MINISTRY OF HEALTH OF UKRAINE

ODESSA NATIONAL MEDICAL UNIVERSITY

APPROVED

Vice-Rector on Educational and Pedagogic Work

Prof. _____ Shmakova I.P.

" " 2021

WORK PROGRAM ON ACADEMIC DISCIPLINE

"BIOLOGICAL PHYSICS WITH PHYSICAL METHODS OF ANALYSIS"

Level of higher education: second (master's **degree)**

Field of expertise: 22 "Healthcare"

Specialty: 226 «Pharmacy, industrial pharmacy»

Educational and professional program: Pharmacy

Odessa 2021 - 2022

The program of study of the academic discipline "Biological Physics with Physical Methods of Analysis" compiled according to the educational and professional program of the second level of higher education for the preparation of masters from the specialty 226 "Pharmacy, Industrial Pharmacy" of ONMedU, approved by the Academic Council of ONMedU from 04.06.2020 (Protocol #11).

Developer: Associate Professor Zhumatii P.G.

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 discipline

Name of indicators	Characteristics of the academic discipline	
	Full-time education	
Total quantity:	Mandatory	
Credits – 4,5	Year of preparation	1
Hours – 135	Semester	I - II
Content subsections – 5	Lecture	20
	Practical	60 hours
	Independent work	55 hours
	Including individual tasks	0
	Form of final control	Diff. test

2. The purpose and objectives of the discipline

- **Purpose:**Mastering the student's basic knowledge and the formation of competencies in the field of professional activity, and laying the foundation for the study of physical and biological chemistry, pharmacokinetics, analytical chemistry, physiology, pathophysiology, radiation medicine, hygiene and ecology, ophthalmology, etc.

Task:

1.Formation of understanding of the basics of modern physical theories and methods of studying living organisms, biological objects and processes that occur in wildlife.

2.Mastering the ability to determine the physical methods necessary for the release of typical most common tasks.

The process of studying the discipline is aimed at the formation of elements of the following competencies:

Integral competence

IC. Ability to solve practical problems in professional activities in the field of pharmacy, or in the learning process, which involves implementation of innovations and is characterized by complexity and uncertainty of conditions and requirements.

General competencies

GC1. Ability to act socially responsibly and consciously.
GC2. Ability to apply knowledge in practical situations.
GC3. The desire to preserve the environment.
GC4. Ability to abstract thinking, analysis and synthesis, to learn and be modernly trained.
GC5. Ability to show initiative and entrepreneurship.
GC6. Knowledge and understanding of the subject area and understanding of professional activity.
GC7. Ability to adapt and act in a new situation.
GC8. Ability to communicate in a professional foreign language (mainly English) at a level that ensures effective professional activity.
GC9. Skills in the use of information and communication technologies.

GC10. Ability to choose communication strategy, ability to work in a team and with experts from other fields of knowledge / types of economic activity.
GC11. Ability to assess and ensure the quality of work performed.
GC13. Ability to exercise their rights and responsibilities as a member of society, to realize the values of civil (free democratic) society and the need for its sustainable development, the rule of law, human and civil rights and freedoms in Ukraine.
GC14. Ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, techniques and technologies, use different types and forms physical activity for active recreation and a healthy lifestyle.

Expected learning outcomes. As a result of studying the academic discipline, the student must:

Know: the basics of biophysics and the use of specific for pharmacy, biological and medical physics, physical and biological chemistry, pharmacokinetics, analytical chemistry physical methods of analysis and metrology.

Be able to:

- to replenish knowledge and understanding of the basic mathematical characteristics of medical and biological systems, the physical foundations of the processes that occur in living organisms
-integrate basic knowledge from physics, chemistry, biology, mathematics, information technology to create a foundation of professional competence.
- collect, record and analyze biomedical research data using appropriate statistical methods and technological means.
-apply quantitative methods in the study of medical and biological processes.
-to interpret the general physical and biophysical laws that underlie the functioning of the human body.
-explain the mathematical foundations of the functioning and application of modern (electronic) medical devices.
-analyze the composition and physical principles of operation of medical devices and equipment.
-to carry out mathematical processing of the results of laboratory researches.

Master skills:

-use of physical methods of analysis and metrology specific for pharmacy, biological and medical physics, pharmacokinetics.
-mathematical processing of laboratory results.
-analysis of the composition and physical principles of operation of medical devices and equipment.

3. Content of academic discipline

Subsection 1. Fundamentals of Biomechanaics.

Topic 1. Translational and rotational motion

Kinematics of rotational motion. Kinematic characteristics of translational and rotational motion and the relationship between them: linear and angular velocity, linear and angular acceleration. Tangential and normal acceleration. Inertial properties of bodies in translational and rotational motion. The moment of inertia of the material point and the solid. Moment of force. Dynamics of rotational motion. The basic equation of rotational motion. Angular momentum. The law of conservation of angular momentum. Work and kinetic energy in rotational motion. Centrifugation.

Topic 2. Oscillation

Oscillations, their varieties: free, forced, parametric. Basic concepts of the theory of oscillations. Differential equation of free oscillations and its solution. Speed and acceleration. Vibration energy. Adding harmonic oscillations of the same frequency. Differential equation of damped oscillations and its solution. Amplitude, frequency, energy of damped oscillations. Differential equation of forced oscillations and its solution of the part. Resonance.

Topic 3. Mechanical waves. Acoustics. Hearing physics.

Wave motion. Mechanical waves. Types of waves. Their speed of propagation. Harmonic wave, its main characteristics. Speed of wave propagation, wavelength, period. Types of waves and conditions of their excitation. Energy and momentum of the wave. Wave equation and its solution (plane and spherical waves). Energy characteristics of the wave. Shock waves. Doppler effect and its use. Nature and types of sound. Physical characteristics of sound. Characteristics of auditory perception. Weber-Feshner law. Sound measurements. Audiometry. Ultrasound and its application in medicine. Infrasound. Vibrations.

Topic 4. Mechanical properties of solids and liquids. Hydro- and hemodynamics.

Solids. Mechanical stress and its components. Types of deformations and their characteristics. Elastic deformations. Mechanical properties of solids. Poisson coefficient. Hooke's Law. Stretch chart.The limit of proportionality. Elasticity limit. Residual deformations. Boundaries of fluidity and strength. Non-Hookean material. Viscoelasthy. Simple viscoelastic models: Maxwell's body, Voigt's body, and Kelvin's body. Viscoelasticity of biomaterials. Liquid. Shear stress and shear rate. Dynamic and kinematic viscosity of liquids. Newton's formula. Newtonian and non-Newtonian liquids: Bingham-Shvedov and Casson. Flow of viscous liquid. The course is laminar and turbulent. Reynolds number. Flow of viscous liquids through pipes. Poiseuille's formula. Movement of bodies in viscous liquids. Stokes' law. Methods for determining dynamic viscosity. Hemodynamics.

