Biophysics of muscle contractions. Dynamometry. Ergometry.

Dynamic and statistical work of the person at various kinds of its activity. Ergometry. Methods and devices for measuring biomechanical characteristics.
Fundamentals of bioreology. Deformation properties of biological tissues. Hooke's law. Young's modulus and Poisson's ratio. Fluidity and relaxation of tension.

Topic 8. Oscillations and waves. Sound, infrasound and ultrasound. Acoustic methods in medicine.

Non-damping, damping and forced oscillations. Differential equations of harmonic, damped, forced oscillations and their solution. Decrement and logarithmic decrement of attenuation. Resonance. Self-oscillation. Relaxation oscillations.
Wave processes and their characteristics. Wave equation. Differential wave equation. Energy flow. Vector Condition. Doppler effect.

Ultrasound and infrasound. Ultrasound and infrasound sources and catchers. Features of distribution and biophysical bases of action of ultrasound and infrasound on biological fabrics. The use of ultrasound in medicine.

Topic 9. Biophysics of the auditory organ. Audiometry.

Physics of hearing. Objective and subjective characteristics of sound. Intensity, intensity level, volume, their units. Threshold of audibility and pain. Weber-Fechner law. Biophysical bases of auditory sensation. Physical basics of audiometry. Audiogram and curves of equal volume.

Topic 10. Surface phenomena. Definition of CPN. Gas embolism.

Surface tension. Surface tension coefficient. Methods of its definition. Gas embolism.

Topic 11. Viscosity of liquids. Methods for determining the viscosity of liquids.

Internal friction, viscosity. Newton's formula for the force of internal friction. Newtonian and non-Newtonian fluids. Methods and devices for measuring viscosity.

Topic 12. Biophysics of blood circulation. Analysis of the heart. Methods of measuring blood pressure.

Stationary fluid flow. The continuity equation and the Bernoulli equation. Linear and volumetric velocities. The basic equation of fluid dynamics. Flow of viscous liquids. Poiseuille and Gauguin-Poiseuille formulas. Hydraulic resistance.
Rheological properties of blood. Blood viscosity and its use in disease diagnosis.
Laminar and turbulent fluid flow. Reynolds number. Methods of measuring blood pressure and blood circulation. Pulse waves.

Topic 13. Structure and functions of biological membranes. Active and passive transport. Study of permeability of biological membranes.

Structural elements of biological membranes. Physical properties of biomembranes. Liquid crystalline state of biomembranes. Dynamic properties of membranes.
Passive transport of substances through membrane structures. Fick's equation. Membrane permeability coefficient for a certain substance. Nernst-Planck equation. Electrochemical potential and Theorell equation. Active transport, main types. Molecular organization of active transport on the example of Na + -K + pump operation. Conjugation of flows. Diffusion rate.

Topic 14. Membrane potentials of rest and action.

Membrane potentials of rest and action. The nature of the resting membrane potential (Nernst equilibrium potential, diffusion potential, Donnan potential, stationary Goldman-Hodgkin-Katz potential).

Action potential. Action potential (PD) and reasons for its occurrence. Equivalent electrical circuit of the membrane. Phenomenological equations of Hodgkin-Huxley. The concept of gate ion currents. Hodgkin-Huxley equation for the process of PD propagation in nerve fibers. Speed and features of PD propagation in axons.

Topic15. Final module control 1.

Module 2. Fundamentals of medical physics.

Submodule 3. Medical physics.

