MINISTRY OF HEALTH OF UKRAINE

KHARKIV NATIONAL MEDICAL UNIVERSITY

Department of Medical and Biological Physics and Medical Informatics
Academic year 2021-2022

SYLLABUS OF THE COURSE «MEDICAL AND BIOLOGICAL PHYSICS»

Normative or selective educational component selective

Form of education Full-time
(full-time, part-time, remote)

Field of knowledge 22 «Health Care»
(the code and name of the training direction)

Major field 221 «Dentistry»
(the code and name of specialization)

Specialization (if available) _____

Educational and professional program «Dentistry»

The second (master's) level of higher education

Year: 1

This syllabus was approved at the meeting of the department of medical and biological physics and medical informatics

Record № 7 dated
27 August 2021,

Acting Head of Department

_____ prof. O.V. Zaytseva

Approved by the methodological committee on international students training (KhNMU)

Record № 1 dated
31 August 2021,

Head

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Consultations (face-to-face consultations: schedule and venue; online consultations: schedule, links to electronic resources): face-to-face and online consultations are conducted according to the schedule of the department or by prior arrangement with the teacher.

Location: Kharkiv, 4 Nauki Ave., main building, 2nd floor, Department of Medical and Biological Physics and Medical Information Science, teaching room 1, 2, 3, 4.

INTRODUCTION

The syllabus of the discipline «MEDICAL AND BIOLOGICAL PHYSICS» compiled in accordance with the educational and professional program (further - EPP) 221 «Dentistry» and the Standard of Higher Education of Ukraine (further - Standard) second (master's) level, areas of knowledge 22 «Health care», specialties 221 «Dentistry».

Description of the discipline (abstract)

The course "Medical and biological physics" is offered for study by students of 1st Course and is selective. The scope of discipline (in ECTS credits with the definition of the distribution of hours for lectures, practical classes, seminars, SSS): 3 ECTS credits, or **90** hours, of which **6** hours of lectures, **34** hours of practical classes, **50** hours of independent work. Type of control – **differential credit**.

The subject of study of the discipline «Medical and Biological Physics» is taught in order to form in students a system of knowledge and new competencies about basic physical principles and approaches to the study of processes in life, physical and technical principles of medical devices, the use of mathematical methods in medical and biological research that are basis of subject competencies in «Medical and Biological Physics» and is an integral part of the professional competence of the future doctor, as well as the basis for the study of professionally oriented natural and clinical disciplines in higher medical educational institutions of Ukraine.

Interdisciplinary connections

Course «Medical and Biological Physics»:

- is based on the study by students of a number of disciplines: medical biology, morphological disciplines and integrates with these disciplines;
- lays the foundations for the study of disciplines: social medicine, hygiene and ecology, physiotherapy, radiology (radiation diagnostics and radiation therapy);
- promotes the study of students of other fundamental, as well as clinical, hygienic and social disciplines;

In the general system of training a future doctor, the discipline «Medical and Biological Physics» belongs to the cycle of natural science training.

- **Prerequisites.** The study of the discipline «Medical and Biological Physics» involves the preliminary mastering of credits in the disciplines «Medical Chemistry», «Medical Biology».
- **Co-requisites.** The main provisions of the discipline «Medical and Biological Physics» should be used in the study of such disciplines as «Modern problems of biophysics», «Social Medicine», «Hygiene and Ecology», «Normal Physiology», «Physiotherapy», «Medical Radiology (radiation diagnostics, and radiation therapy), «Biological Chemistry», «Ophthalmology».

Moodle discipline page: http://31.128.79.157:8083/course/view.php?id=775

1. PURPOSE AND OBJECTIVES OF THE DISCIPLINE

1.1. Purpose and objectives of the discipline The purpose of teaching the discipline "Medical and Biological Physics": the formation of students' knowledge and new competencies of basic physical principles and approaches to the study of processes in life science, physical and technical principles of medical devices, the use of mathematical methods biomedical research, which is the basis of subject competencies in medical and biological physics and is an integral part of the professional competence of the future doctor, as well as the basis for the study of professionally oriented natural and clinical disciplines in higher medical educational institutions of Ukraine.

1.2. The main tasks of the discipline: acquisition of knowledge and skills in mathematical methods in biology and medicine, biomechanics and biological thermodynamics, electrical phenomena in biology and medicine, basics of medical electronics, medical and biological aspects of atomic and nuclear physics.

1.3. Competencies and learning outcomes facilitated by the discipline of «Medical and Biological Physics» (correlation with the normative content of higher education applicants' training, formulated in terms of the learning outcomes in the EPP and Standard).

As a result of studying the discipline the student must

know:

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

be able:

- perform mathematical and computer processing of biomedical information;
- use medical equipment used in diagnostics, electrical stimulation and physiotherapy (in particular, electrocardiography, rheography, impedance-plethysmography, audiometry, optical and quantum-mechanical devices and systems, radiometric and dosimetric monitoring devices.

1.3.1. According to the requirements of the standard, the discipline provides for the students to acquire **competencies**:

1	*Integral competence*	Ability to solve typical and complex specialized problems and practical problems in health care professional activity and / or in the process of further education using modern physical theories and methods of research of living organisms, biological objects and processes occurring in living using a complex of interdisciplinary knowledge and in the absence of information.
2	*General competencies*	1. The ability to apply knowledge of medical and biological physics in practical situations. 2. Knowledge and understanding in the sciences that form the basis of

		biological and medical physics. 3. Ability to communicate on topics related to biophysics in the mother tongue, both orally and in writing. 4. Ability to understand the principles and methods of graphical and analytical presentation of scientific information. 5. The ability to use information technology for the study of biomedical processes. 6. The ability to acquire new knowledge and to be modernly educated, to be aware of the possibility of lifelong learning. 7. Ability to work both independently and in a team. 8. Life safety skills. 9. The desire to preserve the natural environment and ensure the sustainable development of society. 10. Recognition of moral and bioethical aspects of scientific research and the need for intellectual integrity, as well as professional codes of conduct.
3	*Special (professional) competencies*	1. The ability to supplement the knowledge and understanding of the basic physical characteristics of medical and biological systems, the physical basis of processes occurring in living organisms. 2. Ability to integrate basic knowledge of physics, chemistry, biology, mathematics, information technology to create a foundation of professional competencies. 3. Ability to collect record and analyze biomedical research data through appropriate methods and technological means. 4. Ability to apply quantitative methods in the study of biomedical processes. 5. The ability to interpret the general physical and biophysical patterns that underlie the functioning of the human body. 6. Ability to explain the physical basis and biophysical mechanisms and effects of the interaction of physical fields with the human body. 7. Ability to explain the physical foundations of the operation and use of modern (electronic) medical devices. 8. Ability to analyze the composition and physical principles of operation of medical devices and equipment. 9. The ability to perform laboratory tests and observations. 10. Have an understanding of modern methods of mathematical modeling and the possibility of their use in the study of biological and biological processes. 11. Knowledge and use of theories, paradigms, concepts, and principles specific to biological and medical physics. 12. Ability to plan, organize, and conduct biomedical research and report preparation.

