Ministry of Education and Science of Ukraine
V. N. Karazin Kharkiv National University
School of Medicine
School of Radio Physics, Biomedical Electronics and Computer Systems
Department of Molecular and Medical Biophysics

"APPROVED"
Vice-President for Research and Education

_____ Oleksandr HOLOVKO

_____ 2022

SYLLABUS

Medical and Biological Physics

level of higher education second (master's)

knowledge area 22 Healthcare
speciality 222 Medicine
educational program "Medicine"
specialization
type of discipline mandatory
school of medicine

2022 / 2023 academic year

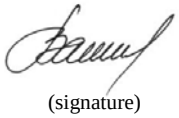
The program is recommended for approving by the Academic Council of the school of Medicine
_____, 2022, record #10/1

Program developer:
Volodymyr BEREST, Ph.D., Dr. Sci., Docent, Head of the Department of Molecular and Medical Biophysics

The program is approved at the meeting of the Department of Molecular and Medical Biophysics

Record # 5 of June 16, 2022

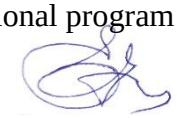
The Head of the Department of Molecular and Medical Biophysics



(signature) Volodymyr BEREST
(surname and initials)

The program is agreed with the guarantor of the educational program "Medicine"

The guarantor of the educational program "Medicine"



(signature) Yevhenii NIKOLENKO
(surname and initials)

The program was approved by the Scientific and Methodical Commission of the School of Medicine

Record # 10 of June 09, 2021

The head of the Scientific and Methodical Commission of the School of Medicine

(signature) Diana DOROSH
(surname and initials)

Introduction

The program for the discipline "Medical and biological physics" is developed in accordance with the educational and professional preparation program of the second (master's) degree of higher education on the specialty 222 Medicine.

1. Description of the Academic Discipline

1.1. The Purpose of Teaching the Academic Discipline:

to acquire knowledge of the fundamental laws of physics and their application for the human body in health and disease, to understand the interaction of external fields with the human body for the sake of medical diagnostics and treatment. In addition, the discipline of Medical and Biological Physics aims at mastering student's practical skills in the operation of modern medical electronic equipment and forming the background for comprehension of specialized disciplines on contemporary healthcare approaches for biomedical research, clinical diagnostic, therapeutic, and rehabilitation methods of modern medicine, based on physical phenomena and laws.

1.2. The Main Tasks of the Discipline Studying:

Efficient comprehension of the discipline “Medical and Biological Physics” will provide students with the following **General competencies** according to the Educational and Professional Program:

GC 01. Ability to think abstractly, analyze and synthesize, learn and master modern knowledge;

GC 02. Ability to learn and acquire new skills;

GC 03. Ability to apply knowledge in practical situations

GC 04 Knowing and understanding the subject area and understanding professional activities

GC 10. Ability to use information and communication technologies

GC 11 Ability to retrieve, comprehend and analyze information from different sources

and **Professional Competencies**:

PC1 – Ability to acquire medical information about the patient and analyze clinical data

PC2 - Ability to determine the required list of laboratory tests and instrumental examinations and evaluate their results.

PC17- Ability to access the impact of the environment, social, economical and biological determinants on the health of the individual, family, population

In particular medical students will

1) be having the knowledge of fundamental physical and biophysical laws underlying human life for solving professionally oriented problems;
2) be understanding the physical foundations of diagnostic and physiotherapeutic methods underlying the medical equipment operation used for solving typical problems in the doctor’s work;
3) prescribe laboratory, functional and/or instrumental examination of a patient by making a valid decision according to a certain algorithm based on the most probable or syndrome diagnosis according to standard schemes, using knowledge about human body and clinical diagnostic methods, adhering to the relevant ethical and rules on law;
4) perform medical procedures based on preliminary and/or final clinical diagnosis for different groups of the population in different conditions;
5) be having the knowledge of the physical basis and biophysical mechanisms of external physical factors influence on the organs and systems of the human body in order to do professional tasks performance related to activities in the medical field;
6) study the indoor environment (indicators of microclimate, sound, vibration and initiating radiation, individual radiometry) and assess the impact of the environment (external physical factors) on human health;

7) be able to organize the required level of individual safety in case of typical dangerous situations in a particular occupational activity.