Subsection 2. Thermal motion.

Topic 5. Molecular physics.

Ideal gas: pressure, temperature, kinetic energy of translational motion. The equation of state of an ideal gas. Maxwell's distribution by speed. RMS, average and most probable velocities of molecules. The average length of the free run of molecules. Molar heat capacity of the ideal gas. Degrees of freedom of the molecule and molar heat capacity. Adiabatic expansion of an ideal gas. Real gases. Equation of state for a real gas (van der Waals equation). Phase transitions. .

Topic 6. Fundamentals of Thermodynamics.

Thermodynamic system and its parameters. Open, closed, and isolated systems. Thermodynamic processes. Reversible and irreversible processes. Internal energy of bodies and means of its change: work and heat transfer. The first law of thermodynamics. The second law of thermodynamics. Entropy. Boltzmann principle. The basic equation of thermodynamics. Thermodynamic potentials. Chemical and electrochemical potential. Nonequilibrium thermodynamics. Stationary condition. Prigogine's principle. The body as an open system.

Subsection 3. Biophysics of cell membranes.

Topic 7. Transport through cell membranes.

Passive transport of molecules. Diffusion of neutral molecules. Fick's Law. Permeability of membranes and resistance of the flow of substances. Facilitated and exchange diffusion. Osmosis. Osmotic pressure. Filtration. Passive transport of ions. Theorell's law. Nernst-Planck equation. Active transport in biosystems Mechanism of active transport of ions and organic substances. Sodium-potassium pump.

Topic 8. Biopotentials.

Biopotentials of rest. Equilibrium potentials. Donnan's equilibrium and Donnan's potential. Nernst's equilibrium potential. Stationary Goldman-Hodgkin-Katz and Thomas potentials. Biopotentials of action. Ionic currents through membranes. Experiments of Hodgkin, Huxley and Katz, the main conclusions. Sodium channel model. Propagation of the action potential on the unmyelinated nerve fiber. Telegraph equation and main parameters. Myelinated nerve fibers.

Subsection 4. Electricity.

Topic 9. Electric field. Electric current.

Electric charge. The law of conservation of electric charge. The electric field, its strength and energy characteristics and the relationship between them. Gauss's theorem. Electric dipole. Equivalent electrical generator of organs and tissues. Current unipol and dipole. Dipole electric generator of the heart. Heart vector. The concept of multipole. Multi-dipole equivalent electric generator of the heart. Physical basis of electrocardiography. Electric current. Ohm's Law. Electrical conductivity and resistance of body tissues. Galvanization and electrophoresis. The effect of aeroions on the human body. Thermoelectric phenomena. Piezoelectricity. Quasi-stationary currents. Alternating current. Kirchhoff's Laws. Active and reactive resistance. Total resistance of AC circuit. Resonances of voltage and currents. Power in the alternating current. Electrical conductivity of biological tissues and liquids. Rheography.

Topic 10. Magnetic field. Electromagnetic waves.

Magnetic moment of the circuit with current. Magnetic field induction vector. Magnetic flux. Ampere's law. The effect of the magnetic field on the circuit with current. Magnetic field energy. The effect of the magnetic field on the mobile charge. Lorentz power. Electrostatic and magnetic electronic lenses. Magnetic field strength. Biot-Savart-Laplace law. The law of total current. The Law of Electromagnetic Induction. Physical basis of electrocardiography. Free electromagnetic oscillations. Fading electromagnetic oscillations. Maxwell's theory. Displacement current. Maxwell's equation. Electromagnetic waves and their properties. The speed of propagation of electromagnetic waves. Refractive index. Energy of electromagnetic waves. Poynting vector. Scale of electromagnetic waves. Effect of electromagnetic waves on the tissues of the body.

Subsection 5. Optics.

Topic 11. Wave optics.

Light waves**.** Coherent sources and coherent light waves. Light interference. Maximum and minimum conditions. Interference of light in thin plates (films). Interferometers and their application. Interference microscope. The Guygens-Fresnel principle. Diffraction. Diffraction on the slits. Diffraction grating. Fundamentals of X-ray diffraction analysis. The concept of holography. Natural and polarized light. Plane of polarization. Polarizer and analyzer, their main planes. Malus' law. Polarization phenomena in the reflection and refraction of light. Angle of complete polarization, Brewster's law. The phenomenon of double refraction. Optical axis. Positive and negativecrystals. Structure and purpose of the Nicol prism. Dichroism. Polaroids. Reversal of the plane of polarization. Optically active substances. Polarimetry. Polarization microscopy.

Topic 12. Geometric optics.

Geometric optics as the limiting case of wave optics. The laws of reflection and refraction of light. Lenses and their main aberrations. Centered optical system. The structure of the human eye. The eye is centered optical system. Accommodation, the distance of the best vision. The near point of view, visual acuity.Defects of the optical system of the eye. Hypermetropia and myopia, astigmatism. Optical system of biological microscope. Useful microscope magnification. Fiber optics and its use in endoscopy.

Topic 13. Thermal radiation.

Thermal radiation. Nature and properties of thermal radiation. Characteristics of thermal radiation. Black and gray bodies. Kirchhoff's law. Laws of blackbody radiation. Thermography. Solar radiation. Infrared radiation. Ultraviolet radiation, its biological effect. Photovoltaic effect. Photoelectronic devices. Basic light quantities.

Topic 14. Quantum optics.

Radiation and absorption of energy by atoms and molecules. Types of quantum transitions. Radiation spectra and absorption. Light absorption. Bouguer -Lambert-Beer law. Colorimetry. Light scattering. Relay's Law. Nephelometry. Optical atomic spectra. The spectrum of the hydrogen atom. Molecular spectra. Luminescence. Fluorescence and phosphorescence. Stokes' law. Luminescent analysis. Luminescent microscopy. Chemoluminescence. Photobiological processes. Visual adaptation and reception.

Subsection 6. Quantum mechanics.

Topic 15. Elements of quantum mechanics

De Broglie's wavelength. Wave properties of microobjects. Electron microscope and its use. Wave function and its physical content. Schrödinger equation. Heisenberg uncertainty relation. Hydrogen atom. Quantum numbers. Bohr's theory. The complementarity principle. Correspondence principle. Multi-electron atoms. Exclusion principle. Electronic configuration of the atom. *S*hell and sub-shell. Energy levels of molecules.

Topic 16. Quantum-mechanical methods of research of biological object.

