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 normative

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 222 «Medicine»
(the code and name of specialization)

Specialization (if available) _____

Educational and professional program (educational and scientific program) «Medicine»

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

_____ S.O.Krasnikova

SYLLABUS DEVELOPERS:

1. Olga Zaytseva, Acting head of the department, Professor, Doctor of
(surname, name, position, academic title, scientific degree)
Biological Sciences
2. Maryna Bondarenko, Associate Professor, Associate Professor, Candidate of
(surname, name, position, academic title, scientific degree)
Physical and Mathematical Sciences
3. Ganna Chovpan, Associate Professor, Associate Professor, Candidate of Physical
(surname, name, position, academic title, scientific degree)
and Mathematical Sciences
4. Hanna Borodkina, Associate Professor, Associate Professor, Candidate of
(surname, name, position, academic title, scientific degree)
Physical and Mathematical Sciences

INFORMATION ABOUT TEACHERS OF THE EDUCATIONAL COMPONENT

1. Surname, name, position, academic title, scientific degree:
   Zaytseva Olga Vasylivna, Acting as the head of the department, Professor, Doctor of Biological Sciences, Professor
   Link to the teacher's profile in the Moodle system:
   http://distance.knmu.edu.ua/user/profile.php?id=1616
   Contact phone: (057)707-73-67
   Corporate mail of the teacher: ov.zaitsevs@knmu.edu.ua

2. Surname, name, position, academic title, scientific degree:
   Bondarenko Maryna Anatoliyivna, Associate Professor, Associate Professor, Candidate of Physical and Mathematical Sciences
   Link to the teacher's profile in the Moodle system:
   http://distance.knmu.edu.ua/user/profile.php?id=1707
   Contact phone: (057)707-73-67
   Corporate mail of the teacher: ma.bondarenko@knmu.edu.ua

3. Surname, name, position, academic title, scientific degree:
   Borodkina Hanna Mykolayivna, Associate Professor, Associate Professor, Candidate of Physical and Mathematical Sciences
   Link to the teacher's profile in the Moodle system:
   http://distance.knmu.edu.ua/user/profile.php?id=292
   Contact phone: (057)707-73-67
   Corporate mail of the teacher: hm.borodkina@knmu.edu.ua

4. Surname, name, position, academic title, scientific degree:
   Batyuk Liliya Vasylivna, Associate Professor, Associate Professor, Candidate of Biological Sciences
   Link to the teacher's profile in the Moodle system:
   http://distance.knmu.edu.ua/user/profile.php?id=72
   Contact phone: (057)707-73-67
   Corporate mail of the teacher: lv.batyuk@knmu.edu.ua

5. Surname, name, position, academic title, scientific degree:
   Morozova Oksana Mykolayivna, senior lecturer of the department
   Link to the teacher's profile in the Moodle system:
   http://distance.knmu.edu.ua/user/profile.php?id=10101
   Contact phone: (057)707-73-67
   Corporate mail of the teacher: om.morozova@knmu.edu.ua

6. Surname, name, position, academic title, scientific degree:
   Dieiev Oleksiy Stepanovych, Associate Professor, Associate Professor, Candidate of Physical and Mathematical Sciences

Link to the teacher's profile in the Moodle system:
http://distance.knmu.edu.ua/user/profile.php?id=9950
Contact phone: (057)707-73-67
Corporate mail of the teacher: os.dieiev@knmu.edu.ua

7. Surname, name, position, academic title, scientific degree:
Rukin Oleksiy Sergiyovych, senior lecturer of the department, Candidate of Physical and Mathematical Sciences
Link to the teacher's profile in the Moodle system:
http://distance.knmu.edu.ua/user/profile.php?id=803
Contact phone: (057)707-73-67
Corporate mail of the teacher: os.rukin@knmu.edu.ua

8. Surname, name, position, academic title, scientific degree:
Utytskyh Tetyana Oleksandrivna, Associate Professor, Candidate of Technical Sciences
Link to the teacher's profile in the Moodle system:
http://distance.knmu.edu.ua/user/profile.php?id=5154
Contact phone: (057)707-73-67
Corporate mail of the teacher: tatiana.utyts@gmail.com

Professional interests:
mathematical modeling in biology and medicine
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 Informatics, 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) 222 «Medicine» and the Project of Standard of Higher Education of Ukraine (further - Standard) second (master's) level, areas of knowledge 22 «Health care», specialties 222 «Medicine».

Description of the discipline (abstract)

The course "Medical and biological physics" is offered for study by students of 1st Course and is normative. 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 **16** hours of lectures, **44** hours of practical classes, **30** 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

Name of indicators	Field of knowledge, specialty, educational degree, EPP	Characteristics of the discipline
		full-time education
Number of credits – **3,0**	Field of knowledge: 22 "Health care" (the code and name)	Normative discipline
Total number of hours - **90**	Specialty 222 «Medicine» (the code and name of specialization)	**Year of preparation (course):**
		1-st
		Semester
		1-st або 2-nd
Hours for day (or evening) form of study: classrooms – 60 hours independent student work – 30 hours	Educational degree: master EPP: 222 «Medicine»	**Lecture** – 16 hours
		Practical classes
		44 hours
		Laboratory work
		-
		Independent work
		30 hours
		Individual tasks: 0 год.
		Type of control – **differential credit**

2.1 Description of the discipline

2.2.1. Topics of lectures

№ з/п	The name of topic	Number of hours
1	Elements of theory probability. Random variables	2
2	Mechanics of fluids. Haemodynamics	2
3	Mechanical vibrations and waves. Bioacoustics.	2
4	Physical principles of electrography	2
5	Electromagnetic fields effect on biological objects	2
6	Geometrical optics. Lenses. Optical system of human eye.	2
7	Roentgen radiation and its application in medicine	2
8	Dosimetry of ionizing radiation	2
Total lecture hours		**16**