1.3.2. The study of the discipline provides students with the acquisition of the following **program learning outcomes:**

PLO 1 the student's ability to acquire knowledge sufficient to understand the basic physical characteristics of medical and biological systems, the physical basis of the processes occurring in living organisms;

PLO 2 ability to solve typical and complex specialized problems;

PLO 3 ability to solve practical problems in professional activities in the field of health care and / or in the process of further training with the use of modern physical theories;

PLO 4 ability to apply methods of research of living organisms and biological objects;
PLO 5 ability to interpret processes occurring in wildlife using a set of interdisciplinary knowledge and in the absence of information.

1.3.3. The study of the discipline provides students with the following **social skills (Soft skills):**
1) the ability to analyze and apply in medical practice the basic concepts, laws of biophysics;
2) the ability to explain the physical basis and biophysical mechanisms and effects of the interaction of electric currents and electromagnetic fields with the human body;
3) the ability to correctly explain the physical basis of operation and application of modern electronic medical devices used in medical diagnostics and therapy (in particular, in electrocardiography, rheography, impedance plethysmography, audiometry, optical and quantum mechanical devices and systems, radiometric and radiometric devices).

2. INFORMATION SCOPE OF THE COURSE

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">Field of knowledge, specialty, educational degree, EPP</td><td>Characteristics of the discipline</td></tr>
<tr><td>full-time education</td></tr>
<tr><td>Number of credits – 3,0</td><td>Field of knowledge:
22 "Health care"
(the code and name)</td><td>Selective</td></tr>
<tr><td rowspan="5">Total number of hours - 90</td><td rowspan="5">Specialty 221 «Dentistry»
(the code and name of specialization)</td><td>Year of preparation (course):</td></tr>
<tr><td>1-st</td></tr>
<tr><td>Semester</td></tr>
<tr><td>2-nd</td></tr>
<tr><td></td></tr>
<tr><td rowspan="10">Hours for day (or evening) form of study:
classrooms – 40 hours
independent student work – 50 hours</td><td rowspan="10">Educational degree:
the second (master's) level of higher education

EPP:
221 «Dentistry»</td><td>Lecture – 6 hours</td></tr>
<tr><td>Practical classes</td></tr>
<tr><td>34 hours</td></tr>
<tr><td>Laboratory work</td></tr>
<tr><td>-</td></tr>
<tr><td>Independent work</td></tr>
<tr><td>50 hours</td></tr>
<tr><td>Individual tasks: 0 год.</td></tr>
<tr><td>Type of control – differential credit</td></tr>
</table>

2.1 Description of the discipline

2.2.1. Topics of lectures

№ з/п	The name of topic	Number of hours
1	Fundamentals of bioreology and hemodynamics.	2
2	Fundamentals of bioacoustics. Acoustic methods in medicine.	2
3	Ionizing radiation. Dosimetry.	2
Total lecture hours		**6**

2.2.2. Topics of seminars

№ з/п	The name of topic	Number of hours
Total lecture hours		**-**

2.2.3. Topics of practical classes

№ з/п	Topic	Number of hours
1	Fundamentals of hydrodynamics, bioreology and hemodynamics.	2
2	Mechanical oscillations and waves. Bioacoustics.	4
3	Transport of substances across biomembranes. Biopotentials.	2

4	The concept of electrography of organs and tissues. Electrocardiography.	
5	The effect of electric currents and electromagnetic fields on biological objects.	
6	Medical electronics/	
7	*Control work for Section 1*	2
8	Geometrical optics. Lenses. The optical system of the human eye.	2
9	Optical microscopy. Special methods of optical microscopy.	2
10	Polarization of light. Sacharimetry.	2
11	Interaction of light with matter (absorption, scattering, dispersion of light).	
12	Elements of photobiology.	2
13	Thermal radiation, basic concepts and laws. Medical applications of thermal radiation.	2
14	Ionizing radiation. X-ray radiation and its use in medicine.	2
15	Dosimetry. Radiation diagnostics and therapy.	
16	*Control work for Section 2*	2
17	**Differential credit**	2
Total hours of practical lessons		**34**

2.2.4. Topics of laboratory classes

№ з/п	The name of topic	Number of hours
Total laboratory hours		-

2.2.5. Materials for student's self-study

№ з/п	The name of topic	Number of hours
1	Viscoplastic properties of blood. Hematocrit index. Models of Shvedov-Bingham, Quezon. Linear velocity of blood flow in the human circulatory system. Cardiac blood pressure cycle. The physical basis of Korotkov's method of measuring blood pressure. Work and power of the heart. Pulse wave	8
2	Decrement and logarithmic decrement of attenuation of oscillation amplitude. Resonance, vibration. Self-oscillation. Relaxation oscillations. Wave processes and their characteristics. Wave equation. Energy flow. Primary mechanisms of ultrasound therapy. The effect of infrasonic waves on the human body. Hygienic normalization of noise, infrasound, vibration levels.	8
3	Biological thermodynamics. Thermodynamic method of studying medical and biological systems. The first and second laws of thermodynamics, entropy, thermodynamic potentials. Entropy. Negentropy.	8
4	The concept of electroencephalography and other electrographic techniques.	2
5	Magnetic phenomena. Elements of magnetobiology. The effect of a magnetic field on biological objects. Biomagnetism. Magnetocardiography. Hygienic standardization of electromagnetic fields.	4
6	Metrological Health Service.	2
7	Polarization of light. Refractometry. Concentration colorimetry.	4

	Concentration polarimetry. Basic concepts and formulas of wave optics.	
8	Light scattering. Nephelometry. Dispersion of light.	2
9	Basic concepts of radiobiology and radiation medicine.	2
10	Photometry. Hygienic rationing of photometric quantities.	2
11	Photoeffect and its application in medicine.	2
12	Basic concepts and laws of quantum physics. Spectroscopy. Thermal radiation of bodies, its characteristics. Luminescence. Elements of photobiology. Electron microscope. Induced radiation.	6
Total hours for students for self-study		**50**

3. Evaluation policy

3.1. Evaluation of the success of education of students is carried out on the basis of the current "Instructions for evaluating the educational activities of students of KhNMU".