Spontaneous and induced radiation. Metastable states. Inverse population of energy levels. Quantum generators (maser, lasers, gazer, razers). Helium-neon laser. Properties of induced radiation. Splitting of energy levels of atoms in a magnetic field. Electron paramagnetic resonance (EPR) and nuclear magnetic resonance NMR). NMR introscopy.

Subsection 7. Ionizing radiation.

Topic 17. X-radiation.

X-ray tube. Continuous and characteristic X-rays. Moseley's Law. Primary processes of interaction of an X-ray photon with an atom. Effects of X-rays on matter. Attenuation of X-ray radiation by matter. Bouguer law**.** Linear and mass attenuation coefficients. Absorption of X-ray radiation by matter. Linear and mass absorption coefficients. Physical bases of X-ray diagnostics and radiotherapy. Computed X-ray tomography.

Topic 18. Radioactivity. Dosimetry.

The basic law of radioactive decay. Activity and specific activity, units of measurement. Alpha decay and beta decay. Electronic capture. Spontaneous fission**.** Interaction of ionizing radiation with matter. Electron-positron pairs. Annihilation. The action of gamma radiation. Biophysical bases of action of ionizing radiation on the body. Detectors of ionizing radiation. Absorption dose. Exposure dose. Equivalent dose. Relative biological efficiency (RBE) of ionizing radiation. Major types of radiation injury**. Differential test.**

4. Structure of academic discipline

Subject	Number of hours			
	Altogether	Including		
		Lec.	Prac.	IWS
Subsection 1. Fundamentals of Biomechanaics.				
Topic 1. Translational and rotational motion.	5,0	0	4,0	1,0
Topic 2. Oscillation.	8,0	2	4,0	2,0
Topic 3. Mechanical waves. Acoustics. Hearing physics.	8,0	2	4,0	2,0
Topic 4. Continuum mechanics.	8,0	2	4,0	2,0
Subsection 2. Thermal motion.				
Topic 5. Molecular physics.	7,0	0	4,0	3,0
Topic 6. Fundamentals of Thermodynamics.	9,0	2	4,0	3,0
Subsection 3. Biophysics of cell membranes.				
Topic 7. Transport through cell membranes.	6,0	1	2,0	3,0
Topic 8. Biopotentials.	6,0	1	2,0	3,0
Subsection 4. Electricity.				
Topic 9. Electric field. Electric current.	9,0	2	4	3,0
Topic10. Magnetic field. Electromagnetic waves.	9,0	2	4	3,0
Subsection 5. Optics.				
Topic 11. Wave optics.	9,0	2	4	3,0
Topic 12. Geometric optics.	5,0	0	2	3,0
Topic 13. Thermal radiation.	6,0	1	2	3,0
Topic 14. Quantum optics.	7,0	0	4	3,0

Subsection 6. Quantum mechanics.				
Topic 15. Elements of quantum mechanics.	8,0	1	4	3,0
Topic 16. Quantum-mechanical research methods.	5,0	0	2	3,0
Subsection 7. Ionizing radiation.				
Topic 17. X-radiation.	6,0	1	2	3,0
Topic 18. Radioactivity. Dosimetry.	8,0	1	4	3,0
Preparation for differential test**.**	6,0	0	0	6,0
Total hours:	135,0	20	60	55

5. Topics of lectures

№	Topic	Hours
1	**Mechanical oscillations**. Oscillation, their varieties: free, forced, parametric and self-oscillation. Basic concepts of the theory of oscillations. Differential equation of free non-attenuating oscillations and its solution. Adding harmonious oscillations of the same frequency. Differential equation of attenuating oscillations and its solution. Differential equation of forced oscillations and its partial solution. Resonance.	2
2	**Mechanical waves.** Acoustics. Types of waves. Their speed propagation. Harmonious wave, its main characteristics. Wave velocity, wavelength, period. Wave equation and its solution (plane and spherical waves) Energy characteristics of waves. Shock waves. Doppler effect and its use. Physical characteristics of sound. Characteristics of auditory perception. Weber-Fachner law. Ultrasound and its application in pharmacy and medicine. Infrasound. Vibrations.	2
3	**Fundamentals of Bioreology. Hydro and hemodynamics.**Mechanical stress and its components. Types of deformations and their characteristics. Elastic deformations. Poisson coefficient. Hooke's law. Stretch diagram. Liquid. Shear rate. Dynamic and kinematic viscosity of liquids. Newton's formula. Newtonian and non-Newtonian liquids. The flow of the binder. Reynold's number. Poiseuille's formula. Stokes' law. Hemodynamics.	2
4	**Thermodynamics.** Thermodynamic system and its parameters. Thermodynamic processes. The first law of thermodynamics. Heat, work, and internal energy. The second law of thermodynamics. Entropy. Boltzmann principle. The basic equation of thermodynamics. Thermodynamic potentials. Nonequilibrium thermodynamics. Prigogine's principle.	2
5	**Physics of cell membranes**. Passive transport of molecules. Diffusion of neutral molecules. Fick's Law. Permeability of membranes and resistance of the flow of substances. Facilitated and exchange diffusion. Osmosis. Osmotic pressure. Filtration. Passive transport of ions. Theorell's law. Nernst-Planck equation. Active transport in biosystems Mechanism of active transport of ions and organic substances. Sodium-potassium pump.Biopotentials of rest. Equilibrium potentials. Donnan's equilibrium and Donnan's potential. Ernst's potential. Stationary Goldman-Hodgkin-Katz and Thomas potentials. Biopotentials of action. Telegraph equation and main parameters. Myelinized nerve fibers.	2
6	**Electricity**: An electric field, its characteristics. Conductors and dielectrics in an electric field. Polarization. Electric dipole. Current dipole. The electric vector of the heart. Electrocardiography. Electric current. Direct current. Ohm's Law. Thermoelectric effects. Piezoelectricity. Aeroions and their effect on the human body. Quasi-stationary currents.Alternating current. Total resistance of the alternating current circle. Resonances of voltages and currents. Power in the AC circuit. Rheography	2
7	**Electromagnetism.**Magnetic field and its characteristics. Ampere's law. Biot-Savart-Laplace law. Full current law. The Law of Electromagnetic Induction. Magnetocordiography. Electromagnetic oscillations. Maxwell's theory. Maxwell's equation. Electromagnetic waves and their properties. Poynting vector. Scale of electromagnetic waves.HF-Therapy.	2
8	**Optics.** Coherent light waves. Interference. The Guygens-Fresnel principle. Diffraction and diffraction grating. Holography and its use. Natural and polarized light. Malus' law. Brewster's Law. The phenomenon of double refraction. Optical	2