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	Elements of the theory of probability.	2
2	Random variables.	4
3	Mathematical statistics	2
4	*Control work for Section 1*	2
5	Mechanics of liquids. Some applied problems of haemodynamic.	2
6	Mechanical vibrations and waves. Bioacoustics.	2
7	*Control work for Section 2*	2
8	Transport of substances through biological membrane. Biopotentials.	
9	The physical basis of the electrography. The electrical properties of biological tissues.	2
10	Electromagnetic fields effect on biological objects.	2
11	Medical electronics	2
12	*Control work for Section 3*	2
13	Geometrical optics. Lenses. The optical system of the human eye	2
14	Optical microscopy.	2
15	Light polarization	2
16	*Control work for Section 4*	2
17	Thermal radiation	
17	X-ray radiation and its application in medicine	2
18	Dosimetry of ionizing radiation.	2
19	*Control work under Section 5*	2
21	**Differential credit**	2
Total hours of practical lessons		**34**

2.2.4. Materials for student's self-study

№ з/п	The name of topic	Number of hours
1	Basis of the differential and integral calculus. Study of the gradient of a scalar function. Differential equations of the first order with variables shared. Linear differential equations of the first-order. Methods for solving differential equations. Study of solving Bernoulli equation and the equation of Lagrange. Get an idea about the linear differential equations of higher orders with constant coefficients.	2
2	Methods of nonparametric statistics. Spearman correlation coefficient	2
3	The Fundamentals of Biomechanics Some issues and the laws of mechanics (absolutely rigid body, rotational motion, angular velocity, angular acceleration, moment of force, moment of inertia, angular momentum). Musculoskeletal of the person. Dynamic and static work of the man in various types of activities. Ergometria. Hill's equation. The method of measuring blood pressure by Korotkov. Mechanical work and power of heart. Pulse wave.	2
4	Differential equation of harmonic damping, damping, forced oscillations and their solution. The decrement and the logarithmic decrement of damping. Resonance. Vibrations. Self-oscillation. Relaxation oscillations. Umov vector. Doppler effect. Hygienic regulation of noise, infrasound, vibration levels. Support system equilibrium of the body in space. Support system equilibrium of the body in space.	2

5	Thermodynamic systems, their types. The first and second laws of thermodynamics. Hess's law. The concept of thermodynamic potentials: enthalpy, Gibbs energy, Helmholtz free energy. The Prigogine theorem, the Prigogine-Glandsdorff principle. The concept of synergy.	2
6	Biophysics of macromolecules. Nature of primary, secondary, tertiary, quaternary structure of proteins.	2
7	Magnetic field and its characteristics. Magnetic properties of substances. Biot-Savart law. Electromagnetic induction. Effects of magnetic field on biological objects. Elements of the magnetobiology. Unipolar reinforced withdrawals during electrocardiogram removal. Medical electronics. Hygienic regulations of the levels of electromagnetic fields.	2
8	Wave optics (light interference, diffraction of light, basic concepts, formulas, laws, and use in biomedical researches). Polarization of light	2
9	Scattering and dispersion of light. Elements of photometry. Objective physical characteristics of light and physiological characteristics of the subjective perception of light by eye	2
10	Photo-biological processes, their types, stages. The notion of cross-section of photochemical reaction. The range of photo-biological action. Photo sensitised photobiological processes	2
11	Spectroscopy. Emission and absorption of light by atoms and molecules. Emission and absorption spectra. Spectrophotometry	2
12	Basic concepts of quantum physics. Luminescence. Induced radiation. Lasers. Magnetic resonance. Electronic microscope. Radioactive decay of atoms. Interaction of ionizing radiation with matter.	6
13	Biophysical basis of radiobiological processes.	2
Total hours for students for self-study		**30**

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 the Table 1.

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

Table 1

4-point scale	200-point scale
5	120

4-point scale	200-point scale
3.91-3,94	94

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

4. Complex function, its differentiation
5. Derivatives of higher orders
6. Functions of several variables
7. Partial derivative functions
8. Function differential
9. Differentials of higher orders
10. Partial and complete differentials of a function
11. Application of the differential in approximate calculations
12. Gradient of the scalar function
13. Initial function
14. Indefinite integral and its properties
15. The method of integration by replacing the variable
16. Method of integration by parts
17. Defined integral
18. Newton-Leibniz formula
19. Geometric content of a definite integral
20. Differential equations:
    - definition
    - ordinary differential equations
    - differential equations in partial derivatives
    - order of differential equation
    - solution of the differential equation
21. Differential equations with separable variables
22. Differential equations homogeneous with respect to the variables *y* and **x**
23. Differential linear equations
24. Differential equations of the n_{th} order
25. Differential equations with constant coefficients
26. Random events
27. Test, test result: favorable and unfavorable
28. The relative frequency of the event, its formula
29. Statistical definition of probability, formula
30. Equivalent consequences, probable event, impossible event
31. Incompatible events, independent events, dependent events
32. Probability of a random event according to the classical definition, formula
33. The theorem for adding probabilities for incompatible events
34. Complete group of events
35. Opposite events
36. Probability multiplication theorem for independent events and for dependent events
37. Bernoulli's formula
38. The formula of total probability
39. Bayesian formula
40. Determination of a random variable
41. Discrete and continuous random variables
42. The law of distribution and the condition of normalization of a discrete random variable