3.1.1. Evaluation of current educational activities of students:

Control of mastering the topic (current control) in practical classes is carried out in accordance with specific objectives with the use of entrance test control, oral examination and testing of practical skills.

After conducting the last practical lesson and grading in the electronic journal, the teacher calculates the average grade for the entire period of study of the discipline (on the traditional scale).

Recalculation of the average grade for the current activity into a multi-scale scale is carried out in accordance with Table 1.

Table 1

Recalculation of the average score for the current activity into a multi-scale scale
(for subjects completed in the diff. credit)

4-point scale	200-point scale	4-point scale	200-point scale
5	120	3.91-3,94	94
4.95-4,99	119	3.87-3,9	93
4.91-4,94	118	3.83- 3,86	92
4.87-4,9	117	3.79- 3,82	91
4.83-4,86	116	3.74-3,78	90
4.79-4,82	115	3.7- 3,73	89
4.75-4,78	114	3.66- 3,69	88
4.7-4,74	113	3.62- 3,65	87
4.66-4,69	112	3.58-3,61	86
4.62-4,65	111	3.54- 3,57	85
4.58-4,61	110	3.49- 3,53	84
4.54-4,57	109	3.45-3,48	83
4.5-4,53	108	3.41-3,44	82
4.45-4,49	107	3.37-3,4	81
4.41-4,44	106	3.33- 3,36	80
4.37-4,4	105	3.29-3,32	79
4.33-4,36	104	3.25-3,28	78
4.29-4,32	103	3.21-3,24	77

4-point scale	200-point scale
4.25- 4,28	102
4.2- 4,24	101
4.16- 4,19	100
4.12- 4,15	99
4.08- 4,11	98
4.04- 4,07	97
3.99-4,03	96
3.95- 3,98	95

4-point scale	200-point scale
3.18-3,2	76
3.15- 3,17	75
3.13- 3,14	74
3.1- 3,12	73
3.07- 3,09	72
3.04-3,06	71
3.0-3,03	70
Less than 3	Not enough

Conducting and evaluating differentiated credits in the discipline «Medical and Biological Physics».

Differentiated credit (DC) is conducted by a teacher of an academic group in the last lesson in the discipline in the form of writing 40 test tasks. Admission to the DC is determined in CLA points, namely: min - 70, max -120 points. The DC is estimated from 50 to 80 points directly.

The criteria for assessing differentiated credit are the following:

24-31 Correct Answers - A grade of "3",

32-37 Correct Answers - A grade of "4"

38-40 Correct Answers - A grade of "5".

The assessment of the differentiated credit is carried out in accordance with the recommendation "Instructions for the evaluation of educational activities under the European Credit Transfer System of the organization of the educational process". The traditional differentiated credit grade ("3", "4", "5") is translated as follows: a grade of "3" is 50 points, a grade of "4" is 65 points, a grade of "5" is 80 points.

3.1.2. Assessment of individual tasks of the student

The total maximum number of additional points for individual work of students is 10 points (according to the «Guidelines for the evaluation of educational activities under the European Credit Transfer System of the organization of the educational process», assessment of individual tasks of the student).

Scores for individual assignments are only awarded to the student once a commission (commission - head of department, head teacher, group teacher) only if they are successfully fulfilled and protected. The total amount of points for the CLA may not exceed 120 points.

3.1.3. Assessment in the discipline «Medical and Biological Physics»

The discipline score is defined as the arithmetic mean of the CLA scores for all semesters during which the discipline was studied, which translates into a 120-point ECTS scale (Table 1) with the addition of scores obtained directly on the differentiated credit.

The maximum number of points that a student can earn for studying a discipline is 200 points, including the maximum number of points for current educational activity - 120 points, and the maximum number of points for the results of the differentiated credit or examination - 80 points. The minimum number of credits is 120, including the minimum of the current educational activity - 70 and according to the results of the exam or differentiated credit - 50 points.

The discipline score is defined as the sum of the points for the CLA and differentiated credit and is min - 120 to max - 200. The correspondence of the scores on the 200 point scale, the four-point (national) scale and the ECTS scale are shown in Table 2 «Guidelines for the evaluation of learning activities at European Credit -transfer system of organization of educational process».

Table 2

Relevance of estimates on a 200 point scale, four-point (national) scale and ECTS scale

Score by 200 point scale	Score by ECTS scale	Score for four-point (national) scale
180–200	A	Perfectly
160–179	B	Good
150–159	C	Good
130–149	D	Satisfactory
120–129	E	Satisfactory
Less than 120	F, Fx	Unsatisfactory

Students who have not completed the curriculum requirements are given a FX score if they have been admitted to the differential test but have not passed it. Grade F is given to students who are not admitted to the differentiated credit.

After completing the study of the discipline responsible for the organization of teaching and methodical work at the department or the teacher put the student an appropriate grade on the scale (Table 6) in the book and fill in the data of the students of the discipline in the form: У-5.03В - differentiated credit.