Specific objectives:

- To know the basic concepts of electrodynamics.
- To master the basic concepts (current, voltage, electrical resistance) and laws (Ohm, Kirchhoff, conductor connections).
- To know the methods of measuring electrical resistance.
- Tu use skills in measuring the electrical resistance of a conductor using a bridge circuit (Wheatstone bridge) and calculating the value of electrical resistance in series, parallel and mixed connection of resistors.
- To classify electronic medical equipment used in diagnostics, electrical stimulation and physiotherapy.
- To interpret the genesis of the electrocardiogram based on the analysis of the basic concepts of electrocardiography.
- To explain the physical basis of the action of constant and alternating electric fields on the human body and distinguish between physiotherapeutic (therapeutic) techniques that use them;
- To analyze the equivalent electrical circuits of biological tissues and blood, the dispersion of the impedance of biological tissues in normal and pathology
- To classify electronic medical equipment used in diagnostics, electrical stimulation and physiotherapy.
- To explain the mechanism of action of magnetic (constant and alternating) and electromagnetic fields 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.
- To draw a conclusion about the biophysical mechanisms of interaction of electric and magnetic fields with biological tissues;
- To analyze the physical processes that occur during the collection of medical and biological information;
- To explain the basic laws of geometric optics;
- To draw the course of rays at the boundary of two media and in the refractometer;
- To analyze various diagnostic techniques using refractometry;
- To explain the physical and biophysical characteristics of the human eye and the mechanisms of photoreception.
- To determine the optical characteristics of the eye and the microscope as a centered optical system;
- To interpret the basic provisions of thermodynamics of open biological systems;
- To analyze intermolecular interactions in biopolymers;

- To explain the importance of thermodynamics and synergetics;
- To interpret the physical mechanisms underlying the measurement of the size of micro-objects using an electron microscope;
- To compare the relevant characteristics of optical and electron microscopes;
- To explain the physical basis of the laser and the principle of its operation;
- To classify lasers and distinguish areas of use of lasers in medicine;
- To master the ability to determine the size of erythrocytes by diffraction;
- To explain the primary mechanisms of interaction of X-rays with matter and distinguish areas of application of X-rays in medicine;
- To analyze the main types, properties and doses of radioactive radiation;
- To explain the main mechanisms of interaction of ionizing radiation with biological objects, draw conclusions about ways to protect against the action of ionizing radiation.

Topic16. Fundamentals of electrodynamics. Analysis of the work of the Wheatstone Bridge.

Basic concepts of electrodynamics. Operation of the bridge scheme. Basic concepts (current, voltage, electrical resistance) and laws (Ohm, Kirchhoff, conductor connections). Methods of measuring electrical resistance. Measurement of electrical resistance of a conductor using a bridge circuit (Wheatstone bridge) and calculation of the value of electrical resistance in series, parallel and mixed connection of resistors.

Topic 17. Medical equipment. Devices for recording medical and biological information.

General characteristics and classification of electronic medical devices. Use of electronic medical equipment in diagnostics, electrical stimulation and physiotherapy. Electrodes and sensors. Signal amplification and generation. Safety rules when working with electronic medical equipment.

Physical processes that occur during the collection of medical and biological information. Devices for recording medical tabiological information. The simplest electrical circuits.

Different methods of diagnosis and physiotherapy using electrodes and sensors.

Topic 18. Physical foundations of electrocardiography.

The concept of electrography of organs and tissues.

Physical and biophysical bases of electrocardiography. Einthoven's first concept of the genesis of the ECG (heart - electric dipole, electric dipole potential, lead system). Ohm's law in differential form, electrical conductivity of biological tissues. The second concept of the ECG (heart - current dipole, current dipole potential).

Topic 19. Physical foundations of rheography.

Physical and biophysical bases of rheography. Relationship between deformation of blood vessels and changes in their electrical resistance. AC circuits containing active, capacitive and inductive supports. Vector charts and impedance. Capacitive properties and equivalent electrical circuits of biological tissues. Specificity of vector diagrams and impedance of biological tissues. Impedance dispersion coefficient.

Topic 20. Electrokinetic phenomena. Electrophoresis.