43. Determination of probability density and distribution function of a continuous random variable
44. The formula for calculating the probability of getting a continuous random variable in a given interval at a known probability density
45. The formula for calculating the probability of a continuous random variable in a given interval with a known distribution function
46. Condition of normalization of a continuous random variable
47. Formulas that relate the distribution function and the probability density of a continuous random variable
48. Numerical characteristics of random variables (discrete and continuous): mathematical expectation, variance, standard deviation
49. Binomial distribution of discrete random variables (Bernoulli distribution)
50. Formulas for calculating the mathematical expectation, variance, standard deviation of a discrete random variable with a binomial distribution
51. Normal distribution of continuous random variables (Gaussian distribution):
    - the formula for the probability density of a continuous random variable
    - graph of normally distributed continuous random variable
    - influence of numerical values of parameters of normal distribution (a) and (σ) on the form and location of the graph
    - the concept of the Laplace function
    - a formula that relates the Laplace function to the distribution function of a normally distributed continuous random variable
    - formula for calculating the probability of a normally distributed continuous random variable falling into a given interval using the Laplace function
52. Definition of the basic concepts of mathematical statistics:
    - an assembly (entire and selected)
    - elements of the assembly
    - variant
53. Statistical characteristics of the population
54. Point sample estimates of mathematical expectation, variance, standard deviation, mean error
55. Interval (confidence) assessment of statistical characteristics
56. Confidence interval, confidence probability and level of significance
57. Formulas for calculating the boundaries of the reliable interval for the mathematical expectation of a normally distributed random variable with known and unknown values of the variance of the random variable
58. The concept of the null hypothesis about the probability of the difference between the average values of two sample populations
59. Simplified formula for calculating the value of T (for the case when the sample sizes are large and approximately equal to each other)
60. Correlation between random variables
61. Correlation field
62. Regression functions Y on X and X on Y, regression line, regression coefficients
63. Selective Pearson correlation coefficient, its value
64. The least squares method

65. Spearman's rank correlation coefficient
66. Definition of measurement, types of measurements
67. Measurement errors: absolute and relative
68. Measurement accuracy
69. The origin of systematic errors, their elimination
70. The origin of random errors, ways to reduce them
71. Additive and multiplicative errors
72. Methods of processing the results of direct measurements
73. Accuracy class of the device
74. Methods of processing the results of indirect measurements
75. Methods of processing the results of compatible measurements
76. Types of deformation: elastic, inelastic, highly elastic
77. Mechanical stress, allowable mechanical stress, elongation
78. Hooke's law in tensile deformation (compression)
79. Diagram of the dependence of mechanical stress on the relative elongation at tensile deformation
80. Fragile and plastic materials, Poisson's ratio
81. Shear deformation, Hooke's law for shear deformation
82. Linear and volumetric coefficients of thermal expansion
83. The concept of an absolutely solid body
84. Characteristics of uniform circular motion: angular velocity, angular acceleration;
85. The moment of force, the condition of equilibrium of the body when moving in a circle
86. The moment of inertia of a material point
87. The momentum of the body, the law of conservation of momentum
88. The musculoskeletal system of man
89. Dynamic and static human work in different types of its activities
90. Egrometry
91. Deformation properties of biological tissues
92. Anisotropy of mechanical properties of tissues
93. Muscle contraction, Hill's equation
94. Tension relaxation, creep
95. Ideal and real fluid
96. Bernoulli's equation
97. Equation of continuous flow
98. Newton's formula for the force of viscous friction
99. Viscosimetry
100. Newtonian and non-Newtonian fluids
101. Laminar and turbulent fluid flow
102. Reynolds number
103. Poiseuille's formula
104. Hydraulic resistance of the system
105. The flow of real fluid as a shear deformation
106. The main rheological characteristics and the relationship between them (shear rate, shear stress)
107. Flow curves for Newtonian and non-Newtonian fluids

108. Properties of blood as a viscoelastic fluid
109. Hematocrit index
110. Shvedov-Bingham equation, Quezon formula
111. Change in the average linear velocity of blood flow in the great circle of blood circulation
112. Change in the average for the period of the cardiac cycle blood pressure in the great circle of blood circulation
113. Work and power of the heart
114. Pulse wave
115. Clinical method of measuring blood pressure (according to Korotkov)
116. Working formulas for determining the viscosity of a liquid by the methods of Ostwald and Hess
117. Oscillatory process, its main physical characteristics
118. Classification of oscillations (undamped, damping and forced oscillations)
119. Resonance, resonant frequency
120. Forced oscillations, forced oscillating systems
121. Wave processes, their characteristics
122. General form and solution of differential equations of undamped, damping and forced oscillations
123. Logarithmic decrement of attenuation
124. Methods of measuring blood velocity in blood vessels and blood pressure (Doppler effect), electromagnetic method (electromagnetic flowmetry)
125. The system of equilibrium of the body in space
126. Acoustics, acoustic waves
127. Physical (objective) characteristics of sound
128. Physiological (subjective) characteristics of sound
129. Weber-Fechner law
130. Curves of equal volume, threshold of audibility of sound and threshold of painful sensation
131. Sound research methods (audiometry, auscultation, percussion, phonocardiography and ultrasound diagnostics)
132. Ultrasound and its use in medicine
133. Infrasound and its impact on biological objects
134. Biophysical foundations of human perception of sound
135. Hygienic normalization of noise, infrasound and vibration
136. Thermodynamic systems: isolated, closed and open
137. Internal energy of the system
138. Heat transfer (or heat transfer)
139. Amount of heat, unit of measurement (system and non-system)
140. Hess's law
141. Reversible and irreversible processes
142. The concept of entropy, its content and unit of measurement
143. The principle of non-decay of entropy
144. The first, second and third laws of thermodynamics