1.3. The number of credits – 3.

1.4. Total hours – 90.

1.5. The Academic Discipline Characteristics	
Compulsory	
Full-time study	External study mode (e-learning)
Study year	
1st	-
Semester	
1st and 2nd	-
Lectures	
10 hours	-
Practical sessions	
44 hours	-
Lab practicals	
-	-
Self-study	
36 hours	-
Including individual tasks	
-	

1.5. Planned learning outcomes:

Fulfillment of all types of educational activities during the study of the discipline “Medical and Biological Physics” is aimed at achieving the following **Program Learning Outcomes**:

PLO 1 – To have a deep knowledge of the structure of professional activity. Be able to work professionally engaging knowledge updating and integration. Take responsibility for professional growth, eager for autonomous professional development;

PLO 2 – Understanding and competence of the fundamental and clinical biomedical sciences at a level sufficient for problem-solving in the healthcare industry.

PLO 7 – To prescribe and analyze additional (mandatory and elective) examinations (laboratory, functional, and\or instrumental methods) (according to list 4) for patients with pathologies of different organs and body systems aiming at differential diagnostics of deceases (according to nomenclature 2);

2. Thematic Plan of the Academic Discipline

Section 1. Fundamentals of Biological Physics

Topic 1. Fundamentals of Biomechanics and Bioacoustics

Subject and methods of biophysics, relationship with other sciences. The main branches of Biophysics. Basic concepts of mechanics of translational and rotational motions. The equation of motion and conservation laws. Elements of biomechanics. Human musculoskeletal system. Dynamic and static work for different types of human activities. Ergometry. Methods and devices for measuring biomechanical characteristics. Undamped, damped, and forced oscillations. Differential equations of harmonic, damped, and forced oscillations and their solutions. Decrement and logarithmic decrement. Resonance. Self-oscillations. Relaxation oscillations. Wave processes and their characteristics. Wave equation. Differential wave equation. The flow of energy. The Umov-Poynting vector. Doppler effect. Physics of hearing. Objective and subjective characteristics

of sound. The intensity, intensity level, loudness and their units. Hearing threshold and pain threshold. Weber- Fechner law. Biophysical bases of auditory sensation. Biophysical bases of audiometry. Audiogram and contours of identical loudness. Ultrasound and infrasound. Sources and detectors of ultrasound and infrasound. The peculiarities of ultrasound and infrasound propagation. Biophysical bases of ultrasound and infrasound effects on biological tissues. Use of ultrasound in medicine. Deformation properties of biological tissues. Hooke's law. Young's modulus and Poisson's ratio. Creep test and stress relaxation.

Topic 2. Fundamentals of Biorheology and Hemodynamics

Surface tension. Surface tension coefficient. Methods of their determination. Gas embolism. Internal friction, viscosity. Newton's law of viscous force. Newtonian and non-Newtonian fluids. Methods and devices for viscosity measuring. The stationary flow of fluids. Continuity equation and Bernoulli's equation. Linear and volume flow rate. The basic equation of fluid dynamics. The flow of viscous fluids. Hagen- Poiseuille equation. Hydraulic resistance. Rheological properties of blood. Blood viscosity and its use in disease diagnostics. Laminar and turbulent fluid flow. Reynolds number. Methods for measuring blood pressure and blood flow velocity. Pulse waves.

Topic 3. Thermodynamics of Open Biological Systems. Elements of Molecular Biophysics

Thermodynamics of open biological systems and elements of molecular biophysics. Intermolecular interactions in biopolymers (covalent interaction, electrostatic and dispersion interaction, hydrophobic interaction, hydrogen bond). Structural organization of proteins and nucleic acids. Thermodynamic method for studying medical and biological systems. The first and the second laws of thermodynamics, entropy, thermodynamic potentials. Thermodynamics of open systems near equilibrium position (linear law for the fluxes and thermodynamic forces, reciprocal processes of transport, Onsager reciprocal relations, entropy production, conjugation of flows, stationary state, Prigogine's theory Thermodynamics of open systems far from equilibrium (the ordering process in physical, chemical and biomedical systems, the concept of synergetics). The importance of thermodynamics and synergetics in environmental protection issues. Biophysics of reception processes on the example of the visual reception. General characteristics of the human eye. Reduced eye model. Shortages of the optical eye system. The structure of the retina. Photoisomerization of rhodopsin.

