MINISTRY OF HEALTH OF UKRAINE
ODESSA NATIONAL MEDICAL UNIVERSITY

APPROVED
Vice-Rector on Educational and Pedagogic Work
Prof. _____ Shmakova I.P.
"30" august 2021

SUBJECT PROGRAM FOR THE COURSE

"Medical and Biological Physics"

Level of higher education: Second (Master's)

Field of knowledge: 22 "Health"

Specialty: 222 "Medicine"

Educational qualification: "Master of Medicine"

Odesa 2021 – 2022

Composed on the basis of the educational-professional program of the second level of higher education for the preparation of Masters in the specialty 222 "Medicine" ONMedU, approved by the Academic Council of ONMedU from 04.06.2020.

The program was discussed at a meeting of the Department of Biophysics, Informatics and Medical Devices.
Protocol #1 from August 27, 2021
Head of the Department, Professor L.S. Godlevsky

The program was approved at a meeting of the Cycle Subject Commission of Biomedical Science of ONMedU.
Protocol #1 from August 30, 2021
Head of the Cycle Subject Commission of Biomedical Science, Professor O.L. Appelhans

The program was certified at a meeting of the Central Coordination and Methodological Council of ONMedU on August 30, 2021, Protocol #1.

1. Description of the Course

Names of the indexes	Characteristics of the Course	
	Daytime studying	
General number of : Credits – 4,0 Hours – 120 Contents blocks - 12	Elective course	
	Year of studying	1, 2
	Semesters	I - II
	Lectures	20 hrs
	Practices	60 hrs
	Homework	40 hrs
	Individual tasks	0
	Form of final control	Differential test

2. The goal and purpose of the Course

Goal: Formation of students' knowledge of 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 form the basis of subject competencies in medical and biological physics and is an integral part of the professional competence of the future doctor and healthcare specialist, as well as the basis for the study of professional-oriented natural and clinical disciplines in higher medical educational institutions of Ukraine.

Purposes to achieve:

1. Apply scientific and professional knowledge; to formulate ideas, concepts for the purpose of use in work of educational and scientific direction.
2. Demonstrate knowledge of research methodology in general and methods of a particular area of scientific interest, in particular.
3. Interpret and analyze information, correctly evaluate new and complex phenomena and problems with scientific accuracy critically, independently and creatively.
4. Identify unresolved problems in the subject area of medicine and identify ways to solve them.
5. Formulate scientific hypotheses, goals and objectives of scientific research.
6. Perform and improve modern research methods in the chosen area of research and educational activities.
7. Use the results of scientific research in medical and pharmaceutical practice, educational process and society.
8. Present the results of scientific research in oral and written forms in the scientific community and society as a whole, in accordance with national and international standards.
9. Manage the work of a team of students, colleagues, interdisciplinary team.
10. Use ethical principles in working with patients, laboratory animals, adhere to scientific ethics.
11. Demonstrate academic integrity and act responsibly regarding the reliability of the obtained scientific results.

The process of studying the Course is aimed at forming elements of the following competencies:

Integral competence

IC. Ability to solve complex problems and problems in the field of health care or in the learning process, involving research and / or innovation with the involvement of information on modern physical theories and methods of research of living organisms, biological objects and processes occurring in wildlife using a set of interdisciplinary knowledge and is characterized by complexity and uncertainty of conditions and requirements.

General competencies

GC1. Ability to abstract thinking, analysis and synthesis.
GC2. Ability to know and understand the subject of medical and biological physics and its role in professional activities.
GC3. Ability to communicate on topics related to the problems of biophysics in the native language both orally and in writing.
GC4. Ability to learn and master modern knowledge in the field of medical and biological physics, use information and communication technologies; ability to search, process and analyze information from various sources, to realize the possibility of lifelong learning.
GC5. Ability to adapt and make an informed decision in a new situation.
GC6. Ability to work both independently and in a team.
GC8. Ability to evaluate and ensure the quality of work performed using information technology.
GC9. Ability to act on the basis of ethical considerations, socially responsible and consciously, to have life safety skills.
3K10. Ability to be aware of equal opportunities and gender issues; appreciate and respect diversity and multiculturalism.
3K11. The desire to preserve the environment and ensure the sustainable development of society.

Special competencies

SC2. Basic ability to determine the list of necessary instrumental research, understand the physical basis of their work and evaluate their results.
SC10. Basic ability to plan and carry out sanitary and preventive measures.
SC11. Basic ability to plan and carry out preventive and anti-epidemic measures for infectious diseases.
SC15. Ability to conduct medical and statistical research; assess the biophysical impact of the environment on the health of the individual, family, population.
SC16. Ability to use methods of mathematical statistics in planning and analysis of measures for the organization and integration of medical care.

Expected learning results. As a result of studying the Course the student must

To know:

- general physical and biophysical patterns that underlie the processes occurring in the human body;
- basics of mathematical processing of medical and biological data;
- characteristics of physical external factors affecting the human body and biophysical mechanisms of these influences;
- physical and biophysical bases of medical materials science;
- purpose and principles of electronic medical equipment, safety precautions when working with it.