	ests. Nicol prism. Dichroism. Polaroids. Optically active substances. Polarimetry. Polarization microscopy. Geometric optics. Perfect centered optical system. Optical system of the eye. Microscope. Fiber optics.	
9	**Thermal radiation. Elements of quantum mechanics.** Nature, properties and characteristics of thermal radiation.Kirchhoff's law. Laws of blackbody radiation.Radiation of the Sun. Thermography. Infrared radiation. Ultraviolet radiation. Photovoltaic effect. De Broglie's wavelength. Wave properties of microobjects. Electron microscope and its use. Wave function and its physical content. Schrödinger equation. Heisenberg uncertainty relation. Hydrogen atom. Quantum numbers. Bohr's theory. The complementarity principle. Correspondence principle. Multi-electron atoms. Exclusion principle. Electronic configuration of the atom. *S*hell and sub-shell. Energy levels of molecules.	2
10	**X-radiation. Radioactivity.** X-ray tube. Continuous and characteristic X-rays. Moseley's Law. Primary processes of interaction of an X-ray photon with an atom. Effects of X-rays on matter. Attenuation of X-ray radiation by matter. Bouguer law**.** Linear and mass attenuation coefficients. Absorption of X-ray radiation by matter. Linear and mass absorption coefficients. The basic law of radioactive decay. Activity and specific activity, units of measurement. Alpha decay and beta decay. Electronic capture. Spontaneous fission**.** Interaction of ionizing radiation with matter. Electron-positron pairs. Annihilation. Biophysical bases of action of ionizing radiation on the body. Detectors of ionizing radiation. Absorption dose. Exposure dose. Equivalent dose. Relative biological efficiency (RBE) of ionizing radiation. Major types of radiation injury**.**	2
Altogether		**20**

6. Topics of practical training

№ s/n	Topic	Hours
1	**Translational and rotational motion**. Kinematics of rotational motion. Kinematic characteristics of translational and rotational motion and the relationship between them: linear and angular velocity, linear and angular acceleration. Tangential and normal acceleration. Inertial properties of bodies in translational and rotational motion. The moment of inertia of the material point and the solid. Moment of force. Dynamics of rotational motion. The basic equation of rotational motion. Angular momentum. The law of conservation of angular momentum. Work and kinetic energy in rotational motion. Centrifugation.	4
2	**Oscillations** Oscillations, their varieties: free, forced, parametric. Basic concepts of the theory of oscillations. Differential equation of free oscillations and its solution. Speed and acceleration. Vibration energy. Adding harmonic oscillations of the same frequency. Differential equation of damped oscillations and its solution. Amplitude, frequency, energy of damped oscillations. Differential equation of forced oscillations and its solution of the part. Resonance.	4
3	**Mechanical waves. Acoustics. Hearing physics.** Wave motion. Mechanical waves. Types of waves. The speed of their spread. Harmonic wave, its main characteristics. Wave propagation speed, wavelength, period. Types of waves and conditions of their excitation. Energy and momentum of the wave. Wave equation and its solution (plane and spherical waves) Energy characteristics of the wave. Shock waves. The Doppler effect and its use. Acoustics. Hearing physics. Nature and types of sound. Physical characteristics of sound. Characteristics of auditory perception. Weber-Feshner law. Sound measurements. Audiometry. Ultrasound and its application in medicine. Infrasound. Vibration.	4
4	**Continuum** mechanics. Mechanical properties of solids and liquids. Solids. Mechanical stress and its components. Types of deformations and their characteristics. Elastic deformations. Mechanical properties of solids. Poisson coefficient. Hooke's Law. Stretch chart.The limit of proportionality. Elasticity limit. Residual deformations. Boundaries of fluidity and strength. Non- Hooken material. Viscoelasticity. Simple viscoelastic models: Maxwell's body, Voigt's body, and Kelvin's body. Viscoelasticity of biomaterials. Liquid. Shear stress and shear rate. Dynamic and kinematic viscosity of liquids. Newton's formula. Newtonian and non-Newtonian liquids: Bingham-Shvedov and Casson. Flow of viscous liquid. The course is laminar and turbulent. Reynolds number. Flow of viscous liquids through pipes. Poiseuille's formula. Movement of bodies in viscous liquids. Stokes' law. Methods for determining dynamic viscosity. Hemodynamics. Models of the circulatory system.	4
5	**Molecular Physics** Ideal gas: pressure, temperature, kinetic energy of translational motion. The equation of state of an ideal gas. Maxwell's distribution by speed. RMS, average and most probable velocities of molecules. The average length of the free run of	4

	molecules. Molar heat capacity of the ideal gas. Degrees of freedom of the molecule and molar heat capacity. Adiabatic expansion of an ideal gas. Real gases. Equation of state for a real gas (van der Waals equation). Phase transitions.	
6	**Fundamentals of Thermodynamics** Thermodynamic system and its parameters. Open, closed, and isolated systems. Thermodynamic processes. Circulating and irreversible processes. Internal energy of bodies and means of its change: work and heat transfer. The first law of thermodynamics. The second law of thermodynamics. Entropy. Boltzmann principle. The basic equation of thermodynamics. Thermodynamic potentials. Chemical and electrochemical potential. Nonequilibrium thermodynamics. Stationary condition. Prigogine's principle. The body as an open system.	4
7	**Transport through cell membranes.** Passive transport of molecules. Diffusion of neutral molecules. Fick's Law. Permeability of membranes and resistance of the flow of substances. Facilitated and exchange diffusion. Osmosis. Osmotic pressure. Filtration. Passive transport of ions. Theorell's law. Nernst-Planck equation. Active transport in biosystems Mechanism of active transport of ions and organic substances. Sodium-potassium pump.	2
8	**Biopotentials.** Rest biopotentials. Equilibrium potentials. Donnan equilibrium and Donnan potential. Equilibrium Nernst potential. Goldman-Hodgkin-Katz and Thomas stationary potentials. Action biopotentials. Ionic currents through membranes. Hodgkin, Huxley, and Katz experiments, main conclusions. Sodium channel model. Propagation of the action potential over unmyelinated nerve fiber. Telegraph equation and main parameters. Myelinated nerve fibers.	2
9	**Electric field. Electric current** Electric charge. The law of conservation of electric charge. The electric field, its strength and energy characteristics and the relationship between them. Gauss's theorem. Electric dipole. Equivalent electrical generator of organs and tissues. Current unipol and dipole. Dipole electric generator of the heart. Heart vector. The concept of multipole. Multi-dipole equivalent electric heart generator. Physical basis of electrocardiography. Electric current. Ohm's Law. Electrical conductivity and resistance of body tissues. Galvanization and electrophoresis. The effect of aeroions on the human body. Thermoelectric phenomena. Piezoelectricity. Quasi-stationary currents. Alternating current. Kirchhoff's Laws. Active and reactive resistance. Total resistance of AC circuit. Resonances of voltage and currents. Power of the AC circuit. Electrical conductivity of biological tissues and liquids. Rheography.	4
10	**Magnetic field. Electromagnetic waves.** Magnetic moment of the circuit with current. Induction vector magnetic field. Magnetic flux. Ampere's law. Effect of magnetic field on circuit with current. Magnetic field energy. Effect of magnetic field on movable charge. Lorentz power. Electrostatic and magnetic electronic lenses. Magnetic field strength. Biot-Savart-Laplace Law. Law full current. The Law of Electromagnetic Induction. Physical basics electrocardiography. Free electromagnetic oscillations. Fading electromagnetic oscillations. Maxwell's theory. Displacement current. Maxwell's equation. Electromagnetic waves and their properties. The speed of propagation of electromagnetic waves. Refractive index. Energy of electromagnetic waves. Poynting vector. Scale of electromagnetic waves. Effect of electromagnetic waves on the tissues of the body.	4
11	**Wave optics.**	4