Topic 4. Biophysics of Membrane Processes

Structural elements of biological membranes. Physical properties of biological membranes. Liquid crystal state of biomembranes. Dynamic properties of membranes. Passive transport of substances through the membranes. Fick's equation. The coefficient of membrane permeability for a particular substance. Nernst-Planck equation. Electrochemical potential and Teorell's equation. The active transport. Molecular organization of active transport on the example of Na+ /K+ pump. Conjugation of flows. The diffusion rate. The resting membrane potential and the action potential. Nature of the resting membrane potential (Nernst equilibrium potential, diffusion potential, Donnan potential, Goldman-Hodgkin-Katz stationary potential). The action potential and its generation. The equivalent circuit diagram of the membrane. Hodgkin-Huxley equations. The concept of gate ionic currents. Hodgkin-Huxley equations for the process of the action potential propagation in nerve fibers. Speed and peculiarities of the action potential propagation in axons.

Section 2. Fundamentals of Medical Physics

Topic 1. Electrodynamics, Its Medical Use. Fundamentals of Medical Equipment

The concept of electrography of organs and tissues. Physical and biophysical principles of electrocardiography. Einthoven's concept of ECG genesis (heart as an electric dipole, potential of electric field, system of leads). Ohm's law in a differential form, electrical conductivity of biological tissues. The second concept of ECG (heart as a current dipole, potential of the current dipole). Physical and biophysical principles of reography. The relation between the deformation of blood vessels and changes in their electrical resistance. Alternating circuits containing active, capacitive and inductive resistance. Vector diagrams and impedance. Capacitive properties and equivalent electrical circuits of biological tissues. Specificity of vector diagrams and impedance of biological tissues. The impedance dispersion coefficient. Magnetic field and its characteristics.

Biot-Savart-Laplace-law. Magnetic properties of substances. Physical principles of magnetobiology. Electromagnetic waves and oscillations in biological media. The displacement current. Maxwell's equations. The wave equation and speed of propagation of electromagnetic waves in biological objects. The effects of electric field on biological tissues. The physical and biophysical processes in biological tissues under the influence of direct and alternating electric fields (conduction and displacement currents, thermal effects). Therapeutic factors and their application in medical techniques (galvanization, electrophoresis, franklinization, electric stimulation, electric impulsation, diathermy, electrotomy, electrocoagulation). Effects of direct and alternating magnetic fields on biological objects. Primary mechanisms, induction currents and thermal effects. Therapeutic factors and their use in medical techniques (magnetotherapy, inductothermy). Effects of electromagnetic fields on biological objects. Primary mechanisms, currents and thermal effects. Therapeutic factors and their use in medical techniques (UHF therapy, SHF therapy, microwave resonance therapy). General characteristics and classification of electronic medical devices. The use of electronic medical equipment in diagnostics, electrical stimulation and physiotherapy. Electrodes and sensors. Amplification and generation of signals. Safety precautions when working with electronic medical equipment.

Topic 2. Optical Methods and Their Use in Biology and Medicine

Elements of geometrical optics. Centered optical system. Optical microscopy. The main characteristics of the microscope. Optical refractometry. Light polarization. Ways of obtaining polarized light. Birefringence. Nicola's prism. Malus's law. Optically active substances. Biot's law. Concentrating polarimetry. Light absorption. Burger's law. Light absorption by solutions. Burger-Lambert-Beer's law. Concentrating colorimetry. Light scattering. Light scattering in dispersive media. Molecular scattering of light. Rayleigh's law. Nephelometry. Light dispersion. Refractometry and fiber optics, their application in medicine.

Topic 3. Elements of Quantum Biophysics.

Thermal radiation of bodies, its characteristics. A black body and a grey body. Kirchhoff's law. Laws of black body radiation: Planck's law, Stefan-Boltzmann's law, Wien's displacement law. Thermal radiation of the human body. The concept of thermography. The basic ideas of quantum mechanics. Wave properties of microparticles, de Broglie's formula, wave function and its physical meaning, and Heisenberg's uncertainty relations. The concept of the electronic microscope. Schrödinger equation. Quantum-mechanical model of the hydrogen atom. Quantum numbers. Energy levels. Pauli's principle. The emission and absorption of light by atoms and molecules. Emission and absorption spectra. Spectrophotometry. Resonance methods of quantum mechanics. Nuclear magnetic resonance, electron paramagnetic resonance, and their use in medicine (Nuclear magnetic tomography). Luminescence. Types of luminescence, basic laws and properties. Stokes's law. Use of luminescence in medicine. The phenomenon of photoeffect. External and internal photoelectric effects and their application in medicine. Stimulated radiation. Equilibrium (Boltzmann) and inversion filling of energy levels. Lasers, the principle of operation and use in medicine.