To be able to:

- carry out mathematical and computer processing of medical and biological information;
- use medical equipment used in medicine, 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.
- measure the resistance of biotissues to direct and alternating current;
- to measure the density of the liquid using a refractometer;
- determine the optical activity of solutions using a polarimeter;
- be able to analyze the nature of the action of ionizing radiation on biotissues.

Medical and biological physics as an academic course:

• integrates such courses as medical chemistry, biology and medicine etc. lays the foundation for students to study physiology, biological and bio-organic chemistry, medical chemistry, biostatistics, histology, pathophysiology, nuclear medicine, hygiene and ecology, ophthalmology, otorhinolaryngology, and other subjects.

The program "Medical and Biological Physics" is divided into 12 content blocks.

Content of blocks

1. Foundations of probability theory and mathematical statistics
2. Processing of errors of medical and biological measurements.
3. The mechanics of rotational and vibrational motion.
4. Bioacoustics
5. Liquids and solids. Basics of rheology and Hemodynamics.
6. Thermodynamics of biological systems.
7. Mechanisms of particle transport in biological systems.
8. Electrostatics. DC.
9. Electromagnetism.
10. Optical methods and their use in biology and medicine.
11. Ionizing radiation.
12. Radiation Physics. Fundamentals of dosimetry.

Kinds of classes according to the curriculum are:

a) lectures, b) practices, c) independent work of students (IWS), d) consultation.

Lecture course on “Medical and Biological Physics” is accompanied by practice classes that are laboratory classes by their organization. It gives students more practical skills in medical and biological physics, including the use of modern diagnostic and physiotherapy electronic equipment, dosimetry radiation monitoring devices, viscosimetro and optical methods in medicine and so on. Students are encouraged to write reports of the studies, formulating the process, research results and conclusions.

3. Contents of the subject plan

Content block 1. Probability theory and mathematical statistics.

Topic 1.Introductory class. Foundations of probability theory.

Random events, their relative frequency and probability. Drafting and multiplying the probability of events, calculating the total probability. Bayes Theorem. Random variables: discrete and continuous.

Topic 2. Fundamentals of Mathematical Statistics.

Distribution, number and distribution of polygonal distributions of discrete random variable. Distribution function and its graph. Activities center position distribution. Measures of variability values of random variable. The density distribution curve of distribution of continuous random variable.

Content block 2. Probability theory and mathematical statistics ..

Topic 3. Mathematical processing of medical and biological data.
The concept of statistical evaluation. Check sample of homogeneity. Confidence interval for mathematical expectation. Estimation of random errors of direct measurements. Verification of hypothesis of equality of parameters of normal populations of independent random variables. Estimation of random errors of indirect measurements. Accounting for instrumental error.

Topic 4. Boundary control on the material of content blocks 1-2.

Content block 3. Mechanics of rotation and oscillations.

Topic 5. Rotation.

Mechanics. Translational and rotational motion. Kinematics of rotation. Kinematic characteristics of translational and rotational motion and the link between them: linear and angular velocity, linear and angular acceleration. Tangential and normal acceleration. Inertia properties of bodies in the translation and rotational motion. Moment of inertia of the material point and rigid body. Torque.
Dynamics of rotational motion. The basic equation of rotational motion. Angular momentum.
Conservation of angular momentum. Work and kinetic energy of rotation. Centrifugation.
Elements of biomechanics.

Topic 6. Mechanical vibrations

Fluctuations, their types: free, forced, and parametric oscillations. Basic concepts of the theory of fluctuations. Differential equation of free oscillations and its solution. Speed and acceleration at oscillations. Energy at oscillations. Summation of oscillations. Differential equation of dumped oscillations and its solution. Amplitude, frequency, energy of dumped oscillations. Differential equations of forced oscillations and its solution. Resonance.

Content block 4. Bioacoustics.

Topic 7. Mechanical waves. Acoustics. Physics of Hearing

Wave motion. Mechanical waves. Types of waves, speed of propagation. Harmonic wave, its main characteristics. Speed of propagation, wavelength, period. Types of waves and their excitation conditions. Energy and momentum of a wave. Wave equation and its solutions (flat and spherical waves) Energy characteristics of waves. Shock waves. Doppler effect and its use in medicine.
Nature and types of sound. Physical characteristics of sound. Characteristics of auditory perception. Weber-Fechner law. Sound measurement. Audiometry. Ultrasound and its application in medicine. Infrasound. Vibration and its application in medicine.

Content block 5. Liquids and solids. Basics of rheology and hemodynamics

Topic 8. Mechanical properties of solids and liquids.

Liquids and solids. Rheology. Mechanical stress and its components. Elasticity and plasticity. Types of deformations and their characteristics. Elastic deformation. Mechanical properties of solids. Hooke's law. Limit of elasticity. Residual deformation. The limits of fluidity and strength. Relaxation of tension. Reversible viscoelastic deformation.

Topic 9. Basics of biorheology. Mechanical properties of liquids.

Dynamic and kinematic viscosity of liquids. Newton's formula. Newtonnian and non-Newtonian liquids. Flow of a viscous liquid. Laminar and turbulent flows. Reynolds number. Flow of viscous liquids through pipes. Poiseuille's formula. Motion of bodies in viscous liquids. Stokes' law. Methods for determining the dynamic viscosity. Basics of hemodynamics. Models of the circulatory system.