The effect of an electric field on biological tissues. Physical and biophysical processes occurring in biological tissues under the action of constant and alternating electric fields (conduction and displacement currents, thermal effects). Therapeutic factors and their use in medical methods (galvanization, electrophoresis, franklinization, electrical stimulation, electrical impulse, diathermy, electrotomy, electrocoagulation, etc.).

Topic 21. Basics of UHF therapy inductothermy.

The effect of constant and alternating magnetic fields on biological objects. Primary mechanisms, induction currents, thermal effects. Therapeutic factors and their use in medical methods (magnetic therapy, inductothermy, etc.).

The effect of electromagnetic fields on biological objects. Primary mechanisms, currents and thermal effects, specific action. Therapeutic factors and their use in medical methods (UHF therapy, microwave therapy, microwave resonance therapy, etc.).

General characteristics and classification of electronic medical devices. Use of electronic medical equipment in diagnostics, electrical stimulation and physiotherapy. Electrodes and sensors. Signal amplification and generation. Safety rules when working with electronic medical equipment.

Topic 22. Refractometry. Determination of the refractive index of liquids.

Physical processes that occur during the collection of medical and biological information.

Basic laws of geometric optics. Methods for determining the refractive index.

The concept of geometric optics. The course of rays at the boundary of two media and in the refractometer.

Different methods of diagnosis using refractometry.

Topic 23. Biophysics of vision.

Biophysics of reception processes on the example of visual reception. General characteristics of the human eye. Verbytsky's eye is reduced. Disadvantages of the optical system of the human eye. The structure of the retina. Photoisomerization of rhodopsin.

Topic 24. Optical microscopy. Microscopy techniques.

Elements of geometric optics. Centered optical system. Optical microscopy. The main characteristics of the microscope.

Optical refractometry.

Polarization of light. Methods of obtaining polarized light. Double refraction. Prism of Nicolas. Malus's law. Optically active substances.

Topic 25. A thermal irradiation of bodies, its characteristics. The concept of thermography.

Thermodynamics of open medical and biological systems and elements of molecular biophysics. Intermolecular interaction in biopolymers (covalent interaction, electrostatic and dispersion interaction, hydrophobic interaction, hydrogen bond). Structural organization of proteins and nucleic acids.

Thermodynamic method of studying medical and biological systems. The first and second laws of thermodynamics, entropy, thermodynamic potentials.

Thermodynamics of open systems near equilibrium (linear law for flows and thermodynamic forces, cross-transfer processes, Onsager ratio, entropy production, flow conjugation, steady state, Prigogine's theorem).

Thermodynamics of open systems, far from equilibrium (ordering processes in physical, chemical and medical-biological systems, the concept of synergetics). The importance of thermodynamics and synergetics in the problem of environmental protection.

Topic 26. Interaction of light with substance (dispersion, absorption, scattering, photoeffect). Photometry.

Polarization of light. Methods of obtaining polarized light. Double refraction. Prism of Nicolas. Malus's law. Optically active substances. Bio Law. Concentration polarimetry.

Light absorption. Bouguer's law. Absorption of light by solutions, the law of Bouguer Lambert-Ber. Concentration colorimetry.

Light scattering. Light scattering in dispersion media. Molecular scattering of light. Rayleigh's law. Nephelometry.

Dispersion of light. Refractometry and fiber optics, their use in medicine. The concept of holography.

Topic 27. Induced irradiation. Dimensioning erythrocytes with the help of a diffraction of a laser radiance.

Structure and principle of operation of helium-neon laser; processes of excitation of laser radiation and diffraction of laser radiation rays; formation of maxima and minima according to Huygens' theory.

The method of determining the size of erythrocytes by diffraction.

Topic 28. X-rays.

X-rays. Spectrum and characteristics. Primary mechanisms of interaction of X-rays with matter. Law of attenuation and protection against X-rays. Application of X-rays in medicine (X-ray therapy, X-ray tomography, etc.)

Topic 29. Radioactivity. The use of ionizing radiation in medicine. Dosimetry of ionizing radiation.