145. Functions of the state of a thermodynamic system (thermodynamic potentials), their formulas.
146. Enthalpy (H)
147. Gibbs free energy (G)
148. Helmholtz free energy (F)
149. The concept of chemical potential
150. The phenomenon of osmosis and its role in biological processes, osmotic pressure
151. The concept of negentropy
152. Biophysics of macromolecules
153. Levels of structural organization of proteins
154. Types of interactions of atomic groups that are part of macromolecules
155. Levels of structural organization of nucleic acids (RNA and DNA)
156. The main functions of biological membranes
157. Liquid-mosaic model of the structure of biological membranes
158. The main types of transport of substances through surface (plasma) membranes
159. Diffusion of uncharged molecules, Fick's equation
160. Diffusion through membrane pores, facilitated diffusion, exchange diffusion
161. Electrodiffusion, Nernst-Planck equation, Theorell equation
162. Electrochemical potential
163. Active transport of substances across membranes, types of ion pumps
164. Sodium-potassium pump of plasma membranes, its work
165. Calcium pump of sarcoplasmic reticulum membranes, its work
166. Proton pump of mitochondria and chloroplasts, its work
167. Membrane potential
168. Membrane potential of rest
169. Equilibrium potential of Nernst
170. Diffusion potential
171. Donnan's potential
172. Goldman-Hodgkin-Katz equation
173. Membrane permeability, formula
174. The ratio of membrane permeability for ions at rest and at excitation
175. Action potential, its generation and dissemination
176. Electric field and its characteristics (voltage and potential, the relationship between them)
177. The principle of superposition of fields
178. Electric dipole
179. Dipole moment of an electric dipole, formula
180. Characteristics of direct current (current strength, current density, resistance of the conductor, resistivity, specific conductivity)
181. Ohm's law in differential form
182. Current dipole
183. Dipole moment of a current dipole, formula
184. Multipole decomposition of the field potential formed by a system of currents
185. The main postulates of the second model of Einthoven's theory of electrocardiography

186. The concept of electrocardiogram
187. Standard assignments
188. Chest assignments
189. Reinforced leads
190. Analysis of a normal electrocardiogram in the second standard lead
191. The concept of vector cardiography
192. The concept of electroencephalography (EEG)
193. The concept of electromyography (EMG)
194. The concept of electroneurography (ENG)
195. The concept of electroretinography (ERG)
196. The concept of electrical activity of the skin
197. Electrically conductive properties of biological tissues for alternating current, their impedance and its components
198. Dependence of the tissue impedance modulus on the cyclic frequency of alternating current
199. Electrical equivalent of biological tissue
200. Dispersion coefficient, formula
201. The main mechanism of action of direct electric current on biological tissues, EMF polarization
202. Galvanization, electrophoresis, drug electrophoresis
203. Pulsed electric current, its characteristics
204. The main mechanism of action of pulsed electric current on biological tissues
205. Dubois-Raymond's law
206. Electrodiagnostics in medicine
207. Horweg-Weiss-Lapik equation, the concept of rheobase and chronaxy
208. Therapeutic techniques based on the use of pulsed current (pacing, electrosleep, electrogymnastics, defibrillation)
209. Alternating electric current, its characteristics
210. Mechanisms of action of alternating current on biological tissues depending on its frequency
211. Nernst's law at different frequencies of alternating current
212. Rheography (impedance - plethysmography)
213. Diathermy (electrosurgery), its varieties (diathermotomy and diathermocoagulation)
214. Local darsonvalization
215. The main mechanism of action of an alternating electromagnetic field on biological tissues
216. Inductothermy, UHF therapy, microwave therapy (MW and DMW therapy)
217. The effect of a constant electric field on biological tissues
218. The effect of electromagnetic radiation in the radio frequency range on biological tissues
219. Hygienic rationing of electromagnetic field levels
220. Magnetic field and its characteristics
221. Induction of a magnetic field
222. Ampere force

223. Magnetic moment
224. Lorentz force
225. Magnetic permeability, magnetic properties of substances
226. The strength of the magnetic field
227. Bio-Savar-Laplace law
228. The phenomenon of electromagnetic induction
229. Magnetic flux
230. The law of electromagnetic induction
231. The phenomenon of self-induction
232. Magnetobiology and biomagnetism
233. Magnetocardiography
234. Control and diagnostic equipment (KDA), its purpose and composition
235. Electrotherapeutic equipment, its purpose and composition
236. Cybernetic electronic devices
237. The concept of "breakdown on the body" and "leakage currents"
238. Methods of combating the danger of electric shock in the event of a breakdown on the body of the device
239. Classification of electronic devices by the value of the allowable leakage current
240. Reliability of the electronic device; the probability of trouble-free operation of the electronic device
241. Intensity of failures; curve of dependence of intensity of failures on time
242. The relationship between the probability of failure-free operation and the intensity of failures for the area of normal operation
243. Classification of medical electronic devices by the criterion of reliability
244. Electrodes and basic requirements for them
245. Classification of sensors: energy and biocontrolled
246. Types of biocontrolled sensors: generator and parametric
247. Classification of sensors on the basis of physical phenomena underlying their work
248. Sensor conversion function and its sensitivity
249. The main disadvantages and general requirements for sensors, hysteresis
250. Purpose of amplifiers and their types
251. The main characteristics of amplifiers: the formulas of the gain for AC and DC amplifiers
252. Amplitude and amplitude-frequency characteristics of alternating current amplifiers
253. The bandwidth of the AC amplifier and determine its boundaries
254. Purpose and types of generators, their application in medicine
255. Devices for display and registration of medical and biological information, their types
256. Laws of reflection and refraction of light
257. Absolute and relative refractive indices
258. The phenomenon of the extreme refraction of light, the ultimate angle of refraction