3.2. Questions to differentiated credit:

1. Types of deformation: elastic, inelastic, highly elastic
2. Mechanical stress, allowable mechanical stress, elongation
3. Hooke's law in tensile deformation (compression)
4. Diagram of the dependence of mechanical stress on the relative elongation at tensile deformation
5. Fragile and plastic materials, Poisson's ratio
6. Shear deformation, Hooke's law for shear deformation
7. Linear and volumetric coefficients of thermal expansion
8. The concept of an absolutely solid body
9. Characteristics of uniform circular motion: angular velocity, angular acceleration;
10. The moment of force, the condition of equilibrium of the body when moving in a circle
11. The moment of inertia of a material point
12. The momentum of the body, the law of conservation of momentum
13. The musculoskeletal system of man
14. Dynamic and static human work in different types of its activities
15. Egrometry
16. Deformation properties of biological tissues
17. Anisotropy of mechanical properties of tissues

18. Muscle contraction, Hill's equation
19. Tension relaxation, creep
20. Ideal and real fluid
21. Bernoulli's equation
22. Equation of continuous flow
23. Newton's formula for the force of viscous friction
24. Viscosimetry
25. Newtonian and non-Newtonian fluids
26. Laminar and turbulent fluid flow
27. Reynolds number
28. Poiseuille's formula
29. Hydraulic resistance of the system
30. The flow of real fluid as a shear deformation
31. The main rheological characteristics and the relationship between them (shear rate, shear stress)
32. Flow curves for Newtonian and non-Newtonian fluids
33. Properties of blood as a viscoelastic fluid
34. Hematocrit index
35. Shvedov-Bingham equation, Quezon formula
36. Change in the average linear velocity of blood flow in the great circle of blood circulation
37. Change in the average for the period of the cardiac cycle blood pressure in the great circle of blood circulation
38. Work and power of the heart
39. Pulse wave
40. Clinical method of measuring blood pressure (according to Korotkov)
41. Working formulas for determining the viscosity of a liquid by the methods of Ostwald and Hess
42. Oscillatory process, its main physical characteristics
43. Classification of oscillations (undamped, damping and forced oscillations)
44. Resonance, resonant frequency
45. Forced oscillations, forced oscillating systems
46. Wave processes, their characteristics
47. General form and solution of differential equations of undamped, damping and forced oscillations
48. Logarithmic decrement of attenuation
49. Methods of measuring blood velocity in blood vessels and blood pressure (Doppler effect), electromagnetic method (electromagnetic flowmetry)
50. The system of equilibrium of the body in space
51. Acoustics, acoustic waves
52. Physical (objective) characteristics of sound
53. Physiological (subjective) characteristics of sound
54. Weber-Fechner law
55. Curves of equal volume, threshold of audibility of sound and threshold of painful sensation

56. Sound research methods (audiometry, auscultation, percussion, phonocardiography and ultrasound diagnostics)
57. Ultrasound and its use in medicine
58. Infrasound and its impact on biological objects
59. Biophysical foundations of human perception of sound
60. Hygienic normalization of noise, infrasound and vibration
61. Thermodynamic systems: isolated, closed and open
62. Internal energy of the system
63. Heat transfer (or heat transfer)
64. Amount of heat, unit of measurement (system and non-system)
65. Hess's law
66. Reversible and irreversible processes
67. The concept of entropy, its content and unit of measurement
68. The principle of non-decay of entropy
69. The first, second and third laws of thermodynamics
70. Functions of the state of a thermodynamic system (thermodynamic potentials), their formulas.
71. Enthalpy (H)
72. Gibbs free energy (G)
73. Helmholtz free energy (F)
74. The concept of chemical potential
75. The phenomenon of osmosis and its role in biological processes, osmotic pressure
76. The concept of negentropy
77. Biophysics of macromolecules
78. Levels of structural organization of proteins
79. Types of interactions of atomic groups that are part of macromolecules
80. Levels of structural organization of nucleic acids (RNA and DNA)
81. The main functions of biological membranes
82. Liquid-mosaic model of the structure of biological membranes
83. The main types of transport of substances through surface (plasma) membranes
84. Diffusion of uncharged molecules, Fick's equation
85. Diffusion through membrane pores, facilitated diffusion, exchange diffusion
86. Electrodiffusion, Nernst-Planck equation, Theorell equation
87. Electrochemical potential
88. Active transport of substances across membranes, types of ion pumps
89. Sodium-potassium pump of plasma membranes, its work
90. Calcium pump of sarcoplasmic reticulum membranes, its work
91. Proton pump of mitochondria and chloroplasts, its work
92. Membrane potential
93. Membrane potential of rest
94. Equilibrium potential of Nernst
95. Diffusion potential
96. Donnan's potential
97. Goldman-Hodgkin-Katz equation
98. Membrane permeability, formula

99. The ratio of membrane permeability for ions at rest and at excitation
100. Action potential, its generation and dissemination
101. Electric field and its characteristics (voltage and potential, the relationship between them)
102. The principle of superposition of fields
103. Electric dipole
104. Dipole moment of an electric dipole, formula
105. Characteristics of direct current (current strength, current density, resistance of the conductor, resistivity, specific conductivity)
106. Ohm's law in differential form
107. Current dipole
108. Dipole moment of a current dipole, formula
109. Multipole decomposition of the field potential formed by a system of currents
110. The main postulates of the second model of Einthoven's theory of electrocardiography
111. The concept of electrocardiogram
112. Standard assignments
113. Chest assignments
114. Reinforced leads
115. Analysis of a normal electrocardiogram in the second standard lead
116. The concept of vector cardiography
117. The concept of electroencephalography (EEG)
118. The concept of electromyography (EMG)
119. The concept of electroneurography (ENG)
120. The concept of electroretinography (ERG)
121. The concept of electrical activity of the skin
122. Electrically conductive properties of biological tissues for alternating current, their impedance and its components
123. Dependence of the tissue impedance modulus on the cyclic frequency of alternating current
124. Electrical equivalent of biological tissue
125. Dispersion coefficient, formula
126. The main mechanism of action of direct electric current on biological tissues, EMF polarization
127. Galvanization, electrophoresis, drug electrophoresis
128. Pulsed electric current, its characteristics
129. The main mechanism of action of pulsed electric current on biological tissues
130. Dubois-Raymond's law
131. Electrodiagnostics in medicine
132. Horweg-Weiss-Lapik equation, the concept of rheobase and chronaxy
133. Therapeutic techniques based on the use of pulsed current (pacing, electrosleep, electrogymnastics, defibrillation)
134. Alternating electric current, its characteristics
135. Mechanisms of action of alternating current on biological tissues depending on its frequency