	Coherent sources and coherent light waves. Interference of light. Maximum and minimum conditions. Interference of light in thin plates (films). Interferometers and their application. Interference microscope. The Guygens-Fresnel principle. Diffraction. Diffraction on the slits. Diffraction grating. Fundamentals of X-ray diffraction analysis. The concept of holography. Natural and polarized light. Plane of polarization. Polarizer and analyzer, their main planes. Malus' law. Polarization phenomena in the reflection and refraction of light. Angle of complete polarization, Brewster's law. The phenomenon of double refraction. Optical axis. Positive and negative crystals. Structure and purpose of The Nicol prism. Dichroim. Polaroids. Reversal of the polarization plane. Optically active substances. Polarimetry. Polarization microscopy.	
12	**Geometric optics.** Geometric optics as the limiting case of wave optics. The laws of reflection and refraction of light. Lenses and their main aberrations. Centered optical system. The structure of the human eye. The eye is centered optical system. Accommodation, the distance of the best vision. The near point of view, visual acuity.Defects of the optical system of the eye. Hypermetropia and myopia, astigmatism. Optical system of biological microscope. Useful microscope magnification. Fiber optics and its use in endoscopy.	2
13	**Thermal radiation**. Thermal radiation. Nature and properties of thermal radiation. Characteristics of thermal radiation. Black and gray bodies. Kirchhoff's law. Laws of blackbody radiation. Thermography. Solar radiation. Infrared radiation. Ultraviolet radiation, its biological effect. Photovoltaic effect. Photoelectronic devices. Basic light quantities.	2
14	**Quantum optics.** Radiation and absorption of energy by atoms and molecules. Types of quantum transitions. Radiation spectra and absorption. Light absorption. Bouger-Lambert-Baer law. Colorimetry. Light scattering. Relay's Law. Nephelometry. Optical atomic spectra. The spectrum of the hydrogen atom. Molecular spectra. Luminescence. Fluorescence and phosphorescence. Stokes' law. Luminescent analysis. Luminescent microscopy. Chemoluminescence. Photobiological processes. Visual adaptation. Visual reception.	4
15	**Elements of quantum mechanics.** De Broglie's wavelength. Wave properties of microobjects. Electron microscope and its use. Wave function and its physical content. Schrödinger equation. Heisenberg uncertainty relation. Hydrogen atom. Quantum numbers. Bohr's theory. The complementarity principle. Correspondence principle. Multi-electron atoms. Exclusion principle. Electronic configuration of the atom. *S*hell and sub-shell. Energy levels of molecules.	4
16	**Quantum-mechanical research methods.** Spontaneous and induced radiation. Metastable states. Inverse population of energy levels. Quantum generators (maser, lasers, gazer, razers). Helium-neon laser. Properties of induced radiation. Splitting of energy levels of atoms in a magnetic field. Electron paramagnetic resonance (EPR) and nuclear magnetic resonance NMR). NMR introscopy.	2
17	**X-radiation.** X-ray tube. Continuous and characteristic X-rays. Moseley's Law. Primary processes of interaction of an X-ray photon with an atom. Effects of X-rays on matter. Attenuation of X-ray radiation by matter. Bouguer law**.** Linear and mass	2

	attenuation coefficients. Absorption of X-ray radiation by matter. Linear and mass absorption coefficients. Physical bases of X-ray diagnostics and radiotherapy. Computed X-ray tomography.	
18	**Radioactivity. Dosimetry.** The basic law of radioactive decay. Activity and specific activity, units of measurement. Alpha decay and beta decay. Electronic capture. Spontaneous fission**.** Interaction of ionizing radiation with matter. Electron-positron pairs. Annihilation. The action of gamma radiation. Biophysical bases of action of ionizing radiation on the body. Detectors of ionizing radiation. Absorption dose. Exposure dose. Equivalent dose. Relative biological efficiency (RBE) of ionizing radiation. Major types of radiation injury**. Differential test.**	4
Total:		60

7. Independent work

№ g/n	**Types of IWS**	Hours **hours**
1	Preparation for practical classes	49,0

№	**Topic**	Hours
1	**Translational and rotational motion**. Kinematics of rotational motion. Kinematic characteristics of translational and rotational motion and the relationship between them: linear and angular velocity, linear and angular acceleration. Tangential and normal acceleration. Inertial properties of bodies in translational and rotational motion. The moment of inertia of the material point and the solid. Moment of force. Dynamics of rotational motion. The basic equation of rotational motion. Angular momentum. The law of conservation of angular momentum. Work and kinetic energy in rotational motion. Centrifugation.	1
2	**Oscillations** Oscillations, their varieties: free, forced, parametric. Basic concepts of the theory of oscillations. Differential equation of free oscillations and its solution. Speed and acceleration. Vibration energy. Adding harmonic oscillations of the same frequency. Differential equation of damped oscillations and its solution. Amplitude, frequency, energy of damped oscillations. Differential equation of forced oscillations and its solution of the part. Resonance.	2
3	**Mechanical waves. Acoustics. Hearing physics.** Wave motion. Mechanical waves. Types of waves. The speed of their spread. Harmonic wave, its main characteristics. Wave propagation speed, wavelength, period. Types of waves and conditions of their excitation. Energy and momentum of the wave. Wave equation and its solution (plane and spherical waves) Energy characteristics of the wave. Shock waves. The Doppler effect and its use. Acoustics. Hearing physics. Nature and types of sound. Physical characteristics of sound. Characteristics of auditory perception. Weber-Feshner law. Sound measurements. Audiometry. Ultrasound and its application in medicine. Infrasound. Vibration.	2
4	**Continuum** mechanics. Mechanical properties of solids and liquids. Solids. Mechanical stress and its components. Types of deformations and their characteristics. Elastic	3