259. The phenomenon of total internal reflection, the maximum angle of total reflection
260. Fiber optics, endoscopes and laparoscopes, their use in medicine
261. Lenses and their characteristics
262. Construction of images of the object in the prefabricated and scattering lenses
263. The formula of a thin lens and the linear magnification of the object in the lens
264. Types of lens aberrations (spherical aberration, chromatic aberration, astigmatism, distortion)
265. Principles of operation of the refractometer
266. Optical microscope, the course of rays in it
267. Angular magnification of the optical system
268. Magnification of the microscope
269. Resolution of a microscope
270. The limit of resolution of the microscope (with normal and inclined incidence of rays on the subject)
271. Ways to reduce the resolution of the optical microscope
272. Ultraviolet microscope
273. Special methods of microscopy: microprojection and microphotography; dark field method; phase contrast method; polarization and fluorescence microscopy
274. Optical system of the human eye: light-conducting and light-receiving
275. Optical power of the human eye
276. The process of accommodation, the distance of the best vision
277. Construction of the image of an object in the optical system of the human eye
278. Disadvantages of light-conducting and light-receiving systems of the human eye, their correction
279. Photoreceptors, their types
280. The process of adaptation, its mechanisms
281. Angle of view, the smallest angle of view, the limit of the human eye
282. Resolution of the eye
283. Visual acuity
284. The nature of light
285. Light wave and its characteristics
286. The phenomenon of light interference
287. The phenomenon of light diffraction
288. The phenomenon of polarization of light
289. Natural light, partially polarized light, plane-polarized light
290. Polarizer and analyzer
291. Malus's law
292. Polarization of light during its reflection and refraction at the boundary of two transparent dielectrics
293. Brewster's law
294. Polarization of light in birefringence
295. The course of rays in the prism of Nicolas
296. The phenomenon of dichroism
297. The method of polarimetry and its use in medicine

298. Polarizing microscope
299. Absorption of light by matter
300. Bouguer's law
301. Natural monochromatic indicator of light absorption
302. Absorption of light by solutions
303. Bouguer-Lambert-Beer law
304. Natural molar absorption index and molar absorption index
305. Transmission coefficient and optical density of the solution
306. Absorption spectra of matter
307. Photoelectrocolorimetric determination of the concentration of solutions
308. Objective (physical) characteristics of light (energy photometric quantities): radiation flux, spectral density of radiation flux, relative spectral light efficiency (visibility function) and visibility curve
309. Subjective (physiological) characteristics of light perception (light quantities): light intensity, luminous flux, illuminance, luminosity, brightness
310. Physical and visual photometers
311. Photobiological processes, their classifications
312. General stages of photobiological processes
313. Photochemical reactions: photoionization, photoreduction, photooxidation, photodissociation, photoisomerization, photodimerization
314. Spectrum of photobiological action
315. Photosensitized photobiological processes
316. Photosensitizers of the first and second types
317. Biophysics of visual reception
318. Thermal radiation of bodies
319. Energy luminosity and spectral density of energy luminosity
320. The spectrum of thermal radiation of the body
321. Black and gray bodies
322. Kirchhoff's law
323. Stefan-Boltzmann law
324. The law of shift of Wine
325. Optical pyrometry
326. Thermal radiation of man
327. Diagnostic techniques: thermoscopy, thermometry, thermography
328. Wave properties of micoparticles
329. Wave function
330. De Broglie wavelength
331. Schrödinger's equation
332. Quantum-mechanical model of the hydrogen atom
333. Quantum numbers
334. Pauli principle
335. The ratio of Heisenberg uncertainties
336. Selection rules
337. Luminescence and its types
338. The mechanism of photoluminescence, its types (fluorescence and

339. phosphorescence)
340. Stokes' law and deviations from it (anti-Stokes luminescence)
341. Luminescence spectra
342. Luminescent analysis and its use in biomedical research
343. Spectra of absorption and radiation of substances
344. The use of emission and absorption spectroscopy in UV and visible parts of the spectrum
345. The use of absorption spectroscopy in the IR and MW parts of the spectrum
346. Induced radiation
347. The principle of operation of the helium-neon laser
348. Biological action of laser radiation
349. Types of lasers. The use of lasers in medicine
350. The phenomenon of electronic paramagnetic resonance (EPR)
351. Information carried by EPR spectra
352. Spin marks and spin probes
353. The phenomenon of nuclear magnetic resonance (NMR)
354. NMR introscopy (computer tomography (CT))
355. Electron microscope, the resolution of the electron microscope
356. Ionizing radiation, the types of ionizing radiation
357. X-rays
358. Bremsstrahlung breaking and Characteristic X-rays
359. The mechanism of Bremsstrahlung breaking X-rays
360. The minimum wavelength in the spectrum of Bremsstrahlung breaking X-rays
361. The mechanism of Characteristic X-rays
362. The spectrum of Characteristic X-rays
363. Mosley's law
364. X-ray tube
365. X-ray flux generated by an X-ray tube
366. Attenuation of the flux of monochromatic X-rays by a substance, Bouguer's law
367. Mechanisms of interaction of X-rays with matter: coherent scattering, incoherent scattering (Compton effect), photoeffect
368. The attenuation factor of X-rays, its components
369. Mass component of X-ray attenuation
370. X-ray protection
371. X-ray diagnostics (digital radiography, X-ray computed tomography (CT)) and radiotherapy
372. Radioactivity
373. Types of radioactive decay: α - decay, β^- - decay, β^+ - decay, e – capture
374. The law of radioactive decay
375. The half-life of a substance
376. Activity of a substance, units of measurement
377. Interaction of different types of ionizing radiation with matter