Radioactivity, main types and properties. The law of radioactive decay. Half-life. Activity, units of activity. Ionizing radiation, properties and basic mechanisms of interaction

with biological objects. Protection against ionizing radiation. Physical and biophysical problems related to the Chernobyl accident.

Dosimetry of ionizing radiation. Exposure and absorbed doses. Equivalent biological dose. Dose power. Units of doses and capacities of doses.

Topic 30. Final module control 2.

THE STRUCTURE OF EDUCATIONAL DISCIPLINE

Names of modules, submodules and topics	Number of hours		
	Lectuers	Practice – no classes	SRS
1	2	3	4
Module 1. Fundamentals of higher mathematics and biological physics.			
Submodule1. Fundamentals of mathematical processing of medical and biological data.			
Topic 1. Medical and biological quantities. Functions. Derivative and differential function.	-	2	1
Topic 2. Indefinite and definite integrals.		2	1
Topic 3. Fundamentals of probability theory.	2	2	1
Topic 4. Fundamentals of mathematical statistics 1.	1	2	1
Topic 5. Fundamentals of mathematical statistics 2.	1	2	1
Submodule 2. Biological physics.			
Topic 6. Mechanical properties of biological tissues. Determination of the Young's modulus of bone.	3	4	1
Topic 7. Biophysics of muscle contractions. Dynamometry. Ergometry.	3	3	1
Topic 8. Oscillations and waves. Sound, infrasound and ultrasound. Acoustic methods in medicine.	-	3	1
Topic 9. Biophysics of the auditory organ. Audiometry.	-	3	1
Topic 10. Surface phenomena. Definition of CPN. Gas embolism.	-	3	1
Topic 11. Viscosity of liquids. Methods for determining the viscosity of liquids.	-	3	1
Topic 12. Biophysics of blood circulation. Analysis of the heart. Methods of measuring blood pressure.	3	3	1
Topic 13. Structure and functions of biological membranes. Active and passive transport. Study of permeability of biological membranes.	3	3	1
Topic 14. Membrane potentials of rest and action.	3	3	1
Topic 15. Final module control 1.	-	2	6
Total on the module I	**15**	**40**	**20**
Module 2. Fundamentals of medical physics.			

Submodule 3. Medical physics.			
Topic 16. Fundamentals of electrodynamics. Analysis of the work of the Wheatstone Bridge.	3	4	1
Topic 17. Medical equipment. Devices for recording medical and biological information.	2	4	1
Topic 18. Physical foundations of electrocardiography. .		4	1
Topic 19. Physical foundations of rheography.		2	1
Topic 20. Electrokinetic phenomena. Electrophoresis.		2	1
Topic 21. Basics of UHF therapy inductothermy.			1
Topic 22. Refractometry. Determination of the refractive index of liquids.		4	1
Topic 23. Biophysics of vision.	2	2	1
Topic 24. Optical microscopy. Microscopy techniques.	2	4	1
Topic 25. A thermal radiation of bodies, its characteristics. The concept of thermography.	2	4	1
Topic 26. Interaction of light with substance (dispersion, absorption, scattering, photoeffect). Photometry.		3	1
Topic 27. Induced radiation. Dimensioning erythrocytes with the help of a diffraction of a laser radiance.		1	1
Topic 28. X-rays.	2	2	1
Topic 29. Radioactivity. The use of ionizing radiation in medicine. Dosimetry of ionizing radiation.	2	2	1
Topic 30. Final module control 2.		2	6
Total on the module II	**15**	**40**	20
Total	**30**	**80**	40

THE LIST OF THEORETICAL QUESTIONS FOR PREPARATION OF STUDENTS FOR THE FINAL MODULAR CONTROL.

1. Differential equations. Basic concepts.
2. Differential equations with separable variables.
3. Linear second order differential equations with constant coefficients.
4. Random events. Statistical and classical definitions of the probability of a random event. Addition theorem of probabilities of compatible and incompatible events.
5. Complex event. Probability of complex event which consists of two dependent and independent events.