Topic 4. Radiation Physics. Fundamentals of Dosimetry

X-radiation. Spectrum and characteristics. Primary mechanisms of X-ray interaction with a substance. X-ray attenuation and protection against X-rays. Application of X-rays in medicine (X-ray therapy, X-ray tomography). Radioactivity, its types and properties. Law of radioactive decay. Lifetime. Activity, units of activity. Ionizing radiation, properties and basic mechanisms of interaction with biological objects. Protection against ionizing radiation. The physical and biophysical problems related to the Chornobyl disaster. Ionizing radiation dosimetry. Exposure dose and absorbed dose. Biologically effective dose. Power of doses. Units of doses and powers of doses.

3. The Academic Discipline Structure

The sections and topics titles	Amount of hours
	Full-time study

	Total	including				
		l	p	lab	indiv. Tasks	self-study
1	2	3	4	5	6	7
Semester I						
Section 1. Fundamentals of Biological Physics						
Topic 1. Fundamentals of biomechanics and bioacoustics.	11	1	6	-	-	4
Topic 2. Fundamentals of biorheology and hemodynamics.	12	2	6	-	-	4
Topic 3. Thermodynamics of the open biological systems. Elements of molecular biophysics.	6	1	2	-	-	4
Topic 4. Biophysics of membrane processes.	12	1	6	-	-	4
Topic 5. Effect of external Electric and Magnetic fields on Human Body	4	-	2	-	-	2
Total in section 1	45	5	22	-	-	18
Semester II						
Section 2. Fundamentals of Medical Physics						
Topic 1 Electromagnetics, its medical application. Fundamentals of medical electronic equipment	11	2	6	-	-	4
Topic 2. Optical methods and their use in biology and medicine	10	1	6	-	-	4
Topic 3. Elements of quantum biophysics	10	1	4	-	-	4
Topic 4. Radiation physics. Fundamentals of dosimetry	10	1	4	-	-	4
Final Test. Grand Credit	4	-	2	-	-	2
Total in section 2	45	5	22	-	-	18
Total hours	**90**	**10**	**44**	**-**	**-**	**36**

4. The Themes of the Lectures

#	Theme	Amount of hours
Semester I		
Section 1. Fundamentals of Biological Physics		
1	Fundamentals of biomechanics and bioacoustics.	1
2	Fundamentals of biorheology and hemodynamics.	2
3	Thermodynamics of the open biological systems. Elements of molecular biophysics.	1
4	Cell membrane. Mechanisms of uncharged particles and ions transport through the cell membrane.	0.5
5	Equilibrium membrane potential. Generation and propagation of action potential.	0.5
Semester II		
Section 2. Fundamentals of Medical Physics		
6	Fundamentals of electrocardiography and rheography.	1

7	Electric and magnetic properties of biological objects. Electromagnetic waves in biological media. Interaction of electric and magnetic fields with human body.	0.5
8	Physical principles of optical microscopy and refractometry. Human eye.	1
9	Light interaction with a substance. Thermal radiation of the biological objects.	1
10	Methods of quantum physics for studying biological objects.	0.5
11	Effects of ionizing radiation on biological objects and the human body.	1
	Total	10

5. The Themes of Practical Sessions

#	Theme	Amount of hours
Semester I		
Section 1. Fundamentals of Biological Physics		
1	Audiometry, study of audibility threshold.	3
2	Study of elastic properties of biological tissues.	3
3	Study of surface tension of liquids.	3
4	Study of viscosity of biological fluids.	3
5	Study of physical properties of biological membranes, modeling transport processes across the cell membrane.	4
6	Study of Nernst's equilibrium membrane potential.	3
7	Effect of external Electric and Magnetic fields on the human body	3
Semester II		
Section 2. Fundamentals of Medical Physics		
8	Study of electrocardiograph operation.	2
9	Study of physiotherapeutic equipment operation.	4
10	Optical phenomena. Eye, defects of vision. Optical instruments in medicine. Lasers.	4
11	Essentials of nuclear and atomic physics.	2
12	Radiation medicine. Use of isotopes.	4
13	Dosimetry. Radiation protection.	4
	Grand credit	2
	Total	44