136. Nernst's law at different frequencies of alternating current
137. Rheography (impedance - plethysmography)
138. Diathermy (electrosurgery), its varieties (diathermotomy and diathermocoagulation)
139. Local darsonvalization
140. The main mechanism of action of an alternating electromagnetic field on biological tissues
141. Inductothermy, UHF therapy, microwave therapy (MW and DMW therapy)
142. The effect of a constant electric field on biological tissues
143. The effect of electromagnetic radiation in the radio frequency range on biological tissues
144. Hygienic rationing of electromagnetic field levels
145. Magnetic field and its characteristics
146. Induction of a magnetic field
147. Ampere force
148. Magnetic moment
149. Lorentz force
150. Magnetic permeability, magnetic properties of substances
151. The strength of the magnetic field
152. Bio-Savar-Laplace law
153. The phenomenon of electromagnetic induction
154. Magnetic flux
155. The law of electromagnetic induction
156. The phenomenon of self-induction
157. Magnetobiology and biomagnetism
158. Magnetocardiography
159. Control and diagnostic equipment (KDA), its purpose and composition
160. Electrotherapeutic equipment, its purpose and composition
161. Cybernetic electronic devices
162. The concept of "breakdown on the body" and "leakage currents"
163. Methods of combating the danger of electric shock in the event of a breakdown on the body of the device
164. Classification of electronic devices by the value of the allowable leakage current
165. Reliability of the electronic device; the probability of trouble-free operation of the electronic device
166. Intensity of failures; curve of dependence of intensity of failures on time
167. The relationship between the probability of failure-free operation and the intensity of failures for the area of normal operation
168. Classification of medical electronic devices by the criterion of reliability
169. Electrodes and basic requirements for them
170. Classification of sensors: energy and biocontrolled
171. Types of biocontrolled sensors: generator and parametric
172. Classification of sensors on the basis of physical phenomena underlying their work
173. Sensor conversion function and its sensitivity

174. The main disadvantages and general requirements for sensors, hysteresis
175. Purpose of amplifiers and their types
176. The main characteristics of amplifiers: the formulas of the gain for AC and DC amplifiers
177. Amplitude and amplitude-frequency characteristics of alternating current amplifiers
178. The bandwidth of the AC amplifier and determine its boundaries
179. Purpose and types of generators, their application in medicine
180. Devices for display and registration of medical and biological information, their types
181. Laws of reflection and refraction of light
182. Absolute and relative refractive indices
183. The phenomenon of the extreme refraction of light, the ultimate angle of refraction
184. The phenomenon of total internal reflection, the maximum angle of total reflection
185. Fiber optics, endoscopes and laparoscopes, their use in medicine
186. Lenses and their characteristics
187. Construction of images of the object in the prefabricated and scattering lenses
188. The formula of a thin lens and the linear magnification of the object in the lens
189. Types of lens aberrations (spherical aberration, chromatic aberration, astigmatism, distortion)
190. Principles of operation of the refractometer
191. Optical microscope, the course of rays in it
192. Angular magnification of the optical system
193. Magnification of the microscope
194. Resolution of a microscope
195. The limit of resolution of the microscope (with normal and inclined incidence of rays on the subject)
196. Ways to reduce the resolution of the optical microscope
197. Ultraviolet microscope
198. Special methods of microscopy: microprojection and microphotography; dark field method; phase contrast method; polarization and fluorescence microscopy
199. Optical system of the human eye: light-conducting and light-receiving
200. Optical power of the human eye
201. The process of accommodation, the distance of the best vision
202. Construction of the image of an object in the optical system of the human eye
203. Disadvantages of light-conducting and light-receiving systems of the human eye, their correction
204. Photoreceptors, their types
205. The process of adaptation, its mechanisms
206. Angle of view, the smallest angle of view, the limit of the human eye
207. Resolution of the eye
208. Visual acuity
209. The nature of light

210. Light wave and its characteristics
211. The phenomenon of light interference
212. The phenomenon of light diffraction
213. The phenomenon of polarization of light
214. Natural light, partially polarized light, plane-polarized light
215. Polarizer and analyzer
216. Malus's law
217. Polarization of light during its reflection and refraction at the boundary of two transparent dielectrics
218. Brewster's law
219. Polarization of light in birefringence
220. The course of rays in the prism of Nicolas
221. The phenomenon of dichroism
222. The method of polarimetry and its use in medicine
223. Polarizing microscope
224. Absorption of light by matter
225. Bouguer's law
226. Natural monochromatic indicator of light absorption
227. Absorption of light by solutions
228. Bouguer-Lambert-Beer law
229. Natural molar absorption index and molar absorption index
230. Transmission coefficient and optical density of the solution
231. Absorption spectra of matter
232. Photoelectrocolorimetric determination of the concentration of solutions
233. Objective (physical) characteristics of light (energy photometric quantities): radiation flux, spectral density of radiation flux, relative spectral light efficiency (visibility function) and visibility curve
234. Subjective (physiological) characteristics of light perception (light quantities): light intensity, luminous flux, illuminance, luminosity, brightness
235. Physical and visual photometers
236. Photobiological processes, their classifications
237. General stages of photobiological processes
238. Photochemical reactions: photoionization, photoreduction, photooxidation, photodissociation, photoisomerization, photodimerization
239. Spectrum of photobiological action
240. Photosensitized photobiological processes
241. Photosensitizers of the first and second types
242. Biophysics of visual reception
243. Thermal radiation of bodies
244. Energy luminosity and spectral density of energy luminosity
245. The spectrum of thermal radiation of the body
246. Black and gray bodies
247. Kirchhoff's law
248. Stefan-Boltzmann law
249. The law of shift of Wine

250. Optical pyrometry
251. Thermal radiation of man
252. Diagnostic techniques: thermoscopy, thermometry, thermography
253. Wave properties of micoparticles
254. Wave function
255. De Broglie wavelength
256. Schrödinger's equation
257. Quantum-mechanical model of the hydrogen atom
258. Quantum numbers
259. Pauli principle
260. The ratio of Heisenberg uncertainties
261. Selection rules
262. Luminescence and its types
263. The mechanism of photoluminescence, its types (fluorescence and
264. phosphorescence)
265. Stokes' law and deviations from it (anti-Stokes luminescence)
266. Luminescence spectra
267. Luminescent analysis and its use in biomedical research
268. Spectra of absorption and radiation of substances
269. The use of emission and absorption spectroscopy in UV and visible parts of the spectrum
270. The use of absorption spectroscopy in the IR and MW parts of the spectrum
271. Induced radiation
272. The principle of operation of the helium-neon laser
273. Biological action of laser radiation
274. Types of lasers. The use of lasers in medicine
275. The phenomenon of electronic paramagnetic resonance (EPR)
276. Information carried by EPR spectra
277. Spin marks and spin probes
278. The phenomenon of nuclear magnetic resonance (NMR)
279. NMR introscopy (computer tomography (CT))
280. Electron microscope, the resolution of the electron microscope
281. Ionizing radiation, the types of ionizing radiation
282. X-rays
283. Bremsstrahlung breaking and Characteristic X-rays
284. The mechanism of Bremsstrahlung breaking X-rays
285. The minimum wavelength in the spectrum of Bremsstrahlung breaking X-rays
286. The mechanism of Characteristic X-rays
287. The spectrum of Characteristic X-rays
288. Mosley's law
289. X-ray tube
290. X-ray flux generated by an X-ray tube
291. Attenuation of the flux of monochromatic X-rays by a substance, Bouguer's law
292. Mechanisms of interaction of X-rays with matter: coherent scattering, incoherent scattering (Compton effect), photoeffect