6. The random variables. The distribution law of a random variable. Bernoulli's formula, Poisson's distribution.
7. Continuous random variable. The distribution function and the probability density function of a random variable. The probability that a random variable is included within the interval.
8. Probable event. The normalization condition for a continuous random variable. The relation between a distribution function $F(x)$ of a continuous random variable x and the probability density function $f(x)$ of a random variable
9. The mathematical expectation of a discrete and a continuous random variable.
10. The variance of a discrete and a continuous random variable.
11. The normal distribution law. The probability density function of a normal distribution.
12. Rule of three sigma. The significance levels.
13. The subject of mathematical statistics. General population. Sample. Representation. Interval variation series.
14. Histogram. Mode. Median. Sample mean.
15. The empirical function of distribution and density distribution for a variation series.
16. Sample variance. Corrected sample variance. Sample standard deviation.
17. Corrected standard deviation of the average of sample. The likely probability and significance levels.
18. The confidence intervals and a probable values. Half-width confidence interval.
19. Correlation. The correlation coefficient of a random variables.
20. Regression analysis.
21. Mechanical properties of a living tissues.
22. Biophysical properties of muscle contraction.
23. Hill equation. The power of contraction of skeletal muscle.
24. Mechanical waves. Wave equation. Doppler effect, its application in biomedical researches.
25. Acoustics. Physical characteristics of sound. Characteristics of auditory sensation and their relation with physical characteristics of sound. Sound measurements. The acoustic impedance. Audiometry.
26. Physics of hearing. The concept of the sound conductive and the sound perceptive systems The physical bases of a sound methods of research used in the clinics. Reflection and absorption of sound waves. Reverberation.
27. Loudness. Weber-Fechner law.
28. Infrasound, peculiarities of its propagation. Infrasound effects on biological objects. Noise. Vibration, their physical characteristics.
29. Ultrasound. Sources and receivers of ultrasound. Peculiarities of propagation of ultrasonic waves. Effects of ultrasound on the matter. Biophysical bases of ultrasound effects on cells and tissues. The application of ultrasound in diagnostics and treatment.
30. Hearing threshold and pain threshold. Sound intensity scale and loudness scale, units.
31. Internal friction (viscosity of fluids). A Newtonian and a non-Newtonian fluids. Rheological properties of blood, blood plasma and serum.
32. Laminar and turbulent fluid flow. Reynolds number. The flow of a viscous fluids. Hagen-Poiseuille equation. Hydraulic resistance.

33. Stationary flow of fluids. Continuity equation. Linear and volume flow rate. The basic equation of fluid dynamics.
34. Rheological properties of fluids and blood.
35. Basic hemodynamic parameters.
36. General physical regularities of blood motion in vessels.
37. Methods for determination of viscosity of fluids. The clinical method used for determination of blood viscosity.
38. The physical bases of the clinical method of measurement of blood pressure.
39. Determination of flow velocity.
40. Work and power of the heart.
41. A pulse waves, the dependence of propagation velocity on the vessel parameters. Methods for determination of blood circulation velocity.
42. The first principle of thermodynamics for processes of an ideal gas.
43. Thermodynamics of biological systems. Subject and terminology.
44. The first law of thermodynamics and its application to living systems.
45. Body energy consumption. Basal metabolic rate.
46. Temperature homeostasis. Chemical and physical thermoregulation.
47. Thermodynamic method for studying of biological systems. Heat exhange, its types. Thermotherapy. The use of low temperatures in medicine.
48. Work types in the living organism.
49. Thermoregulation in the living organism.
50. The organism as an open system. Prigogine theorem. The comparison of thermodynamic equilibrium and stationary state.
51. The second law of thermodynamics. Criticism of the theory of "heat death" of the universe. Entropy, free energy, electrochemical potential.
52. Thermodynamic potentials.
53. The rate of entropy increase and a dissipative function.
54. Main functions of biological membranes.
55. The structure of biological membranes.
56. Models of biological membranes.
57. Physical methods of studying of structure of biological membranes.
58. Basic types of a passive transport of substances through the membrane.
59. Fick's equation for a passive transport of substances through the membrane.
60. Active transport of substances through the membrane.
61. Electrogenic ion pumps.
62. Secondary active transport of ions.
63. Biomembrane potentials and their ionic nature. Resting membrane potential. Nernst equation.
64. Main properties of an action potential.
65. The mechanism of generation and propagation of action potential in cells.
66. Donnan potential. Donnan equilibrium.
67. Electrodiffusion equation of ions through a membrane. Stationary Goldman-Hodgkin potential.
68. The propagation of excitation along nerve fibers.
69. An electric dipole and characteristics of an electric field.