6. The Themes for Self-Study

#	Theme	Amount of hours
Semester I		
Section 1. Fundamentals of Biological Physics		
1	Undamped, damped and forced oscillations in biological systems.	2
2	Obtaining the tension and compression diagram, the basic indexes of elastic properties of tissues.	2
3	Measurement of surface tension coefficient.	1
4	Measurement of coefficient of viscosity of liquids.	2
5	Rheological properties of blood.	1
6	Thermodynamic method for studying biomedical systems.	5
	Biophysical principles of reception on the example of visual reception	
7	Types of transport of substances through membrane structures.	2
8	The nature of cell membrane electrical potentials.	1
9	Electric circuits.	1
Semester II		
Section 2. Fundamentals of Medical Physics		
10	Physical basis of electrocardiography and mechanisms of biopotentials formation. Work with an electrocardiograph.	1
11	Physical background of connection between the blood volume changes ia a vessel and electrical resistance in the given vessel. Work with a rheograph	1
12	Physical background of features of biological tissues electric behavior in an alternating current circuit.	1
	Investigation of dependence of electrical impedance on the frequency of alternate current for different biological objects.	
	Dispersion curves and assessment of dispersion coefficient for living and damaged tissues.	
13	Main interactions of a magnetic field with biological tissues.	0.5
	Main interactions of an electromagnetic field with biological tissues.	
14	Work with UHF device, a device for local darsonvalization and device for ultrasound therapy.	0.5
15	Measurement of micro-objects size by using optical microscopy.	1
16	Investigation of dependence of solution refraction index on its concentration by using the refractometry method.	1
17	Work with a polarimeter.	1
	Mechanism of rotation of polarization plane by optically active substance and assessment of rotation constant.	
18	Mechanism of absorption and scattering the light, phenomenon of dispersion.	1
19	Mechanism of thermal radiation.	1
20	Main concepts and notions of quantum physics.	1
21	Fluorescence and luminescence in biomedical applications. Resonance methods of quantum mechanics.	1
22	Principles of laser operation and its technical characteristics: wavelength, energy, and impulse of quantum.	1
23	Dosimetry.	2
24	Phenomenon of radioactive radiation attenuation by lead, iron and aluminum screens.	3
25	Revising the scope of the discipline. Preparation for the final test	2
	Total	36

7. Individual Tasks

Performing individual tasks on the discipline of “Medical and Biological Physics” by students is not provided by the syllabus.

8. Teaching Methods

Teaching the discipline of “Medical and Biological Physics” is focused on a combination of active and passive teaching methods. Used teaching methods include explanatory-illustrative, reproductive, problem-based presentation of educational material and partial-search (heuristic) methods. Among the interactive teaching methods that are involved in teaching the educational program component, problem lectures, mini-lectures, work in small groups, case method should be noted.

The above-mentioned information is true upon the condition of teaching the discipline on the basis of Google Apps for Education (Google Classroom, Google Meet) and the open learning management system Moodle while introducing distance or blended learning for the period of quarantine or martial law.

9. The Management Techniques

The forms of monitoring and the knowledge assessment system are closely related to the requirements of the educational and professional program “Medicine” and instructions on the system for assessing the students’ educational activity approved by the Ministry of Health of Ukraine, Ministry of Education and Science of Ukraine, Guidance for the maintenance of academic activities at V.N. Karazin Kharkiv National University. Based on the above mentioned, the educational process on the educational program component involves the following management techniques:

1. Oral control: frontal, individual, and combined;
2. Written control: physical dictation, solving problems;
3. Machine control: current (open and closed) tests and a final test based on the service Google Apps for Education and learning management system Moodle.
4. Practical (laboratory control): testing the ability to solve experimental problems.

10. Scheme of Points

Scoring for this discipline is carried out during the continuous assessment of the achievements and taking the final credit test. The continuous assessment of the achievements is realized in practical sessions by performing a control activity in the form of independent work or a computer test offered on the basis of the service Google Apps for Education / Moodle system at the end of each topic studying. Successful performance of all control activities gives the student an opportunity to accumulate a maximum number of 120 points. The final credit test includes questions submitted for lectures and practical sessions, as well as students’ self-study work. Taking the final credit test is ranked at a maximum of 80 points. A student will get a pass if the sum of the points accumulated due to performing control measures during the semester and points that were got due to taking final credit test is ≥ 120 points.