378. Mechanisms of interaction γ-- radiation with matter: incoherent scattering (Compton effect), photoeffect (internal and nuclear), formation of electron-positron pairs
379. Attenuation of monochromatic flux - radiation by matter, Bouguer's law
380. Characteristics of the interaction of corpuscular ionizing radiation with matter: linear ionization density, linear braking ability, average linear particle path
381. Penetrating ability of ionizing radiation
382. The negative nature of the effects of ionizing correction
383. Methods of protection against ionizing radiation
384. Radiation doses (absorbed dose, exposure dose, equivalent dose), units of measurement
385. Radiation dose rate, exposure dose rate, units of measurement
386. Hygienic rationing of radiation loads
387. Effective equivalent dose
388. Internal irradiation of a person
389. Detectors and dosimeters of ionizing radiation
390. Radionuclide diagnostics: dynamic and static methods
391. Single-photon emission computed tomography (SPECT)
392. Positron emission tomography (PET)
393. Radiation therapy and its methods
394. Modern devices for radiosurgical treatment using ionizing radiation
395. Autoradiography
396. Direct and indirect effects of ionizing radiation on DNA and other biomacromolecules
397. Oxygen effect. Oxygen growth factor
398. Types of radiation damage to cell DNA
399. Reproductive and interphase death of irradiated cells
400. Survival of irradiated cells, survival curve, its analysis

3.3. Control questions

Test questions for the final lesson № 1

1. Derivative of a function of one variable.
2. Geometric and physical contents of the derivative function of one variable
3. Properties of derivatives
4. Complex function, its differentiation
5. Derivatives of higher orders
6. Functions of several variables
7. Partial derivative functions
8. Function differential
9. Differentials of higher orders
10. Partial and complete differentials of a function
11. Application of the differential in approximate calculations
12. Gradient of the scalar function
13. Initial function
14. Indefinite integral and its properties

15. The method of integration by replacing the variable
16. Method of integration by parts
17. Defined integral
18. Newton-Leibniz formula
19. Geometric content of a definite integral
20. Differential equations:
- definition
- ordinary differential equations
- differential equations in partial derivatives
- order of differential equation
- solution of the differential equation
21. Differential equations with separable variables
22. Differential equations homogeneous with respect to the variables y and x
23. Differential linear equations
24. Differential equations of the nth order
25. Differential equations with constant coefficients
26. Random events
27. Test, test result: favorable and unfavorable
28. The relative frequency of the event, its formula
29. Statistical definition of probability, formula
30. Equivalent consequences, probable event, impossible event
31. Incompatible events, independent events, dependent events
32. Probability of a random event according to the classical definition, formula
33. The theorem for adding probabilities for incompatible events
34. Complete group of events
35. Opposite events
36. Probability multiplication theorem for independent events and for dependent events
37. Bernoulli's formula
38. The formula of total probability
39. Bayesian formula
40. Determination of a random variable
41. Discrete and continuous random variables
42. The law of distribution and the condition of normalization of a discrete random variable
43. Determination of probability density and distribution function of a continuous random variable
44. The formula for calculating the probability of getting a continuous random variable in a given interval at a known probability density
45. The formula for calculating the probability of a continuous random variable in a given interval with a known distribution function
46. Condition of normalization of a continuous random variable
47. Formulas that relate the distribution function and the probability density of a continuous random variable

48. Numerical characteristics of random variables (discrete and continuous): mathematical expectation, variance, standard deviation
49. Binomial distribution of discrete random variables (Bernoulli distribution)
50. Formulas for calculating the mathematical expectation, variance, standard deviation of a discrete random variable with a binomial distribution
51. Normal distribution of continuous random variables (Gaussian distribution):
- the formula for the probability density of a continuous random variable
- graph of normally distributed continuous random variable
- influence of numerical values of parameters of normal distribution (a) and (σ) on the form and location of the graph
- the concept of the Laplace function
- a formula that relates the Laplace function to the distribution function of a normally distributed continuous random variable
- formula for calculating the probability of a normally distributed continuous random variable falling into a given interval using the Laplace function
52. Definition of the basic concepts of mathematical statistics:
- an assembly (entire and selected)
- elements of the assembly
- variant
53. Statistical characteristics of the population
54. Point sample estimates of mathematical expectation, variance, standard deviation, mean error
55. Interval (confidence) assessment of statistical characteristics
56. Confidence interval, confidence probability and level of significance
57. Formulas for calculating the boundaries of the reliable interval for the mathematical expectation of a normally distributed random variable with known and unknown values of the variance of the random variable
58. The concept of the null hypothesis about the probability of the difference between the average values of two sample populations
59. Simplified formula for calculating the value of T (for the case when the sample sizes are large and approximately equal to each other)
60. Correlation between random variables
61. Correlation field
62. Regression functions Y on X and X on Y, regression line, regression coefficients
63. Selective Pearson correlation coefficient, its value
64. The least squares method
65. Spearman's rank correlation coefficient
66. Definition of measurement, types of measurements
67. Measurement errors: absolute and relative
68. Measurement accuracy
69. The origin of systematic errors, their elimination
70. The origin of random errors, ways to reduce them
71. Additive and multiplicative errors
72. Methods of processing the results of direct measurements
73. Accuracy class of the device

74. Methods of processing the results of indirect measurements
75. Methods of processing the results of compatible measurements.