70. Lead. Integral electric vector of the heart.
71. Einthoven's concept of ECG. A current dipole and its characteristics.
72. Components of normal electrocardiogram. Vectorcardiography.
73. The mechanism of the electrical activity of organs and tissues. Electrical phenomena in cardiac muscle.
74. The electrical properties of cells and tissues. Conduction current and displacement currents.
75. Electrical conductivity of cells and tissues at direct current.
76. Application of direct electric current in medicine. Galvanization. Electrophoresis.
77. Application of the constant electric field of high voltage in medicine. Franklinization. Aeroionotherapy.
78. Effects of electric current on the living organism.
79. Passing of alternating current through biological objects. The impedance of tissues and organs.
80. Dispersion of impedance. Polarization coefficient of tissue. Reography.
81. The physical characteristics of pulsed current. Effects of pulsed electric current on the living organism. Cranial electrotherapy stimulation. Electrical stimulators. Defibrillators.
82. Effects of electromagnetic fields on biological objects. Primary mechanisms, currents and thermal effects, specific action.
83. Therapeutic factors and their application in medical techniques (UHF- and SHFtherapy, microwave resonance therapy).
84. Magnetic field and its characteristics. Effects of magnetic fields on the living organism. Magnetobiology.
85. Resonance methods of quantum mechanics. Nuclear magnetic resonance and electron paramagnetic resonance, their application in medicine (magnetic resonance tomography).
86. The nature of light. Optical refractometry.
87. Magnifying glass. Optical microscope and its main characteristics. Some special methods of optical microscopy.
88. The concept of an ideal centered optical system.
89. The optical system of the eye and some its peculiarities.
90. Anomalies of optical system of the eye and their compensation.
91. Biophysical bases of visual reception.
92. The mechanism of light absorption. Main characteristics of light absorption (intensity, absorption coefficient, optical density of medium, transmittance, extinction).
93. The principle of concentration colorimetry. The Beer-Lambert-Bouguer law.
94. The mechanism of light scattering. Rayleigh law. Nephelometry.
95. Light polarization. Ways to obtain polarized light. Birefringence. Nicolas prism.
96. Optically active substances. Biot's law.
97. Spontaneous and induced radiation. The main structural components of a laser and their functions.
98. The main properties of laser radiation.
99. Effects of laser radiation on living tissue.
100. The main types of a laser radiation application in medicine.