Example for the final semester control upon the condition of taking a final credit test

<table>
<tr><td colspan="6">Continuous assessment, independent work, individual tasks</td><td rowspan="2">Final credit test</td><td rowspan="2">Sum</td></tr>
<tr><td colspan="4">Section 2</td><td>Test provided by curriculum</td><td>Individual task</td><td>Total</td></tr>
<tr><td>T1</td><td>T2</td><td>T4</td><td>T5</td><td></td><td></td><td></td><td></td><td rowspan="2">200</td></tr>
<tr><td>40</td><td>40</td><td>20</td><td>20</td><td>-</td><td>-</td><td>120</td><td>80</td></tr>
</table>

T1, T2 … – topics of section 2.

Criteria for Assessing the Academic Achievements

Assessing Criteria	
«Excellent»	students get it if they complete all control activities and a final credit test with a small number of errors, demonstrate deep and systematic knowledge of the material, are fluent in practical skills provided by the syllabus on the subject, are familiar with additional literature and other information sources on the subject material and understand the importance of the acquired knowledge for the study of medical-biological and clinical disciplines in the course of further education.
«Good»	students get it if they complete all control activities and a final credit test with a couple/certain number of errors, demonstrate confident mastery of the material, have good practical skills provided by the discipline syllabus.
«Satisfactory»	students get it if they complete all control activities and a final credit test with a certain number of drawbacks, corresponding to the minimum criteria: demonstrate the basic knowledge of the material, make light mistakes in answering questions, have a satisfactory level of practical skills provided by the discipline syllabus.
«Unsatisfactory»	students get it if they complete all control activities and a final credit test with a great number of bad errors, demonstrate deficiency of the basic level of knowledge on the discipline and practical skills provided by the discipline syllabus.

Grading Scale

The sum of points for all types of educational activities during the semester	Mark	
	four-level grading scale	two-level grading scale
180 – 200	excellent	Credit
150-179	good	
120-149	satisfactory	
1-119	unsatisfactory	not credit

11. References

Required Reading:

1. Medical and Biological Physics / ed. By A. Chalyi. – 3rd ed. – Vinnytsya : Nova Knyha Publ., 2017. – 480 pp.
2. Medical and Biological Physics / V.G.Knigawko, O.V. Zaitseva, M.A.Bondarenko. – Kharkiv: KNMU, 2017. – 556 pp.

Recommended Reading:

1. Introduction to biological physics for the health and life sciences / K. Franklin, P. Muir, T. Scott, P. Yates. – 2nd ed. – Chichester, West Sussex, United Kingdom: John Wiley & Sons Ltd, 2019. – 600 pp.
2. Intermediate Physics for Medicine and Biology / R.K. Hobbie, J.B. Roth – 5th ed. – Switzerland: Springer Int. Pub., 2015. – 630 pp.
3. Biophysics / ed.by A.N. Misra. – Rijeka, Croatia : InTech, 2012. – 253 pp.

4. Glaser R. Biophysics: An Introduction / R. Glaser. – 2nd ed. – N.Y.: Springer-Verlag Berlin Heidelberg, 2012. – 427 pp.
5. Davidovits P. Physics in Biology and Medicine / P. Davidovits. – 3rd ed. – Elsevier, Academic Press, 2008. – 352 pp.
6. Nelson P. Biological physics. Energy, Information, Life / P. Nelson. – N.Y. : W.H. Freeman and Company, 2007. – 532 pp.
7. Cotterill R. M. J. Biophysics. An Introduction / R. M. J. Cotterill. – N. Y. : John Wiley & Sons, 2003. – 395 pp.
8. Nadeau J.L. Introduction to experimental biophysics: biological methods for physical scientists / J.L. Nadeau. – 2nd ed. – Boca Raton, FL : CRC Press, Taylor & Francis Group, 2017. – 791 pp.
9. Nölting B. Methods in Modern Biophysics / B. Nölting. – Berlin: Springer-Verlag Heidelberg, 2006. – 257 pp.
10. Conventional and Unconventional Use of Lasers in Skin Disorders / G. Editors: S. Moretti, M. S. Kaminer, An. LePillouer-Prost, P. Campolmi. – UK: Hindawi Publishing Corporation, 2015. – 300 pp.
11. Kane S. A. Introduction to physics in modern medicine / S. A. Kane, B. A. Gelman. – 3rd ed. – FL: CRC Press, 2020. – 450 pp.