	deformations. Mechanical properties of solids. Poisson coefficient. Hooke's Law. Stretch chart.The limit of proportionality. Elasticity limit. Residual deformations. Boundaries of fluidity and strength. Non- Hooken material. Viscoelasticity. Simple viscoelastic models: Maxwell's body, Voigt's body, and Kelvin's body. Viscoelasticity of biomaterials. Liquid. Shear stress and shear rate. Dynamic and kinematic viscosity of liquids. Newton's formula. Newtonian and non-Newtonian liquids: Bingham-Shvedov and Casson. Flow of viscous liquid. The course is laminar and turbulent. Reynolds number. Flow of viscous liquids through pipes. Poiseuille's formula. Movement of bodies in viscous liquids. Stokes' law. Methods for determining dynamic viscosity. Hemodynamics. Models of the circulatory system.	
5	**Molecular Physics** Ideal gas: pressure, temperature, kinetic energy of translational motion. The equation of state of an ideal gas. Maxwell's distribution by speed. RMS, average and most probable velocities of molecules. The average length of the free run of molecules. Molar heat capacity of the ideal gas. Degrees of freedom of the molecule and molar heat capacity. Adiabatic expansion of an ideal gas. Real gases. Equation of state for a real gas (van der Waals equation). Phase transitions.	3
6	**Fundamentals of Thermodynamics** Thermodynamic system and its parameters. Open, closed, and isolated systems. Thermodynamic processes. Circulating and irreversible processes. Internal energy of bodies and means of its change: work and heat transfer. The first law of thermodynamics. The second law of thermodynamics. Entropy. Boltzmann principle. The basic equation of thermodynamics. Thermodynamic potentials. Chemical and electrochemical potential. Nonequilibrium thermodynamics. Stationary condition. Prigogine's principle. The body as an open system.	3
7	**Transport through cell membranes.** Passive transport of molecules. Diffusion of neutral molecules. Fick's Law. Permeability of membranes and resistance of the flow of substances. Facilitated and exchange diffusion. Osmosis. Osmotic pressure. Filtration. Passive transport of ions. Theorell's law. Nernst-Planck equation. Active transport in biosystems Mechanism of active transport of ions and organic substances. Sodium-potassium pump.	3
8	**Biopotentials.** Rest biopotentials. Equilibrium potentials. Donnan equilibrium and Donnan potential. Equilibrium Nernst potential. Goldman-Hodgkin-Katz and Thomas stationary potentials. Action biopotentials. Ionic currents through membranes. Hodgkin, Huxley, and Katz experiments, main conclusions. Sodium channel model. Propagation of the action potential over unmyelinated nerve fiber. Telegraph equation and main parameters. Myelinated nerve fibers.	3
9	**Electric field. Electric current** Electric charge. The law of conservation of electric charge. The electric field, its strength and energy characteristics and the relationship between them. Gauss's theorem. Electric dipole. Equivalent electrical generator of organs and tissues. Current unipol and dipole. Dipole electric generator of the heart. Heart vector. The concept of multipole. Multi-dipole equivalent electric heart generator. Physical basis of electrocardiography. Electric current. Ohm's Law. Electrical conductivity and resistance of body tissues. Galvanization and electrophoresis. The effect of aeroions on the human body. Thermoelectric phenomena. Piezoelectricity. Quasi-stationary currents. Alternating current. Kirchhoff's Laws. Active and reactive resistance. Total resistance of AC circuit. Resonances of	3

	voltage and currents. Power of the AC circuit. Electrical conductivity of biological tissues and liquids. Rheography.	
10	**Magnetic field. Electromagnetic waves.** Magnetic moment of the circuit with current. Induction vector magnetic field. Magnetic flux. Ampere's law. Effect of magnetic field on circuit with current. Magnetic field energy. Effect of magnetic field on movable charge. Lorentz power. Electrostatic and magnetic electronic lenses. Magnetic field strength. Biot-Savart-Laplace Law. Law full current. The Law of Electromagnetic Induction. Physical basics electrocardiography. Free electromagnetic oscillations. Fading electromagnetic oscillations. Maxwell's theory. Displacement current. Maxwell's equation. Electromagnetic waves and their properties. The speed of propagation of electromagnetic waves. Refractive index. Energy of electromagnetic waves. Poynting vector. Scale of electromagnetic waves. Effect of electromagnetic waves on the tissues of the body.	3
11	**Wave optics.** Coherent sources and coherent light waves. Interference of light. Maximum and minimum conditions. Interference of light in thin plates (films). Interferometers and their application. Interference microscope. The Guygens-Fresnel principle. Diffraction. Diffraction on the slits. Diffraction grating. Fundamentals of X-ray diffraction analysis. The concept of holography. Natural and polarized light. Plane of polarization. Polarizer and analyzer, their main planes. Malus' law. Polarization phenomena in the reflection and refraction of light. Angle of complete polarization, Brewster's law. The phenomenon of double refraction. Optical axis. Positive and negative crystals. Structure and purpose of The Nicol prism. Dichroim. Polaroids. Reversal of the polarization plane. Optically active substances. Polarimetry. Polarization microscopy.	3
12	**Geometric optics.** Geometric optics as the limiting case of wave optics. The laws of reflection and refraction of light. Lenses and their main aberrations. Centered optical system. The structure of the human eye. The eye is centered optical system. Accommodation, the distance of the best vision. The near point of view, visual acuity.Defects of the optical system of the eye. Hypermetropia and myopia, astigmatism. Optical system of biological microscope. Useful microscope magnification. Fiber optics and its use in endoscopy.	3
13	**Thermal radiation**. Thermal radiation. Nature and properties of thermal radiation. Characteristics of thermal radiation. Black and gray bodies. Kirchhoff's law. Laws of blackbody radiation. Thermography. Solar radiation. Infrared radiation. Ultraviolet radiation, its biological effect. Photovoltaic effect. Photoelectronic devices. Basic light quantities.	3
14	**Quantum optics.** Radiation and absorption of energy by atoms and molecules. Types of quantum transitions. Radiation spectra and absorption. Light absorption. Bouger-Lambert-Baer law. Colorimetry. Light scattering. Relay's Law. Nephelometry. Optical atomic spectra. The spectrum of the hydrogen atom. Molecular spectra. Luminescence. Fluorescence and phosphorescence. Stokes' law. Luminescent analysis. Luminescent microscopy. Chemoluminescence. Photobiological processes. Visual adaptation. Visual reception.	3
15	**Elements of quantum mechanics.**	3