Topic 10. External breathing

The structure of the respiratory system and the respiratory muscles. Histological structure of the lungs and airways. Lever principle. Diffusion of gases through the membrane. Mechanical ventilation alone. Basics processes of external breathing. Laws of pressure changes in the lung and pleural vacuum during inhalation and exhalation. Regulatory mechanisms for inhalation and exhalation.

Topic 11. Biomechanics of the human heart

General principles of the heart and the construction of the circulatory system. Composition and rheological properties of the tissues of the heart, blood vessels and blood. Regimes of blood circulation in the heart and blood vessels. The influence of arteriosclerosis, stenosis and other specific conditions on the circulatory regimes. Laplace's law. Transmural pressure. Occurrence of specific noises in heart defects. Normal values of the parameters characterizing the work of a healthy heart. Mechanical efficiency of the heart.

Content block 6. Thermodynamics of biosystems.

Topic 12. Basics of thermodynamics. Thermodynamics of biological systems

Thermodynamic system and its parameters. Open, closed and isolated system. Thermodynamic processes. Reversible and irreversible processes. Internal energy of bodies and means of its change: work and heat. First principle of thermodynamics. Heat, work and internal energy. The second principle of thermodynamics. Entropy. Boltzmann principle. The basic equation of thermodynamics. Thermodynamic potentials. Chemical and electrochemical potential. Non-equilibrium thermodynamics. Steady state. Prigojin's principle. The organism as an open system.

Topic 13. Physical properties of biological membranes.

Membranes. Structure, characteristics, functions and models of biological membranes.

Content block 7. Mechanisms of transport of particles in biological systems

Topic 14. Mechanisms of active and passive transport in biological systems

Passive transport of molecules. Diffusion of neutral molecules. Fick's law. Membrane permeability and resistance to the flow of substances. Passive transport of substances. Fascilitated and exchange diffusion. Osmosis. Osmotic pressure. Filtration. Passive transport of ions. Nernst-Planck equation.. Active transport in biological systems, active transfer of ions and non-organic substances. Sodium-potassium pump.

Topic 15. Bioelectrical potentials

Resting potential. Equilibrium potentials. Donnan's equilibrium and Donnan's potential. Nernst equilibrium potential. Stationary potentials. Hodzhkyn-Goldman-Katz potential. Potentials at work of sodium-potassium pump (Thomas). Action biopotential. Ion currents through the membrane. Research of Hodzhkyn, Huxley and Katz, the main conclusions. Model of sodium channel. Propagation of action potential along the non-mielinized nervous fiber. Telegraph equation. Constant of the length of nervous fiber, its physical sense. Mielinized nervous fibers.

Topic 16. Boundary control on the material of content blocks 3-7.
Content block 8. Electrostatics. DC.

Topic 17. Electric field.

Electric charge. Low of conservation of electric charge. Electric field, its power and energy characteristics and the relationship between them. Electric dipole. Equivalent generator, electric properties of organs and tissues. Current unipol and dipole. Electric vector of a heart. Multipoles. Multidipole equivalent electric generator. Physical principles of electrocardiography.

Topic 18. Electric current. Electrophoresis.

Electric current. Ohm's law. Thermoelectricity, piesoelecricity. Galvanization and electrophoresis procedures. Electrical resistance of body tissues. Air ions and their effects on the human organism.

Content block 9. Electromagnetism.

Topic 19. Magnetic field. Physical basics of magnetobiology.
Magnetic field. Magnetic momentum of a circuit. Vector of magnetic induction. Magnetic flux.

Ampere's law. Effects of magnetic field on a circuit. Energy of a magnetic field. Effects of magnetic field on a mobile charge. Lorentz force. Electronic, magnetic and electrostatic lenses. Magnetic field. Law of Biot-Savart-Laplace. Law of a full current. Law of electromagnetic induction. Quasi-stationary currents.

Topic 20. Electromagnetic Waves

AC, its generation and options. Active and reactive resistance. Full resistance in the AC circuit. Resonances of voltage and currents. Power in AC circuit. Passive electrical properties of biological medias and electrical quantities that describe them. Polarization. Electrical conductivity of biological tissues and fluids. Reography. Maxwell theory. Maxwell equations. Electromagnetic waves and their properties. Speed of propagation of electromagnetic waves. Refractive index. Energy of electromagnetic waves. Poynting vector. Scale of electromagnetic waves.

Content block 10. Basics of electromedical apparatus.

Topic 21. Medical electronics. A medical information system. Electrical medical equipment

Medical electronics. Main types of medical equipment. Effects of alternating current in the tissue of the body. Three-phase power system. Line and phase voltage. Main principles and methods of ensuring safety of electrical devices, safety requirements when working with medical equipment.
Classes of electromedical devices depending on additional protection from a shock. The reliability of medical equipment. Structure of the receipt, transfer and registration of Medical and Biological Information (MBI). Electrodes and sensors, their types and characteristics. Radiotelemetry. Endoradiozondage. Display and recording devices for MBI.
Amplifiers, main features of their structure. Properties of amplifiers. Nonlinear (amplitude) distortions and their ratio. Linear (frequency) distortions. Bandwidth of the amplifier. Specificity of amplifiers for biopotentials. Possible impediments to quality work of amplifier Types of vibration generators.
Electronic oscilloscope. Low and high frequency physiotherapy apparatus. Diadinamotherapy and amplypulstherapy. Stationary and implantable elektrostimulators. The high frequency physiotherapy apparatus. Diathermotomy and diatermocoagulation. General and local darsonvalization. Inductothermy and UHF-therapy. Microwave therapy and therapy with decimeter vawes.