293. The attenuation factor of X-rays, its components
294. Mass component of X-ray attenuation
295. X-ray protection
296. X-ray diagnostics (digital radiography, X-ray computed tomography (CT)) and radiotherapy
297. Radioactivity
298. Types of radioactive decay: α - decay, β^- - decay, β^+ - decay, e – capture
299. The law of radioactive decay
300. The half-life of a substance
301. Activity of a substance, units of measurement
302. Interaction of different types of ionizing radiation with matter
303. Mechanisms of interaction γ -- radiation with matter: incoherent scattering (Compton effect), photoeffect (internal and nuclear), formation of electron-positron pairs
304. Attenuation of monochromatic flux - radiation by matter, Bouguer's law
305. Characteristics of the interaction of corpuscular ionizing radiation with matter: linear ionization density, linear braking ability, average linear particle path
306. Penetrating ability of ionizing radiation
307. The negative nature of the effects of ionizing correction
308. Methods of protection against ionizing radiation
309. Radiation doses (absorbed dose, exposure dose, equivalent dose), units of measurement
310. Radiation dose rate, exposure dose rate, units of measurement
311. Hygienic rationing of radiation loads
312. Effective equivalent dose
313. Internal irradiation of a person
314. Detectors and dosimeters of ionizing radiation
315. Radionuclide diagnostics: dynamic and static methods
316. Single-photon emission computed tomography (SPECT)
317. Positron emission tomography (PET)
318. Radiation therapy and its methods
319. Modern devices for radiosurgical treatment using ionizing radiation
320. Autoradiography
321. Direct and indirect effects of ionizing radiation on DNA and other biomacromolecules
322. Oxygen effect. Oxygen growth factor
323. Types of radiation damage to cell DNA
324. Reproductive and interphase death of irradiated cells
325. Survival of irradiated cells, survival curve, its analysis

3.3. Control questions

Test questions for the final lesson № 1

1. Types of deformation: elastic, inelastic, highly elastic
2. Mechanical stress, allowable mechanical stress, elongation

3. Hooke's law in tensile deformation (compression)
4. Diagram of the dependence of mechanical stress on the relative elongation at tensile deformation
5. Fragile and plastic materials, Poisson's ratio
6. Shear deformation, Hooke's law for shear deformation
7. Linear and volumetric coefficients of thermal expansion
8. The concept of an absolutely solid body
9. Characteristics of uniform circular motion: angular velocity, angular acceleration;
10. The moment of force, the condition of equilibrium of the body when moving in a circle
11. The moment of inertia of a material point
12. The momentum of the body, the law of conservation of momentum
13. The musculoskeletal system of man
14. Dynamic and static human work in different types of its activities
15. Egrometry
16. Deformation properties of biological tissues
17. Anisotropy of mechanical properties of tissues
18. Muscle contraction, Hill's equation
19. Tension relaxation, creep
20. Ideal and real fluid
21. Bernoulli's equation
22. Equation of continuous flow
23. Newton's formula for the force of viscous friction
24. Viscosimetry
25. Newtonian and non-Newtonian fluids
26. Laminar and turbulent fluid flow
27. Reynolds number
28. Poiseuille's formula
29. Hydraulic resistance of the system
30. The flow of real fluid as a shear deformation
31. The main rheological characteristics and the relationship between them (shear rate, shear stress)
32. Flow curves for Newtonian and non-Newtonian fluids
33. Properties of blood as a viscoelastic fluid
34. Hematocrit index
35. Shvedov-Bingham equation, Quezon formula
36. Change in the average linear velocity of blood flow in the great circle of blood circulation
37. Change in the average for the period of the cardiac cycle blood pressure in the great circle of blood circulation
38. Work and power of the heart
39. Pulse wave
40. Clinical method of measuring blood pressure (according to Korotkov)
41. Working formulas for determining the viscosity of a liquid by the methods of Ostwald and Hess

42. Oscillatory process, its main physical characteristics
43. Classification of oscillations (undamped, damping and forced oscillations)
44. Resonance, resonant frequency
45. Forced oscillations, forced oscillating systems
46. Wave processes, their characteristics
47. General form and solution of differential equations of undamped, damping and forced oscillations
48. Logarithmic decrement of attenuation
49. Methods of measuring blood velocity in blood vessels and blood pressure (Doppler effect), electromagnetic method (electromagnetic flowmetry)
50. The system of equilibrium of the body in space
51. Acoustics, acoustic waves
52. Physical (objective) characteristics of sound
53. Physiological (subjective) characteristics of sound
54. Weber-Fechner law
55. Curves of equal volume, threshold of audibility of sound and threshold of painful sensation
56. Sound research methods (audiometry, auscultation, percussion, phonocardiography and ultrasound diagnostics)
57. Ultrasound and its use in medicine
58. Infrasound and its impact on biological objects
59. Biophysical foundations of human perception of sound
60. Hygienic normalization of noise, infrasound and vibration
61. Thermodynamic systems: isolated, closed and open
62. Internal energy of the system
63. Heat transfer (or heat transfer)
64. Amount of heat, unit of measurement (system and non-system)
65. Hess's law
66. Reversible and irreversible processes
67. The concept of entropy, its content and unit of measurement
68. The principle of non-decay of entropy
69. The first, second and third laws of thermodynamics
70. Functions of the state of a thermodynamic system (thermodynamic potentials), their formulas.
71. Enthalpy (H)
72. Gibbs free energy (G)
73. Helmholtz free energy (F)