	De Broglie's wavelength. Wave properties of microobjects. Electron microscope and its use. Wave function and its physical content. Schrödinger equation. Heisenberg uncertainty relation. Hydrogen atom. Quantum numbers. Bohr's theory. The complementarity principle. Correspondence principle. Multi-electron atoms. Exclusion principle. Electronic configuration of the atom. *S*hell and sub-shell. Energy levels of molecules.	
16	**Quantum-mechanical research methods.** Spontaneous and induced radiation. Metastable states. Inverse population of energy levels. Quantum generators (maser, lasers, gazer, razers). Helium-neon laser. Properties of induced radiation. Splitting of energy levels of atoms in a magnetic field. Electron paramagnetic resonance (EPR) and nuclear magnetic resonance NMR). NMR introscopy.	3
17	**X-radiation.** X-ray tube. Continuous and characteristic X-rays. Moseley's Law. Primary processes of interaction of an X-ray photon with an atom. Effects of X-rays on matter. Attenuation of X-ray radiation by matter. Bouguer law**.** Linear and mass attenuation coefficients. Absorption of X-ray radiation by matter. Linear and mass absorption coefficients. Physical bases of X-ray diagnostics and radiotherapy. Computed X-ray tomography.	3
18	**Radioactivity. Dosimetry.** The basic law of radioactive decay. Activity and specific activity, units of measurement. Alpha decay and beta decay. Electronic capture. Spontaneous fission**.** Interaction of ionizing radiation with matter. Electron-positron pairs. Annihilation. The action of gamma radiation. Biophysical bases of action of ionizing radiation on the body. Detectors of ionizing radiation. Absorption dose. Exposure dose. Equivalent dose. Relative biological efficiency (RBE) of ionizing radiation. Major types of radiation injury**. Differential test.**	3
2	Preparation for differential test	6,0
	Total hours	55

8. Individual tasks

Not provided.

9. Teaching methods

Practical classes: checking the level of training, understanding and assimilation of the theoretical material of the topic by students, discussion of complex issues of the topic, correction of possible errors, answers to questions and training exercises aimed at improving students' knowledge.
Independent work: independent work with lecture materials and with a textbook.

10. Methods of control and criteria for assessing learning outcomes

Current control: oral questioning, evaluation of the performance of training exercises and activity in the classroom.
Final control: differential test.

Structure of the current assessment in the practical lesson:

1. Assessment of theoretical knowledge on the topic of the lesson:
- methods: questioning, performing exercises;
- maximum rating – 5, minimum rating – 3, unsatisfactory rating – 2.
2. Assessment of practical skills from the topic of the lesson:
- methods: assessment of the correctness of the exercises;
- maximum rating – 5, minimum rating – 3, unsatisfactory rating – 2;

Criteria for the current assessment in the practical lesson:

«5»	The student is fluent in the material, takes an active part in the discussion of the topic, confidently demonstrates practical skills during the exercises, expresses his thought from the topic of the lesson, demonstrates an understanding of the topic issues.
«4»	The student has a good knowledge of the material, takes part in the discussion and problem solving, demonstrates practical skills during the exercises and interpreting the results with some errors, expresses his thought on the topic of the lesson.
«3»	The student does not have enough knowledge of the material, hesitantly takes part in the discussion and problem solving, demonstrates practical skills during the exercises and interpreting the results with significant errors.
«2»	The student does not know the material, does not take part in the discussion and performance of exercises, does not demonstrate practical skills during the exercises and interpretation of the results.

A student is allowed to the differentiated test, provided that the requirements of the curriculum are met and if he received at least 3.00 points for current educational activities. Differentiated test is held in the last lesson.

Structure of differential test

Content of the activity to be evaluated	Quantity
The answer to theoretical questions.	2

Differential test criteria for assessing the results of students training:

«5»	Student gets «5» if he systematically worked during the semester, showed during the test versatile and deep knowledge of the program material, is able to successfully perform the tasks provided by the program, learned the content of the main and additional literature, realized the relationship of individual sections of the discipline, their importance for the future profession, showed creative abilities in understanding and using educational and program material, showed the ability to independently update and replenish knowledge; level of competence – high (creative);
«4»	Student gets «4» if he has shown full knowledge of the educational and program material, successfully performs the tasks of the program, learned the main literature recommended by the program, showed a sufficient level of knowledge in the discipline and is able to update them independently and update them in the course of further training and professional activities; level of competence – sufficient (constructive-varied)
«3»	Student gets «3» if he has shown knowledge of the main educational and program material to the extent necessary for further study and subsequent work in the profession, copes with the implementation of the tasks provided by the program, made some mistakes in responses to the test, but has the necessary knowledge to overcome the mistakes made under the guidance of the scientific and pedagogical worker; the level of competence - medium (reproductive)
«2»	Student gets «2» if he did not show sufficient knowledge of the main educational and program material, made fundamental mistakes in responses to the test, cannot use knowledge in further training without the help of the teacher, has not been able to master the skills of independent work; the level of competence is low (receptively productive)

11. Distribution of points received by students

The grade for the discipline is compiled by 50.0% on the assessment for the current success and on 50.0% on the assessment of the response on the differentiated test.

The average score for the discipline is translated into a national assessment and converted into points behind a multi-point scale.

Conversion of the traditional assessment for the discipline into a 200-point one is carried out by the information and computing center of the university program "Contingent".

Table of conversion of traditional assessment into multi-point:

National Discipline Score	The amount of points for discipline
«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 scores are not converted to a four-point scale and vice versa. Further accounts are carried out by the information and computing center of the university.

Convertion the traditional grade from the discipline and the amount of points behind the ECTS scale

Grade behind the ECTS scale	Statistics
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 grade behind the ECTS scale is set by the educational subsection of ONMedU or the dean's office after ranking grades in the discipline among students who study in one course and in one specialty. Ranking of students - citizens of foreign countries is recommended by the decision of the Academic Council to be carried out in one array.