101. The mechanism and main characteristics of thermal radiation. Black body.
102. Laws of thermal radiation (Kirchhoff's law, Planck's radiation law).
103. Laws of thermal radiation (Stefan-Boltzmann law, Wiens displacement law).
104. Peculiarities of thermal radiation of the human body. Temperature topography of the human body. The principles of thermal imaging.
105. Infrared and ultraviolet radiation and their application in medicine.
106. Luminescence. Types of luminescence, basic regularities and its properties. Stokes' law. Luminescence application in medicine.
107. The phenomenon of the photoelectric effect. External and internal photoelectric effects and their application in medicine.
108. Properties of X-rays.
109. The mechanism of production of Bremsstrahlung ("braking radiation"). The boundary wavelength.
110. Nature of the characteristic radiation. Moseley's law.
111. X-ray interaction with matter (coherent radiation, photoelectric effect, Compton effect).
112. The principles of X-ray diagnostics (radiography) and X-ray therapy.
113. Radioactivity. Main types of radioactive dacay.
114. Law of radioactive decay. Activity of radioactive source. Lifetime.
115. The doses of ionizing radiation and their units.
116. Biological effects of ionizing radiation. Basic quantitative characteristics of the interaction of ionizing radiation with biological objects.
117. Methods of radioisotope medicine. The main physical and chemical methods of protection from ionizing radiation.

TEACHING METHODS

1. Verbal (lecture, explanation, story, conversation, instruction);
2. Visual (observation, illustration, demonstration);
3. Practical (different types of exercises, graphic works, experiment, practice).

The training process uses the following teaching methods:

-explanatory-illustrative or informational-receptive, which provides for the ready presentation of information by the teacher and its assimilation by students;

-reproductive, which is based on the performance of various types of tasks on the sample;

-method of a problem statement - the teacher puts the problem and he solves it, demonstrating the contradictions that characterize the process of cognition, the task of students is to monitor the sequence of presentation, evidence of materiality, the prediction of the next steps of the teacher; the MN is implemented by teaching students to problem situations to ensure successful preliminary preparation for upcoming work in real conditions of practical medical institutions;

-partially search or heuristic, aims at the mastery of the separate elements of search activity, for example: the teacher formulates the problem, students hypothesis;

-research, the essence of which is to organize teacher search creative activity of students by setting new problems and problem tasks.

-methods to ensure the perception and assimilation of knowledge by students (lectures, independent work, instruction, consultation);

-methods of application of knowledge and acquisition and consolidation of skills (practical sessions, assignments);

-methods of verification and assessment of knowledge and skills.

METHODS OF CONTROL

Current control is performed based on the control of theoretical knowledge, skills and abilities in practical classes. Independent study students are assessed in practical classes, and is an integral part of the final grade of the student. Current control is performed during the training sessions and aims at checking the assimilation of students learning the material. Forms of current control are:

a) test tasks with a choice of one correct answer, with the definition of the correct sequence of actions, with determination of the conformity, defining the specific portion of the photo or diagram ("detection");

b) individual oral questioning, interview;

c) the solution of typical situational tasks;

d) control of practical skills;

e) the typical problems of medical and biological physics.

Form of final control of education is carried out in the form of the exam (written, oral) (second semester).

The semester examination is a form of final control of mastering by the student the theoretical and practical material of the discipline. The final control (exam) is held on the last control class.

To FC allowed students who attended all included in the curriculum for the discipline of classroom training and the study module scored points not less than the minimum (**72 points**). A student who for good or without good reason, had the missing classes, you are allowed to work on academic debt to a fixed term.

The form of the final control should be standardized and include control of theoretical and practical training.

SCHEME OF CALCULATION AND DISTRIBUTION OF POINTS RECEIVED BY APPLICANTS FOR HIGHER EDUCATION.

Evaluation of current educational activities. During the assessment of mastering each topic for the current educational activity of the student scores are set on a 4-point (national) assessment scale. This takes into account all types of work provided by the discipline program. The student must receive a score on each topic. Scores on the traditional scale are converted into points. The final assessment of the current academic activity is the arithmetic mean (the sum of scores for each lesson is divided by the number of lessons per semester) and translated into points according to **Table 1.**

The maximum number of points that a student can collect for current educational activity during semester in order to be admitted to the exam is **120 points.**

The minimum number of points that a student can collect for current educational activity during semester in order to be admitted to the exam is **72 points.**

Calculating of the number of points is based on obtained marks of student according to traditional scale while learning subject during the semester, by calculating the arithmetic mean (AM) that is rounded to two signs after comma.