Content block 11. Optical methods and their use in biologyu and medicine

Topic 22. Interference and diffraction of light.

Coherent sources and coherent light waves. Interference of light. Terms of maximum and minimum. Interference of light in thin plates (films). Interferometers and their application. Interference microscope. Huygens-Fresnel principle. Diffraction of a cleft in parallel rays. Diffraction and diffraction grating. Fundamentals of X-ray analysis. The concept of holography and its application in medicine

Topic 23. Polarized light in medicine.

Natural and polarized light. Plane of polarization. Polarizer and analyzer, their main plane. Malus' law. Polarization phenomena at reflection and refraction of light. Full polarization angle, Brewster's law. The phenomenon of double refraction. Optical axis. Positive and negative crystals. The structure and use of Nicol prism. Dichroism. Polaroids. Rotation of the plane of polarization. Optically active substances. Constant of rotation of optically active substances. Polarimetry and its use in medicine. Polarization microscopy and its use in medical research.

Topic 24. Geometric optics. Optical system of the eye and a microscope

Geometric optics as a limiting case of wave optics. Laws of reflection and refraction of light. Lenses and their main aberration. Ideally centered optical system. Structure of human eye. Eye as a centered optical system. Accommodation, distance of the best view, visual acuity. Disadvantages of optical system of the eye. Biological microscope and it's optical system. Resolving ability of the microscope. Useful zoom of the microscope. Special methods of optical microscopy. Fiber optics and its use in endoscopy.

Topic 25. Thermal radiation. Thermography

Thermal radiation, its nature and properties. Characteristics of thermal radiation. Black body and gray body. Kirchhoff's Law. The laws of black body radiation. Convective heat transfer. Thermographic, LCD thermography. Infrared radiation. Use of infrared radiation in medicine. Ultraviolet radiation and its biological effect. Use of ultraviolet radiation in medicine. Use and sources of UV and infrared radiation in medicine and dentistry. Photoelectric effect, main types and patterns. Photoelectronic devices and their use in medicine. Light measurements, basic charactersitcs of light.

Topic 26. Elements of quantum mechanics. Quantum-mechanical methods of study of biological objects

De Broglie's hypothesis. Wave properties of microscopic objects. Electronic microscope and its use. Wave function and its physical meaning. The ratio of Heisenberg, Schrödinger's equation. Hydrogen atom. Quantum number. The Bohr's theory. Pauli's exclusion principle. Electronic shelves of multi-electronic atoms. Energy levels of molecules. Spontaneous and induced radiation. Inverse populousness of energy levels. Quantum generators (masers, lasers, gasers. The helium-neon laser. Properties of induced radiation. Splitting of energy levels of atoms in a magnetic field. Electronic paramagnetic resonance (EPR) and nuclear magnetic resonance NMR). NMR introscopy.

Topic 27. Radiation and energy absorption of atoms and molecules. Photobiological processes

Types of quantum transitions. Emission and absorption spectras. Law of Buger, Lambert and Baer. Colorimety. Light scattering and its main species. Raleigh's law. Nefelometry. Optical atomic spectra. Spectrum of hydrogen atom. Molecular spectra. Luminescence, its main species. Fluorescence and phosphorescence. Stoks' law. Fluorescence analysis. Fluorescent microscopy. Hemiluminescense. Photobiological processes. Sensitivity of the eye. Mechanisms of visual adaptation. The mechanism of visual reception.

Content block 12. Ionizing radiation

Topic 28. X-rays. Physical principles of X-ray and radiotherapy

X-rays. X-ray tube. Braked X-rays. Characteristic X-rays. Mosley's Law. Primary processes of X-ray photon interaction with atoms. Effects of X-rays on substance. Linear coefficients and mass reduction. X-ray absorption by a substance. Linear and mass absorption coefficients. Physical principles of X-ray and radiotherapy. X-ray diagnostics in dentistry. X-ray Computer Tomography.

Topic 29. Radioactivity. Physical principles of radio diagnostics and radiotherapy

Radioactivity. The main law of radioactive decay. Halflife period. Experimental determination of decay curve. Activity and specific activity, units of measurement. Alpha-decay, energy spectrum of alpha radiation. Electronic and positronic beta decay. Spectrum of energy of beta radiation. Neutrino. Electronic capture. Interaction of ionizing radiation with a substance. Linear density of ionization,

braking ability. Vavilov-Cherenkov's radiation. Formation of electronic-positronic pairs. Annihilation. Effects of gamma radiation.

Topic 30. Elements of dosimetry. Protection from radiation Differential test.