List of questions for differential test

1. Translational and rotational motion.
2. Kinematics of rotational motion.
3. Dynamics of rotational motion.
4. Angular momentum. The law of conservation of angular momentum.
5. Free oscillation. Differential equation of free oscillations.
6. Differential equation of damped oscillations and its solution.
7. Differential equation of forced oscillations and its solution.
8. Amplitude and frequency of forced oscillations. Resonance.
9. Mechanical waves. Types of waves and speed of propagation.
10. Characteristics of waves.
11. The wave equation and its solutions are plane and spherical waves.
12. Energy characteristics of waves.
13. Doppler effect.
14. Physical characteristics of sound.
15. Characteristics of auditory perception.
16. Weber-Feshner law. Sound measurements. Audiometry.
17. Ultrasound and infrasound. Vibration.
18. Mechanical stress and its components.
19. Varieties of deformations and their characteristics.
20. Hooke's Law.
21. Stress-strain diagram.
22. Simple viscoelastic models: Maxwell, Voigt and Kelvin.
23. Liquid. Shear stress and shear deformation rate.
24. Newton's formula. Dynamic and kinematic viscosity.
25. Non-Newtonian liquids. Bingham-Shvedov liquids, Casson.
26. Laminar and turbulent flow. Reynolds number.
27. Flow of binder through the pipe. Hagen-Poiseuille's formula.
28. Movement of bodies in binders. Stokes' law.
29. Hemodynamics. Models of the circulatory system.
30. Perfect gases. Pressure, temperature and progressive kinetic energy.
31. The laws of the ideal gas.
32. Maxwell's distribution of the velocity of molecules.
33. Velocities of molecules: average, mean quadratic and most possible.
34. Degrees of freedom. Molar heat capacity.
35. Real gases. Equation of state of a real gas.
36. Thermodynamic systems, their types and parameters.
37. Thermodynamic processes.
38. Internal energy of bodies. Work and heat
39. The first law of thermodynamics.
40. The second law of thermodynamics.
41. Entropy. Boltzmann principle.
42. Basic thermodynamic equation.
43. Thermodynamic potentials.
44. Chemical and electrochemical potentials.
45. Nonequilibrium thermodynamics. Stationary condition. Prigogine's principle.
46. Diffusion of molecules. Fick's Law.
47. Permeability of membranes and resistance of substance flow.
48. Facilitated exchange diffusion.

49. Osmosis. Osmotic pressure.
50. Filtration.
51. Passive transport of ions. Nernst-Planck equation.
52. Active transport of substances through membranes.
53. Sodium-potassium pump.
54. Donnan equilibrium and Donnan potential.
55. Ernst's equilibrium potential.
56. Stationary potentials.
57. Stationary Goldman-Hodgkin-Katz potential.
58. Thomas' stationary potential.
59. Action potential. Ionic flows through the membrane.
60. Propagation of the action potential along the nerve fiber.
61. Telegraph equation and basic parameters.
62. Electric charge. The law of conservation of electric charge.
63. Electric field and its characteristics.
64. Conductors in an electric field.
65. Dielectrics in an electric field. Polarization.
66. Electric dipole. Equivalent generator of organs and tissues.
67. Current unipol and dipole. Equivalent heart vector.
68. Multi-dipole equivalent generator. Physical basis of ECG.
69. Direct current. Ohm's Law.
70. Thermoelectric effects. Piezoelectricity.
71. Galvanization and electrophoresis.
72. Aeroions, their effect on the human body.
73. Quasi-stationary currents. Alternating current.
74. Active and reactive resistance.
75. Total resistance of the circuit of AC current. Resonance.
76. Power in the circuit of AC current.
77. Electrical conductivity of biological tissues and liquids. Rheography.
78. Magnetic field and its characteristics.
79. Ampere's law. Lorentz power.
80. Magnetic field energy.
81. Biot-Savart-Laplace law.
82. The law of total current.
83. The Law of Electromagnetic Induction.
84. Physical basis of MCG.
85. Electromagnetic oscillations.
86. Displacement current. Maxwell's equation.
87. Flat electromagnetic waves.
88. The speed of propagation of electromagnetic waves. Refractive index.
89. Energy of electromagnetic waves. The Poynting vector.
90. Scale of electromagnetic waves.
91. The effect of AF fields and currents on the body.
92. The interference is light. Conditions of highs and lows.
93. Interferometers and their application.
94. Interference microscope.
95. The Guygens-Fresnel principle.
96. Diffraction. Diffraction grating.
97. The principle of holography and its implementation.
98. Polarizer and analyzer. Malus' law.

99. Polarization phenomena in the reflection and refraction of light.
100. Double refraction of rays.
101. Nicol prism. Dichroism. Polaroids.
102. Optically active substances.
103. Polarimetry. Polarization microscopy.
104. Lenses and their main aberrations.
105. Perfect centered optical system.
106. The human eye is centered by the optical system.
107. Microscope. Separate microscope ability.
108. Fiber optics and its application in endoscopy.
109. Characteristics of thermal radiation.
110. Absolutely black body and gray body. Kirchhoff's law.
111. Laws of radiation of absolutely black body
112. Infrared radiation.
113. Ultraviolet radiation.
114. Photovoltaic effect. Photoelectronic devices.
115. De Broglie's wavelength. Wave properties of microobjects.
116. Electron microscope and its application.
117. Wave function and its interpretation.
118. Schrödinger equation. Quantum numbers.
119. Heisenberg uncertainty relation.
120. The Pauli principle. Multi-electron atoms.
121. Quantum generators. Helium-neon laser.
122. Splitting of energy levels in a magnetic field.
123. EPR and NMR.
124. Types of quantum transitions. Radiation spectra and absorption.
125. Bouguer-Lambert-Baer law. Colorimetry.
126. Light scattering. Rayleigh's Law. Nephelometry.
127. Optical atomic spectra. The spectrum of the hydrogen atom.
128. Molecular spectra.
129. Luminescence. Fluorescence and phosphorescence. Stokes' law.
130. Fluorescence analysis. Fluorescence microscope.
131. Photobiological processes.
132. Photosensitivity of the eye. Mechanisms of visual adaptation and reception.
133. Continuous X-rays.
134. Characteristic X-rays. Moseley's Law.
135. Primary processes of interaction of X-ray photons with atoms.
136. The effect of X-ray radiation on the substance. Absorption coefficients.
137. X-ray diagnostics and radiotherapy. Computed tomography.
138. Radioactivity. The law of radioactive decay.
139. Activity and specific activity, units of measurement.
140. Alpha decay, the energy spectrum of alpha radiation.
141. Beta decay, the energy spectrum of beta radiation. Neutrino.
142. Electronic capture.
143. The effect of radioactive measurement on the substance.
144. Vavilov-Cherenkov radiation. Electron-Positron pairs. Annihilation.
145. Effects of gamma radiation.
146. Biophysical mechanisms of radiation damage to a living being.
147. Dosimeters of ionizing radiation.
148. Exposure dose, its power, units.

149. Absorbed dose, its power, units.
150. Equivalent dose, its power, units.

13. Methodological support:

- Work program of academic discipline
- Silabus of academic discipline
- Tutorials:
  Zhumatii P. G. Lecture Notes on the discipline"Biological Physics with Physical Methods ofAnalysis", 2021.
- Methodical development of practical exercises.

14.Recommended literature

Main:

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 .

Further reading:

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
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