Table 1. Conversion of the average score for the current activity into a multi-scale scale (for disciplines completed by credit)

4- point scale	200- point scale	4- point scale	200- point scale	4- point scale	200- point scale	4- point scale	200- point scale
5	200	4,47	179	3,94	158	3,42	137
4,97	199	4,45	178	3,92	157	3,4	136
4,95	198	4,42	177	3,89	156	3,37	135
4,92	197	4,4	176	3,87	155	3,35	134
4,9	196	4,37	175	3,84	154	3,32	133
4,87	195	4,35	174	3,82	153	3,3	132
4,85	194	4,32	173	3,79	152	3,27	131
4,82	193	4,3	172	3,77	151	3,25	130
4,8	192	4,27	171	3,74	150	3,22	129
4,77	191	4,24	170	3,72	149	3,2	128
4,75	190	4,22	169	3,7	148	3,17	127
4,72	189	4,19	168	3,67	147	3,15	126
4,7	188	4,17	167	3,65	146	3,12	125
4,67	187	4,14	166	3,62	145	3,1	124
4,65	186	4,12	165	3,6	144	3,07	123
4,62	185	4,09	164	3,57	143	3,05	122
4,6	184	4,07	163	3,55	142	3,02	121
4,57	183	4,04	162	3,52	141	3	120
4,55	182	4,02	161	3,5	140	<3	Not enough
4,52	181	3,99	160	3,47	139		
4,5	180	3,97	159	3,45	138		

Evaluation of individual student tasks. Points for individual tasks are accrued only if they are successfully completed and defended. The number of points awarded for different types of individual tasks depends on their scope and significance, but not more than 10-12 points. They are added to the amount of points gained by the student in the classroom during the current educational activity. In no case may the total amount for current activities exceed 120 points.

Evaluation of independent work of students. Independent work of students, which is provided by the topic of the lesson together with the classroom work, is evaluated during the current control of the topic in the relevant lesson. Assimilation of topics that are submitted only for independent work is checked during the final module control.

Evaluation of final control.

The maximum number of points that a student can score during the exam is **80 points.**

The final control is considered credited if the student scored at least 60% of the maximum amount of points (for a 200-point scale - at least **50 points**).

Determining the number of points that a student scored in the discipline: the number of points that a student scored in the discipline is defined as the sum of points for the current academic activity and for the final control (exam).

Conversion of the number of points from the discipline into grades on the ECTS scale and on a four-point (traditional) scale

Scores from disciplines are independently converted into both the ECTS scale and the national assessment scale, but not vice versa. **Table 2.**

Table 2. Conversion of the average score for the current activity into a multi-point scale (for disciplines completed by exam)

4- point scale	120- point scale	4- point scale	120- point scale	4- point scale	120- point scale	4- point scale	120- point 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	<3	Not enough
4,54	109	3,99	96	3,45	83		
4,5	108	3,95	95	3,41	82		

Criteria for establishing the assessment on the traditional 4-point and ECTS scale after passing the exam:

Points by the multi-point (200) scale	Grade by the 4-point scale (National assessment scale)	Score ECTS
180-200	5	A
160-179	4	B
150-159		C
130-149	3	D
120-129		E
50-119	2	FX
0-49		F

The criteria for the evaluation.

During assessment of the assimilation of each topic for current educational activities of the applicant higher education grades are given on a national scale (traditional) scale with regard to the approved evaluation criteria:

- *"excellent" (5)*- student flawlessly learned the theoretical material of the topic, demonstrates deep and comprehensive knowledge of the relevant topics, the main provisions of scientific sources and recommended literature, to think logically and builds a response, freely use the acquired theoretical knowledge in the analysis of practical material, expresses his attitude to certain issues, demonstrates a high level of mastering of practical skills;