Biophysical basis of ionizing radiation effects on the body. Radiation detectors. Use of radionuclides in medicine, neutrons. The main types of charged particle accelerators. The use of accelerators for radiotherapy. The use of accelerators in diagnosis.
Dose and absorbed dose of radiation. Power exposure dose and the radioactive decay activity.
Coefficient of quality (relative biological effectiveness) of ionizing radiation.
Differential test.

4. Structure of the course

Topics	Hours			
	Total	Including:		
		Lectures	Practices	IWS
1	2	3	4	5
Content block 1. Probability theory and mathematical statistics.				
Topic 1. Introductory class. Foundations of probability theory.			2	
Topic 2. Fundamentals of Mathematical Statistics.		2	2	
Total – for content block 1		2	4	

Content block 2. Probability theory and mathematical statistics.				
Topic 3. Mathematical processing of medical and biological data.			2	
Topic 4. Boundary control on the topics of content blocks 1-2.			2	
Total – for content block 2			4	
Content block 3. Mechanics of rotation and oscillations.				
Topic 5. Rotation.			2	
Topic 6. Mechanical oscillations.			2	
Total – for content block 3			4	
Content block 4. Bioacoustics.				
Topic 7. Mechanical waves. Acoustics. Physics of Hearing		2	2	4
Total – for content block 4		2	2	4
Content block 5. Liquids and solids. Basics of rheology and hemodynamics				
Topic 8. Mechanical properties of solids and liquids.		2	2	
Topic 9. Basics of biorheology. Mechanical properties of liquids.			2	4
Topic 10. External breathing			2	
Topic 11. Biomechanics of the human heart			2	
Total – for content block 5		2	8	4
Content block 6. Thermodynamics of biosystems.				
Topic 12. Basics of thermodynamics. Thermodynamics of biological systems		2	2	6
Topic 13. Physical properties of biological membranes.			2	2
Total – for content block 6		2	4	8
Content block 7. Mechanisms of transport of particles in biological systems				
Topic 14. Mechanisms of active and passive transport in biological systems		2	2	
Topic 15. Bioelectrical potentials			2	2
Topic 16. Boundary control on the material of content blocks 3-7.			2	
Total – for content block 7		2	6	2
Content block 8. Electrostatics. DC.				
Topic 17. Electric field.		2	2	
Topic 18. Electric current. Electrophoresis.			2	
Total – for content block 8		2	4	
Content block 9. Electromagnetism.				
Topic 19. Magnetic field. Physical basics of magnetobiology.		2	2	2
Topic 20. Electromagnetic Waves			2	
Total – for content block 9		2	4	2

Content block 10. Basics of electromedical apparatus.				
Topic 21. Medical electronics. A medical information system. Electrical medical equipment			2	2
Total – for content block 10			2	2
Content block 11. Optical methods and their use in biologyu and medicine				
Topic 22. Interference and diffraction of light.		2	2	
Topic 23. Polarized light in medicine.			2	
Topic 24. Geometric optics. Optical system of the eye and a microscope			2	
Topic 25. Thermal radiation. Thermography		2	2	
Topic 26. Elements of quantum mechanics. Quantum-mechanical methods of study of biological objects			2	4
Topic 27. Radiation and energy absorption of atoms and molecules. Photobiological processes			2	4
Total – for content block 11		4	12	8
Content block 12. Ionizing radiation				
Topic 28. X-rays. Physical principles of X-rays and radiotherapy		2	2	2
Topic 29. Radioactivity. Physical principles of radio diagnostics and radiotherapy			2	2
Topic 30. Elements of dosimetry. Protection from radiation Differential test.			2	2
Total – for content block 12		2	6	
Total		20	60	40

5. LECTURE PLAN for first-year students taking the course of "Medical and Biological Physics"

№№	Topic of the lecture	Lectures	
		Hours	Semester
1	Basic theory of probability. Fundamentals of Mathematical Statistics	2	1
2	Mechanical vibrations and waves. Acoustics	2	1
3	Liquids and solids. Fundamentals of rheology and hemodynamics. Models of the circulatory system.	2	1
4	Thermodynamics	2	1
5	The mechanisms of particle transport in biological systems. Bioelectric potentials	2	1
6	Electrostatics. DC. Alternating electric current	2	2
7	The magnetic field. Electromagnetic Waves	2	2

8	Wave optics. Polarization of light. The interaction of light with matter	2	2
9	Thermal radiation. The main provisions of quantum mechanics.	2	2
10	X-ray radiation. Radioactivity. Radiobiology	2	2
		20	