Test questions for the final lesson № 2

1. Laws of reflection and refraction of light
2. Absolute and relative refractive indices
3. The phenomenon of the extreme refraction of light, the ultimate angle of refraction

4. The phenomenon of total internal reflection, the maximum angle of total reflection
5. Fiber optics, endoscopes and laparoscopes, their use in medicine
6. Lenses and their characteristics
7. Construction of images of the object in the prefabricated and scattering lenses
8. The formula of a thin lens and the linear magnification of the object in the lens
9. Types of lens aberrations (spherical aberration, chromatic aberration, astigmatism, distortion)
10. Principles of operation of the refractometer
11. Optical microscope, the course of rays in it
12. Angular magnification of the optical system
13. Magnification of the microscope
14. Resolution of a microscope
15. The limit of resolution of the microscope (with normal and inclined incidence of rays on the subject)
16. Ways to reduce the resolution of the optical microscope
17. Ultraviolet microscope
18. Special methods of microscopy: microprojection and microphotography; dark field method; phase contrast method; polarization and fluorescence microscopy
19. Optical system of the human eye: light-conducting and light-receiving
20. Optical power of the human eye
21. The process of accommodation, the distance of the best vision
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68. Stefan-Boltzmann law
69. The law of shift of Wine
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71. Thermal radiation of man
72. Diagnostic techniques: thermoscopy, thermometry, thermography
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74. Wave function
75. De Broglie wavelength
76. Schrödinger's equation
77. Quantum-mechanical model of the hydrogen atom
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80. The ratio of Heisenberg uncertainties
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113. Mass component of X-ray attenuation
114. X-ray protection
115. X-ray diagnostics (digital radiography, X-ray computed tomography (CT)) and radiotherapy
116. Radioactivity
117. Types of radioactive decay: - decay, - decay, - decay, e – capture
118. The law of radioactive decay
119. The half-life of a substance
120. Activity of a substance, units of measurement
121. Interaction of different types of ionizing radiation with matter

122. Mechanisms of interaction -- radiation with matter: incoherent scattering (Compton effect), photoeffect (internal and nuclear), formation of electron-positron pairs
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125. Penetrating ability of ionizing radiation
126. The negative nature of the effects of ionizing correction
127. Methods of protection against ionizing radiation
128. Radiation doses (absorbed dose, exposure dose, equivalent dose), units of measurement
129. Radiation dose rate, exposure dose rate, units of measurement
130. Hygienic rationing of radiation loads
131. Effective equivalent dose
132. Internal irradiation of a person
133. Detectors and dosimeters of ionizing radiation
134. Radionuclide diagnostics: dynamic and static methods
135. Single-photon emission computed tomography (SPECT)
136. Positron emission tomography (PET)
137. Radiation therapy and its methods
138. Modern devices for radiosurgical treatment using ionizing radiation
139. Autoradiography

3.4 Individual tasks

The total maximum number of additional points for individual work of students is 10 points (according to the «Guidelines for the evaluation of educational activities under the European Credit Transfer System of the organization of the educational process», assessment of individual tasks of the student).

Scores for individual assignments are only awarded to the student once a commission (commission - head of department, head teacher, group teacher) only if they are successfully fulfilled and protected. The total amount of points for the CLA may not exceed 120 points.

3.5. Rules for appealing the assessment

If the student does not agree with the grade obtained in class, he can appeal it. In this case, the student's knowledge will be assessed by a commission consisting of the head or head of the department, an independent teacher and a teacher of the group in which the student is studying. To increase the grade, the group teacher may also ask the student to write an essay or complete an individual task on a chosen topic.

4. DISCIPLINE POLICY

Discipline requirements (system of requirements and rules that the teacher imposes on students of higher education in the study of the discipline)

For successful mastering the discipline it is necessary for the student of higher education systematically be prepared for practical classes, performs the tasks offered for mastering the topics recommended for self-study, read the recommended literature, take an active part in discussing the topic in class.

Attendance and behavior (inadmissibility of skipping a lesson, delays, clothing requirements, medical examination, etc.).

Attendance at practical classes in the discipline is mandatory (except for good reasons). A lesson missed by a student for any reason must be worked out. It is inadmissible to be late for classes. By the time the class begins, the student must be dressed in a medical gown. During the lesson you can not eat or drink, chew gum, contaminate the surfaces of classrooms. When communicating with the teacher and others, the student must be polite, talk quietly and behave calmly.

Use of electronic gadgets

The use of any electronic gadgets (smartphones, watches, tablets, laptops, etc.) throughout the lesson is strictly prohibited. If the teacher sees that the student violates this requirement, he can remove the student from the classroom and put him «absenteeism».

Academic Integrity Policy (including liability for breach of academic integrity)

Adherence to academic integrity by the student provides:

independent performance of educational tasks, tasks of current and final control of learning outcomes; references to sources of information in the case of the use of ideas, statements, information; compliance with copyright law; providing reliable information about the results of their own educational (scientific, creative) activities. Academic plagiarism, writing off, deception, falsification, etc. are considered violations of academic integrity.

For violation of academic integrity, students may be held subject to the following academic liability: re-assessment (test, exam, test, etc.); re-taking the training course; deductions from the educational institution.

Policy for people with special educational needs

For persons with special needs, the requirement of academic integrity is applied taking into account their individual needs and capabilities.

Recommendations for successful completion of the discipline (activity of higher education students during practical classes, fulfillment of the required minimum of educational work) to successfully complete the discipline, the applicant must complete the required minimum of educational (classroom and independent) work specified in the curriculum. The grade for the lesson also takes into account the diligence, accuracy of the student, activity in discussing the topic, speed and creativity of thinking, perseverance in learning.

Encouragement and penalties (additional points for conferences, research, edits, advice, participation in surveys)

To encourage students who are particularly active and persistent in their studies, they are awarded additional points for participating in scientific conferences, research, surveys, etc. For violation of discipline (rules of conduct, clothing, etc.) and academic integrity during classes, the student may be subject to penalties - removal from class, re-

assessment (test, exam, test, etc.); re-taking the training course; deductions from the educational institution.

Safety precautions

During the lesson, the student must follow the rules of life safety.