Test questions for the final lesson № 2

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 № 3

1. The concept of chemical potential
2. The phenomenon of osmosis and its role in biological processes, osmotic pressure
3. The concept of negentropy
4. Biophysics of macromolecules
5. Levels of structural organization of proteins
6. Types of interactions of atomic groups that are part of macromolecules
7. Levels of structural organization of nucleic acids (RNA and DNA)
8. The main functions of biological membranes
9. Liquid-mosaic model of the structure of biological membranes
10. The main types of transport of substances through surface (plasma) membranes
11. Diffusion of uncharged molecules, Fick's equation
12. Diffusion through membrane pores, facilitated diffusion, exchange diffusion
13. Electrodiffusion, Nernst-Planck equation, Theorell equation
14. Electrochemical potential
15. Active transport of substances across membranes, types of ion pumps
16. Sodium-potassium pump of plasma membranes, its work
17. Calcium pump of sarcoplasmic reticulum membranes, its work
18. Proton pump of mitochondria and chloroplasts, its work
19. Membrane potential
20. Membrane potential of rest
21. Equilibrium potential of Nernst
22. Diffusion potential
23. Donnan's potential
24. Goldman-Hodgkin-Katz equation
25. Membrane permeability, formula
26. The ratio of membrane permeability for ions at rest and at excitation
27. Action potential, its generation and dissemination
28. Electric field and its characteristics (voltage and potential, the relationship between them)
29. The principle of superposition of fields
30. Electric dipole
31. Dipole moment of an electric dipole, formula
32. Characteristics of direct current (current strength, current density, resistance of the conductor, resistivity, specific conductivity)
33. Ohm's law in differential form
34. Current dipole
35. Dipole moment of a current dipole, formula
36. Multipole decomposition of the field potential formed by a system of currents
37. The main postulates of the second model of Einthoven's theory of electrocardiography
38. The concept of electrocardiogram
39. Standard assignments
40. Chest assignments
41. Reinforced leads

42. Analysis of a normal electrocardiogram in the second standard lead
43. The concept of vector cardiography
44. The concept of electroencephalography (EEG)
45. The concept of electromyography (EMG)
46. The concept of electroneurography (ENG)
47. The concept of electroretinography (ERG)
48. The concept of electrical activity of the skin
49. Electrically conductive properties of biological tissues for alternating current, their impedance and its components
50. Dependence of the tissue impedance modulus on the cyclic frequency of alternating current
51. Electrical equivalent of biological tissue
52. Dispersion coefficient, formula
53. The main mechanism of action of direct electric current on biological tissues, EMF polarization
54. Galvanization, electrophoresis, drug electrophoresis
55. Pulsed electric current, its characteristics
56. The main mechanism of action of pulsed electric current on biological tissues
57. Dubois-Raymond's law
58. Electrodiagnostics in medicine
59. Horweg-Weiss-Lapik equation, the concept of rheobase and chronaxy
60. Therapeutic techniques based on the use of pulsed current (pacing, electrosleep, electrogymnastics, defibrillation)
61. Alternating electric current, its characteristics
62. Mechanisms of action of alternating current on biological tissues depending on its frequency
63. Nernst's law at different frequencies of alternating current
64. Rheography (impedance - plethysmography)
65. Diathermy (electrosurgery), its varieties (diathermotomy and diathermocoagulation)
66. Local darsonvalization
67. The main mechanism of action of an alternating electromagnetic field on biological tissues
68. Inductothermy, UHF therapy, microwave therapy (MW and DMW therapy)
69. The effect of a constant electric field on biological tissues
70. The effect of electromagnetic radiation in the radio frequency range on biological tissues
71. Hygienic rationing of electromagnetic field levels
72. Magnetic field and its characteristics
73. Induction of a magnetic field
74. Ampere force
75. Magnetic moment
76. Lorentz force
77. Magnetic permeability, magnetic properties of substances
78. The strength of the magnetic field

79. Bio-Savar-Laplace law
80. The phenomenon of electromagnetic induction
81. Magnetic flux
82. The law of electromagnetic induction
83. The phenomenon of self-induction
84. Magnetobiology and biomagnetism
85. Magnetocardiography
86. Control and diagnostic equipment (KDA), its purpose and composition
87. Electrotherapeutic equipment, its purpose and composition
88. Cybernetic electronic devices
89. The concept of "breakdown on the body" and "leakage currents"
90. Methods of combating the danger of electric shock in the event of a breakdown on the body of the device
91. Classification of electronic devices by the value of the allowable leakage current
92. Reliability of the electronic device; the probability of trouble-free operation of the electronic device
93. Intensity of failures; curve of dependence of intensity of failures on time
94. The relationship between the probability of failure-free operation and the intensity of failures for the area of normal operation
95. Classification of medical electronic devices by the criterion of reliability
96. Electrodes and basic requirements for them
97. Classification of sensors: energy and biocontrolled
98. Types of biocontrolled sensors: generator and parametric
99. Classification of sensors on the basis of physical phenomena underlying their work
100. Sensor conversion function and its sensitivity
101. The main disadvantages and general requirements for sensors, hysteresis
102. Purpose of amplifiers and their types
103. The main characteristics of amplifiers: the formulas of the gain for AC and DC amplifiers
104. Amplitude and amplitude-frequency characteristics of alternating current amplifiers
105. The bandwidth of the AC amplifier and determine its boundaries
106. Purpose and types of generators, their application in medicine
107. Devices for display and registration of medical and biological information, their types