6. PRACTICE PLAN for first-year students taking the course of "Medical and Biological Physics"

№№	Topics of the class and its contents	Seminars	
		Hours	Semester
1	Introductory lesson. Basic theory of probability	2	1
2	Fundamentals of Mathematical Statistics	2	1
3	Processing of errors of medical measurements.	2	1
4	Quizzes on the material content blocks 1-2	2	1
5	Rotational motion. Biomechanics	2	1
6	Mechanical vibrations	2	1
7	Mechanical waves. Acoustics. Physics hearing	2	1
8	Mechanical properties of solids and biological tissues	2	1
9	Mechanical properties of biological fluids and flow	2	1
10	The mechanism of respiratory	2	1
11	Biomechanics of heart	2	1
12	Fundamentals of Thermodynamics. Thermodynamics of biological systems.	2	1
13	Physical issues biomembranolohiyi	2	1
14	Mechanisms of active and passive transport	2	1
15	Biopotentials	2	1
16	Quizzes on the material content blocks 3-7	2	2
17	The electric field. Physical basis electrocardiography	2	2
18	The electric current. Electrophoresis	2	2
19	The magnetic field. Physical basis magnetobiology	2	2
20	Electromagnetic Waves. Reography	2	2
21	Medical electronics. Getting health information system and electrical medical equipment	2	2
22	Interference and diffraction of light	2	2
23	Polarized light in medical research	2	2
24	Geometric optics. The optical system of the eye and the microscope	2	2
25	Thermal radiation. Thermography	2	2
26	Elements of quantum mechanics. Quantum mechanical methods of biological objects.	2	2
27	Radiation and energy absorption atoms and molecules. Photo-biological processes	2	2
28	X-ray radiation. Physical principles of X-ray and X-ray	2	2
29	Radioactivity. Physical basis of radio diagnostics and radiotherapy	2	2
30	Elements of dosimetry. Protection against radiation. Differential test.	2	2

		60	

7. PLAN of Individual Work of Students (IWS) for first-year students taking the course of "Medical and Biological Physics"

№	**IWS topic**	Hours
1	Ultrasound. The main properties and features of ultrasound propagation. The effect of ultrasound on biological tissues and human organs.	2
2	Infrasound, physical characteristics of infrasound. The effect of infrasound on biological tissues and human organs.	2
3	Deformation properties of biological tissues.	2
4	Surface tension. Surface tension coefficient and methods of its determination. Gas embolism.	2
5	Basic provisions of equilibrium thermodynamics. Entropy. II law of thermodynamics. Boltzmann principle. Thermodynamic potentials. Thermodynamics and the problem of environmental protection.	2
6	Basic provisions of nonequilibrium thermodynamics (linear law, entropy production,	2

	flow conjugation).	
7	Steady state of open systems. Prigogine's theorem.	2
8	Open biological systems, far from equilibrium. The concept of synergetics.	2
9	Diffusion of hydrophilic and hydrophobic molecules through membranes. Specifics of selective permeability.	2
10	Ionic currents in biological membranes and their role in the formation of biological potentials. The concept of reverse currents.	2
11	Modern diagnostic and physiotherapeutic equipment.	2
12	Magnetic properties of biological tissues. Physical foundations of magnetobiology.	2
13	Medical optics devices (polarimeter, refractometer, concentration colorimeter, nephelometer and others).	2
14	Photo effect and its application. Photovoltaic devices in medicine.	2
15	The use of luminescence in medicine.	2
16	Lasers and their application in medicine.	2
17	X-rays and its application in medicine.	2
18	Attenuation of radioactive radiation as it passes through lead, iron and aluminum screens.	2
19	Computers in medicine.	2
20	***Preparation for Differential Test***	2
	T O T A L	**40**

8. Individual tasks

Students works one all topics under the guidance of teachers. Quality of their work is considered when the final grade for the entire course of medical and biological physics for a student is produced.

9. Methods of studying

Practical classes: study of material from textbooks and manuals. Interviewing students and a teacher's conversation with them, with the identification of fragments of material that seem difficult and unclear to them. An explanation by the teacher of these parts of the material, with an illustration of their practical significance in medicine. Completion of the assignments set by the teacher in the classroom, with their verification and clarification of errors.

Independent work: independent work with a textbook, independent problem solving.

10. Methods of control and criteria for evaluating learning outcomes

Assessment of current educational activities, one practical lesson:

Evaluation of the success of the study of each topic of the discipline is performed on a traditional 4-point scale.
At least 50% of students should be interviewed in a practical (laboratory) lesson, and at least 30% in a seminar.
At the end of the semester (cycle), the number of grades for students in the group should be the same on average.
At the end of the course, the current performance is calculated as the average current score, ie the arithmetic mean of all grades obtained by the student on a traditional scale, rounded to 2 (two) decimal places, for example 4.75.

«5»	The student is fluent in the material, takes an active part in discussing the problems presented in class, confidently demonstrates analytical skills during the class and interpretation of the provided model data of laboratory and instrumental research, expresses his opinion on the topic, demonstrates scientific and analytical thinking.
«4»	The student is well versed in the material, participates in the discussion of problems presented in class, demonstrates analytical skills during the class and interpretation of the provided model data of laboratory and instrumental research with some errors, expresses his opinion on the topic, demonstrates scientific and analytical thinking.
«3»	The student does not have enough material, insecurely participates in the discussion of problems presented in class, demonstrates analytical skills during class and interpretation of the provided model data of laboratory and instrumental studies with significant errors.
«2»	The student does not own the material, does not participate in the discussion of problems presented in class, does not demonstrate analytical skills during class and interpretation of the provided model data of laboratory and instrumental research.

At the last practical lesson, the teacher is obliged to announce to students the results of their current academic performance, and their academic debt (if any). Only those students who do not have academic debt and have an average score of at least 3.00 for current academic activities are allowed to take the final certification.