12. References to Information Internet Resources, Video Lectures, Other Methodical Software

1. books on medical physics http://uamedphys.blogspot.com/
2. medical search system www.mednavigator.net
3. web-site Physics World http://medicalphysicsweb.org/
4. Online information service The Biophysics-Wiki http://www.bio-physics.at/wiki/index.php
5. Journal «Physics in Medicine and Biology» http://iopscience.iop.org/0031-9155/
6. PubMed - free search engine accessing the database of references and abstracts on life sciences and biomedical topics: https://pubmed.ncbi.nlm.nih.gov
7. Additional educational information resources on medical and biological physics https://www.biophysics.org/education-careers/education-resources/additional-education-resources

Appendix 1

Appendix for the syllabus on the discipline _____
(subject)

The program action is extended: for 20_____/20_____academic year.

Vice-dean for academic affairs of school of _____

(signature) (surname, initials)

«____»_____20____.

The head of the Scientific and Methodical Commission of the School of_____

(signature) (surname, initials)

«_____»_____20____.

Examples of Final Exam Questions

1. Angular velocity. Angular acceleration. Rotation with constant angular acceleration. Relation between angular and linear velocity and acceleration.
2. Kinetic energy of rotation. Moment-of-inertia calculations. Parallel-axis theorem. Torque. Work and power in rotational motion.
3. Rotation about a moving axis. Angular momentum and angular impulse. Conservation of angular momentum. Vector representation of angular quantities
4. Periodic motion. Period, frequency, angular frequency, amplitude, phase angle. Equations of simple harmonic motion.
5. Damped oscillations. Decay factor. Forced oscillations. Resonance.
6. Mechanical wave phenomena. Periodic waves. Wave speed, wavelength. Mathematical description of a wave.
7. Wave function. Wave number. Wave equation. Energy in a wave motion.
8. Speed of a transverse wave. Linear and circular polarization. Speed of a longitudinal wave. Sound waves in gases.
9. Sound waves. Intensity. Pressure amplitude. Intensity level. Decibels.
10. Threshold of audibility. Ultrasound. The Doppler effect. A non-invasive way of blood flow rate definition.
11. Surface tension. Fluid flow. Newtonian fluid. Bernoulli's equation.
12. Viscosity. Stokes’s law. Turbulence. Reynolds number.
13. Electric field and electrical forces. Electric-field calculations. Field lines. Gauss's law. Charges on conductors.
14. Electrical potential energy. Potential. Equipotential surfaces. Potential gradient.
15. Capacitors. The energy of a charged capacitor. Effect of a dielectric. Molecular model of induced charge.
16. Current. Resistivity. Resistance. Electromotive force and circuits. Current-voltage relations. Energy and power in electric circuits.
17. Magnetic field. Magnetic field lines and magnetic flux. The motion of charged particles in a magnetic field. Isotopes and mass spectroscopy.
18. Magnetic force on a conductor. The magnetic field of a moving charge. The magnetic field of a current element. The force between parallel conductors Magnetic field of a circular loop.
19. Ampere's law. Magnetic field and displacement current.
20. Induction phenomena. Motional electromotive force. Faraday's law. Induced electric fields. Lenz's law. Eddy currents.
21. Maxwell's equations.
22. Mutual inductance. Self-inductance. Energy in an inductor.
23. Speed of an electromagnetic wave. Energy in electromagnetic waves. Electromagnetic waves in matter. Sinusoidal waves. Standing waves. The electromagnetic spectrum.
24. Nature of light. Sources of light. The speed of light. Waves, wavefronts, and rays.
25. Reflection and refraction. Total internal reflection.
26. Dispersion. Polarization. Polarizing filters. Circular and elliptical polarization. Huygens' principle.
27. Scattering of light. Basic laws.
28. The thin lens. Diverging lenses. Graphical methods. Images as objects. Lens aberrations.
29. The eye. Defects of vision.
30. The magnifier. The camera. The projector. The compound microscope.
31. Interference and coherent sources. Two-source interference. Intensity distribution in interference patterns. Interference in thin films.
32. Fresnel diffraction. Fraunhofer diffraction from a single slit. The diffraction grating.
33. X-ray diffraction. Holography.
34. Emission and absorption of light. The photoelectric effect.

35. Line spectra. Energy levels. Atomic spectra.
36. The laser.
37. Continuous spectra.
38. X-ray production and scattering.