Test questions for the final lesson № 4

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
22. Construction of the image of an object in the optical system of the human eye
23. Disadvantages of light-conducting and light-receiving systems of the human eye, their correction
24. Photoreceptors, their types
25. The process of adaptation, its mechanisms
26. Angle of view, the smallest angle of view, the limit of the human eye
27. Resolution of the eye
28. Visual acuity
29. The nature of light
30. Light wave and its characteristics
31. The phenomenon of light interference
32. The phenomenon of light diffraction
33. The phenomenon of polarization of light
34. Natural light, partially polarized light, plane-polarized light
35. Polarizer and analyzer
36. Malus's law
37. Polarization of light during its reflection and refraction at the boundary of two transparent dielectrics
38. Brewster's law
39. Polarization of light in birefringence
40. The course of rays in the prism of Nicolas
41. The phenomenon of dichroism
42. The method of polarimetry and its use in medicine
43. Polarizing microscope
44. Absorption of light by matter
45. Bouguer's law

46. Natural monochromatic indicator of light absorption
47. Absorption of light by solutions
48. Bouguer-Lambert-Beer law
49. Natural molar absorption index and molar absorption index
50. Transmission coefficient and optical density of the solution
51. Absorption spectra of matter
52. Photoelectrocolorimetric determination of the concentration of solutions
53. Objective (physical) characteristics of light (energy photometric quantities): radiation flux, spectral density of radiation flux, relative spectral light efficiency (visibility function) and visibility curve
54. Subjective (physiological) characteristics of light perception (light quantities): light intensity, luminous flux, illuminance, luminosity, brightness
55. Physical and visual photometers
56. Photobiological processes, their classifications
57. General stages of photobiological processes
58. Photochemical reactions: photoionization, photoreduction, photooxidation, photodissociation, photoisomerization, photodimerization
59. Spectrum of photobiological action
60. Photosensitized photobiological processes
61. Photosensitizers of the first and second types
62. Biophysics of visual reception

Test questions for the final lesson № 5

1. Thermal radiation of bodies
2. Energy luminosity and spectral density of energy luminosity
3. The spectrum of thermal radiation of the body
4. Black and gray bodies
5. Kirchhoff's law
6. Stefan-Boltzmann law
7. The law of shift of Wine
8. Optical pyrometry
9. Thermal radiation of man
10. Diagnostic techniques: thermoscopy, thermometry, thermography
11. Wave properties of micoparticles
12. Wave function
13. De Broglie wavelength
14. Schrödinger's equation
15. Quantum-mechanical model of the hydrogen atom
16. Quantum numbers
17. Pauli principle
18. The ratio of Heisenberg uncertainties
19. Selection rules
20. Luminescence and its types
21. The mechanism of photoluminescence, its types (fluorescence and phosphorescence)

22. Stokes' law and deviations from it (anti-Stokes luminescence)
23. Luminescence spectra
24. Luminescent analysis and its use in biomedical research
25. Spectra of absorption and radiation of substances
26. The use of emission and absorption spectroscopy in UV and visible parts of the spectrum
27. The use of absorption spectroscopy in the IR and MW parts of the spectrum
28. Induced radiation
29. The principle of operation of the helium-neon laser
30. Biological action of laser radiation
31. Types of lasers. The use of lasers in medicine
32. The phenomenon of electronic paramagnetic resonance (EPR)
33. Information carried by EPR spectra
34. Spin marks and spin probes
35. The phenomenon of nuclear magnetic resonance (NMR)
36. NMR introscopy (computer tomography (CT))
37. Electron microscope, the resolution of the electron microscope
38. Ionizing radiation, the types of ionizing radiation
39. X-rays
40. Bremsstrahlung breaking and Characteristic X-rays
41. The mechanism of Bremsstrahlung breaking X-rays
42. The minimum wavelength in the spectrum of Bremsstrahlung breaking X-rays
43. The mechanism of Characteristic X-rays
44. The spectrum of Characteristic X-rays
45. Mosley's law
46. X-ray tube
47. X-ray flux generated by an X-ray tube
48. Attenuation of the flux of monochromatic X-rays by a substance, Bouguer's law
49. Mechanisms of interaction of X-rays with matter: coherent scattering, incoherent scattering (Compton effect), photoeffect
50. The attenuation factor of X-rays, its components
51. Mass component of X-ray attenuation
52. X-ray protection
53. X-ray diagnostics (digital radiography, X-ray computed tomography (CT)) and radiotherapy
54. Radioactivity
55. Types of radioactive decay: - decay, - decay, - decay, e – capture
56. The law of radioactive decay
57. The half-life of a substance
58. Activity of a substance, units of measurement
59. Interaction of different types of ionizing radiation with matter
60. Mechanisms of interaction -- radiation with matter: incoherent scattering (Compton effect), photoeffect (internal and nuclear), formation of electron-positron pairs
61. Attenuation of monochromatic flux - radiation by matter, Bouguer's law

62. Characteristics of the interaction of corpuscular ionizing radiation with matter: linear ionization density, linear braking ability, average linear particle path
63. Penetrating ability of ionizing radiation
64. The negative nature of the effects of ionizing correction
65. Methods of protection against ionizing radiation
66. Radiation doses (absorbed dose, exposure dose, equivalent dose), units of measurement
67. Radiation dose rate, exposure dose rate, units of measurement
68. Hygienic rationing of radiation loads
69. Effective equivalent dose
70. Internal irradiation of a person
71. Detectors and dosimeters of ionizing radiation
72. Radionuclide diagnostics: dynamic and static methods
73. Single-photon emission computed tomography (SPECT)
74. Positron emission tomography (PET)
75. Radiation therapy and its methods
76. Modern devices for radiosurgical treatment using ionizing radiation
77. Autoradiography
78. Direct and indirect effects of ionizing radiation on DNA and other biomacromolecules
79. Oxygen effect. Oxygen growth factor
80. Types of radiation damage to cell DNA
81. Reproductive and interphase death of irradiated cells
401. Survival of irradiated cells, survival curve, its analysis.

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 off. 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