Final control of knowledge in the corse. Criteria for evaluating the learning outcomes of students on a differentiated test:

«5»	It is presented to a student who systematically worked during the semester, showed during the exam versatile and deep knowledge of the program, is able to successfully perform the tasks provided by the program, mastered the content of basic and additional literature, realized the relationship of individual sections of the discipline, their importance for future profession. showed creative abilities in understanding and using educational material, showed the ability to independently update and replenish knowledge; level of competence - high (creative);
«4»	It is presented to a student who has shown full knowledge of the curriculum, successfully performs the tasks provided by the program, mastered the basic literature recommended by the program, showed a sufficient level of knowledge in the discipline and is able to independently update and update during further study and professional activities; level of competence - sufficient (constructive-variable)
«3»	It is presented to a student who has shown knowledge of the basic curriculum in the amount necessary for further study and further work in the profession, copes with the

	tasks provided by the program, made some mistakes in answering the exam and when performing exam tasks, but has the necessary knowledge to overcoming mistakes under the guidance of a research and teaching staff; level of competence - average (reproductive)
«2»	It is presented to a student who did not show sufficient knowledge of the basic curriculum, made fundamental mistakes in performing the tasks provided by the program, can not without the help of the teacher to use the knowledge in further study, failed to master the skills of independent work; level of competence - low (receptive-productive).

11. Distribution of points received by applicants for higher education

The grade for the course consists of 50.0% of the grade for the current performance and 50.0% of the grade for the exam. The average score for the course is translated into a national grade and converted into scores on a multi-point scale. Conversion of the traditional grade for the course in the 200-point is carried out by the information and computer center of the University program "Contingent".

Table for conversion of traditional assessment into multi-point:

National mark for the course	Total scores for the course
«5»	**185 – 200**
«4»	**151 – 184**
«3»	**120 – 150**

Points from the discipline are independently converted into both the ECTS scale and the four-point scale. ECTS scale scores are not converted to a four-point scale and vice versa. Further accounts are carried out by the information and computer center of the university

Table for conversion of traditional assessment and the sum of scores to the ECTS

ECTS scores	Statistical distribution
A	Best 10% of students
B	Next 25% of students
C	Next 30% of students
D	Next 25% of students
E	Next 10% of students

The ECTS scale is given by the ONMedU educational subdivision or the dean's office after ranking the grades in the discipline among students studying in one course and in one specialty. According to the decision of the Academic Council, it is recommended to rank students - citizens of foreign countries in one array.

12. The list of questions to the final control.

1. Classification of phenomena. Probability of random phenomena, probability addition theorem.

2. Probability multiplication theorem for independent random phenomena, conditional probability, probability multiplication theorem for dependent random phenomena.

3. Distribution of random phenomena, mathematical expectation, variance, standard deviation.

4. Basic laws of distribution of random variables (normal law, Poisson distribution, binomial distribution, etc.). Deformations, their types.

5. Elasticity and plasticity. Hooke's law. Jung's module. Poisson's ratio. Deformation properties of biological tissues.

6. Surface tension. Surface tension coefficient and methods of its determination. Gas embolism. Internal friction. Viscosity. Newton's formula for internal friction.

7. Newtonian and non-Newtonian fluids. Blood viscosity. Stationary fluid flow.

8. The equation of continuity. Linear and volumetric velocities. The basic equation of fluid dynamics.

9. Laminar and turbulent flow. Reynolds number. Bernoulli's equation. Flow of viscous liquids. Poiseuille's formula. Hydraulic resistance.

10. The main provisions of equilibrium thermodynamics. Entropy. Boltzmann principle. 11. The importance of thermodynamics in the problem of environmental protection.

12. The main provisions of nonequilibrium thermodynamics (linear law, entropy production, conjugation of flows).

13. Steady state of open systems. Prigogine's theorem.

14. Structural organization of biological membranes. Physical properties of biomembranes.

15. Liquid crystalline state of biomembranes. Dynamic properties of membranes.

16. Passive transport of substances through membrane structures. Fick's equation. Diffusion rate.

17. Nernst-Planck equation. Electrochemical gradient and potential. Theorell's equation.

18. Active transport, main types. Molecular organization of active transport on the example of K-Na-pump operation. Conjugation of flows.

19. The nature of the resting membrane potential (Nernst equilibrium potentials for various ions, diffusion potential, Donnan potential).

20. The nature of the resting membrane potential (stationary Goldman-Hodgkin-Katz potential, stationary conditions, basic equations of electron diffusion of ions in the steady state, the permeability of the membrane for ions at rest).

21. Action potential (PD). Hypothesis of PD occurrence. Equivalent electrical circuit of the membrane.

22. Phenomenological equations Hodgkin-Huxley. The concept of gate ion currents.

23. Propagation of action potential in biological membranes. Telegraph equation.

24. Speed of potential spread. Features of distribution of action potential in myelin fiber.

25. Non-damped and forced oscillations, differential equations and their solution. 26. Resonance. Self-oscillation.

27. Damping oscillations. Differential equation of damped oscillations, its solution. Attenuation coefficient, decrement and logarithmic decrement.

28. Mechanical waves. Wave equation. Energy flow. Vector Condition.

29. Acoustics. Physical characteristics of sound. Physics of hearing, characteristics of auditory sensation. Weber-Fechner law.