When conducting laboratory work or practical classes, it is necessary to follow the rules of fire safety, students need to know the location of the primary means of fire extinguishing (fire extinguisher, capes made of fire-retardant fabric, sand).

In the event of an accident, the victim or eyewitness must immediately notify the teacher. If equipment, computers, fixtures and tools malfunction, stop working and notify the instructor.

During the class, students must follow the order of laboratory work and practical classes, the rules of personal hygiene, remove foreign objects from the workplace and ensure its cleanliness.

Electrical devices and appliances, including computers, should not be left unattended. If malfunctions are found in the operation of electrical devices that are under voltage, their increased heating, sparks, the smell of burnt insulation, smoke, immediately stop work, turn off the power supply and notify the teacher.

Procedure for informing about changes in the syllabus:

the necessary changes in the syllabus are approved by the methodical commission of KhNMU on the problems of natural science training and are published on the site of KhNMU, the site of the department of medical and biological physics and medical informatics of KhNMU.

5. ACADEMIC INTEGRITY

Adherence to academic integrity by the student provides:

independent performance of educational tasks, tasks of current and final control of learning outcomes; references to sources of information in the case of the use of ideas, statements, information; compliance with copyright law; providing reliable information about the results of their own educational (scientific, creative) activities.

Academic plagiarism, writing off, deception, falsification, etc. are considered violations of academic integrity. For violation of academic integrity, students may be held subject to the following academic liability: re-assessment (test, exam, test, etc.); re-taking the training course; deductions from the educational institution.

6. RECOMMENDED LITERATURE

Basic

1. «Медична та біологічна фізика: підручник для студентів медичних ВНЗ / за ред. В.Г. Кнігавка» авторів В.Г.Кнігавко, О.В.Зайцева , М.А.Бондаренко та ін. – Харків: ХНМУ, 2017.- 354 с.
2. Medical and biological physics: Textbook for students studying the subject in English. V.G. Knigavko, O.V. Zaytseva, M.A. Bondarenko. – Kharkiv: KhNMU, 2016.- 556 p. (з грифом МОЗ)

3. Медицинская и биологическая физика: адаптированный учебник для иностранных русскоязычных студентов медицинских вузов / под. ред. В.Г. Книгавко – Харьков: ХНМУ, 2017. – 262 с.
4. «Тлумачний словник термінів з медичної та біологічної фізики» авторів В.Г.Кнігавко, О.В.Зайцева , М.А.Бондаренко та ін. –Харків: ХНМУ, 2017. – 96 с.
5. Glossary of terms on Medical and Biological Physics V.G. Knigavko, O.V. Zaytseva, M.A. Bondarenko. – Kharkiv: KhNMU, 2017.- 110 p.
6. Толковый словарь терминов по медицинской и биологической физике. В.Г. Книгавко, О.В.Зайцева , М.А.Бондаренко и др. – Харьков: ХНМУ, 2017. – 100 с.
7. Чалий О.В. та ін. Медична і біологічна фізика: Підручник для студентів вищих медичних закладів освіти III-IV рівнів акредитації.- К.:"ВІПОЛ", 1999.- С. 6-33.

Auxiliary

1. «Медична фізика. Динамічні та статистичні моделі»/ Булавін Л.А. (ред.), Гречко Л.Г., Лерман Л.Б., Чалий О.В. – К.: ВПЦ «Київський університет», 2011.
2. Ремизов А.Н.. Медицинская и биологическаяфизика. – М: Высшая школа, 1992.
3. Антонов В.Ф. и др. Биофизика. – М.: Владос, 2000.
4. Чернавский Д.С. Синергетика и информатика. М.: УРСС, 2004.
5. Чалый А.В., Цехмистер Я.В.. Флуктуационные модели процессов самоорганизации. К.: Випол, 1994.
6. Чалый А.В. Неравновесные процессы в физике и биологии. – К.: Наукова Думка, 1997.
7. «Биофизика»/Тиманюк В.А., Животова Е.Н. – Харьков, Изд-во НФАУ, 2003.
8. «Медична і біологічна фізика. Практикум»/ За ред. О.В.Чалого. – К.: Книга плюс, 2003.
9. «Біофізика»/ П.Г.Костюк (ред.), В.Л.Зима, І.С.Магура, Мірошниченко М.С., Шуба М.Ф. – К.: ВПЦ «Київський університет», 2008.
10. «Медична і біологічна фізика» / За ред. О.В.Чалого. - К. : Книга плюс, 2004.
11. «Вища математика»/ Чалий О.В., Стучинська Н.В., Меленевська А.В. – К.: Техніка,2001.

7. INFORMATION RESOURCES

educational portal
- multimedia lectures
- computer training programs

Information resources can be found at:
http://repo.knmu.edu.ua/handle/123456789/21258
http://repo.knmu.edu.ua/handle/123456789/16713

http://nmu.ua/zagalni-vidomosti/kafedri/department-medical-biological-physics/informatsiya-dlya-studentiv/

8. OTHER

Useful links:

1. Положення про запобігання, попередження та врегулювання випадків, пов'язаних із сексуальними домаганнями і дискримінацією у ХНМУ http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/polog-sex.doc
2. Положення про академічну доброчесність та етику академічних взаємовідносин в Харківському національному медичному університеті http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/polog_ad_etyka_text.pdf
3. Порядок проведення занять з поглибленого вивчення студентами Харківського національного медичного університету окремих дисциплін понад обсяг навчального плану http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/nak-poriad-pogl-vyv-dysc.docx
4. Положення про Комісію з академічної доброчесності, етики та управління конфліктами ХНМУ http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/polog_komis_ad_text.pdf
5. Положення про визнання результатів неформальної освіти в Харківському національному медичному університеті http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/polog_neform_osv.pdf
6. Інклюзивна освіта: http://www.knmu.kharkov.ua/index.php?option=com_content&view=article&id=7108%3A2021-03-10-14-08-02&catid=12%3A2011-05-10-07-16-32&Itemid=33&lang=uk
7. Академічна доброчесність: http://www.knmu.kharkov.ua/index.php?option=com_content&view=article&id=2520%3A2015-04-30-08-10-46&catid=20%3A2011-05-17-09-30-17&Itemid=40&lang=uk http://files.knmu.edu.ua:8181/upload/redakt/doc_uchproc/kodex_AD.docx