30. Audiometry. Intensity scale and volume scale, units. Thresholds of audibility and pain. Audiogram.

31. Ultrasound. Basic properties and features of ultrasound propagation. 32. Infrasound, physical characteristics of infrasound. Effect of ultrasound and infrasound on biological tissues and human organs.

33. Electrical characteristics of biological tissues. Ohm's law in differential form. Conductivity of biological tissues.

34. Capacitive properties of biological tissues. Equivalent electrical circuit.

35. Biophysical foundations of electrography. The concept of an equivalent electric generator.

36. Einthoven's concept of the genesis of the ECG (integral electrical vector of the heart, dipole potential, lead system).

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

38. Alternating current circuit containing active, capacitive and inductive resistance. The concept of a vector chart. Impedance.

39. Impedance of biological tissues. Impedance variance. Physical foundations of rheography.

40. Magnetic field and its characteristics. Bio-Savar-Laplace law.

41. Magnetic properties of substances. Physical foundations of magnetobiology.

42. Maxwell's theory of electromagnetic waves (bias current, Maxwell's equation, velocity of electromagnetic waves).

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

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

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

46. Polarization of light. Methods of obtaining polarized light.

47. Double refraction. Prism of Nicolas. Malus's law.

48. Optically active substances. The angle of rotation of the plane of polarization. Bio Law. Concentration polarization.

49. Absorption of light. Bouguer's law. Absorption of light by solutions. Bouguer-Lambert-Behr law. Concentration colorimetry.

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

51. Rayleigh's law. Nephelometry.

52. Basic ideas of quantum mechanics: wave properties of microparticles, de Broglie's formula.

53. Wave function and its physical content, the ratio of Heisenberg uncertainties. The concept of the electron microscope.

54. Quantum mechanical model of the hydrogen atom. Schrödinger's equation. Quantum numbers. Energy levels. Pauli principle.

55. Radiation and absorption of light by atoms and molecules. Radiation and absorption spectra. Spectrophotometry.

56. Thermal radiation of bodies, its characteristics. Absolutely black and gray bodies. Kirchhoff's law. Thermal radiation

57. Biophysical bases of interaction of ionizing radiation with biological tissues. 58. Dosimetry of ionizing radiation. Exposure and absorbed doses. Biological action of radiation, biologically equivalent dose.

59. Dose rate. Dose units and dose rates. human body. The concept of thermography.

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

61. Photo effect and its application. Internal and external photo effects. Photovoltaic devices in medicine.

62. Luminescence: types, basic patterns, properties. Stokes' law. Application of luminescence in medicine.

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

64. Resonant methods of quantum mechanics, their application in medicine. Electronic paramagnetic and nuclear magnetic resonances.

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

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

67. Ionizing radiation and its types. Interaction of ionizing radiation with matter. Protection against ionizing radiation.

68. Biophysical basis of interaction of ionizing radiation with biological tissues. 69. Dosimetry of ionizing radiation. Exposure and absorbed doses.

70. Biological action of radiation, biologically equivalent dose. Dose rate. Dose units and dose rates.

13. Methodical support:

- Working program of the course
- The syllabus of the course
- Multimedia presentations
- Methodical units for practical classes

14. Recommended literature

Basic:

1. Intermediate Physics for Medicine and Biology / Russell K. Hobbie (Author), Bradley J. Roth. — 5th ed. — Springer Science+Business Media, 2015. — ISBN-13: 978-3319126814, ISBN-10: 3319126814
2. Compendium of Biophysics / Andrey B. Rubin First © 2017 Scrivener Publishing LLC ISBN:9781119160250 |Online ISBN:9781119160281 |DOI:10.1002/9781119160281

Additional:

1. Biophysics: An Introduction / Roland Glaser. Springer-Verlag Berlin Heidelberg, 2012. ISBN 978-3-642-25212-9

2. Physics in Biology and Medicine - 5th Edition / Paul Davidovits. Academic Press, 2018. ISBN: 9780128137178
3. Membrane Structural Biology With Biochemical and Biophysical Foundations 2nd Edition / Mary Luckey, San Francisco State University, 2014 ISBN: 9781107030633
4. Biophysics: Tools and Techniques / Betty Karasek. East West Books, 2017. ISBN-13: 978-1632385444. ISBN-10: 1632385449

15. Online resources

1. https://info.odmu.edu.ua/chair/biophysics/files/428/en (Methodic resources of the department)
2. http://amphu.org (Medical Physics in Ukraine)
3. http://uamedphys.blogspot.com (Books on Medical Physics)
4. http://iopscience.iop.org/0031-9155 (Journal of Physics in Medicine and Biology)
5. http://mednavigator.net (Medical search engine)
6. https://physicsworld.com/c/medical-physics (Information resources of medical and biological physics)
7. http://iomp.org (International Organization of Medical Physics)
8. https://aapm.org/default.asp (Website of the American Association of Physicists in Medicine)
9. https://aapm.onlinelibrary.wiley.com/journal/24734209 ((Journal «Medical Physics»)
10. https://efomp.org (Website of the European Federation of Medical Physicists)
11. https://www.facebook.com/AmericanMedicalAssociation/ (American Medical Association)