MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

Petro Mohyla Black Sea National University

Medical Institute

Department of medical biology, microbiology, histology, physiology and pathophysiology

«APPROVED»
The first-vice rector
Ishchenko N.M. _____
«___» _____ 2021 p.

Course Discription

«MEDICAL AND BIOLOGICAL PHYSICS»

field of knowledge 22 «Health care»

in the specialty 222 «Medicine»

Developer	Yaremchuk O.M.	_____
Head of the Developer's Department	Korolova O.V.	_____
Guarantor of the Educational Program	Klymenko M.O.	_____
Director of the Institute	Hryshenko G.V.	_____
Head of educational and methodical department	Shkirchak S.I.	_____

Mykolaiv - 2021

1. Description of the discipline

Name of the indicator	Characteristics of discipline	
Name of discipline	Medical and biological physics	
Field of knowledge	22 "Healthcare"	
Specialty	222 "Medicine"	
Specialization (if any)		
Educational Program	Medicine	
Higher Education	Master's degree	
Discipline Status	Normative	
Course	1st course	
Academic Year	2021-2022	
Semesters' Number(s):	Full-time	Extramural
	1st	-
Total number of ECTS credits/hours	3 credits / 90 hours	
Couse structure: – lectures – practical classes – hours of independent study	Full-time 15 hours 30 hours 45 hours	Extramural
The percentage of auditor's workload	50 %	
Language of instruction		
Form of interim control (if any)		
Final control form	Exam	

2. Aim, objectives and planned learning outcomes

The aim of teaching the discipline is the formation of students system of knowledge about basic physical principles and approaches to the study of processes in wildlife, physical and technical principles of functioning of medical and technical devices used in practical dentistry, the use of mathematical methods in biomedical research which form the basis of subject competencies in medical and biological physics and is an integral part of the professional competence of the future doctor and specialists healthcare, as well as the basis for the study of professionally indicative natural and clinical disciplines in medical institutions of higher education in Ukraine.

The objectives of education/study of the discipline are gaining professional competence in practice:

- to interpret the general physical and biophysical patterns underlying the functioning of the human body;
- to explain the physical foundations and biophysical mechanisms and effects of interaction of physical fields with the human body;
- to explain the physical basics of functioning and application of modern (electronic) medical devices;
- to process the results of medical and biological studies, to prove the probability of conclusions using mathematical (statistical) methods.

Prerequisites for the study of discipline (interdisciplanary connections). Medical and biological physics as an academic discipline:

- integrates with such disciplines as medical chemistry, medical biology, and others;
- lays the physical and biophysical foundations of students' study of normal and pathological physiology, biological and bioorganic chemistry, biostatistics, histology, radiology and radiation medicine, hygiene and ecology, ophthalmology, otorinolaringology, dentistry and other disciplines.

Expected learning outcomes. As a result of studying the discipline, students have:

- **know:**

- basics of mathematical processing of medical and biological data;
- general physical and biophysical regularities underlying the processes that occur in the human body;
- characteristics of physical external factors affecting the human body and biophysical mechanisms of these influences;
- appointment and principles of electronic medical equipment, safety equipment when working with it;

- **be able to:**

- carry out mathematical and computer processing of medical and biological information;
- use medical equipment used in dentistry, diagnostics, electrostimulation and physiotherapy (in particular, in electrocardiography, reography, impedance-pleticography, audiometry, optical and quantum-mechanical devices and systems, radiometric and dosimetric control devices)

The developed program corresponds to the ***educational and professional program***

(EPP) and is focused on the formation of ***competencies:***

- ***general (GC) – GC1 EPP:***

GC1. Ability to abstract thinking, analysis and synthesis, ability to learn and master modern knowledge.

- ***professional (PC) – PC 2,3,5, EPP:***

PC2. Ability to determine the required list of laboratory and instrumental studies and assess their results.

PC3. Ability to establish a preliminary and clinical diagnosis of the disease.

PC5. Ability to determine the nature of nutrition in the treatment of diseases.

According to the educational and professional program, the expected ***program educational outcomes (PEO)*** include the skills of ***PEO1, PEO12 EPP***:

- To know how to analyze, synthesize and further modern learning. Be able to analyze information, make informed decisions, be able to acquire modern knowledge. Establish appropriate links to achieve goals. Be responsible for the timely acquisition of modern knowledge.

- To assess information about the diagnosis in the conditions of the health care institution, its subdivision, applying the standard procedure, using knowledge about a person, his organs and systems, based on the results of laboratory and instrumental studies (on the list 4).

3. Program of discipline

The organization of the educational process is carried out according to the European credit transfer and accumulation system (ECTS).

The program of academic discipline consists of:

1. Basics of mathematical processing of medical and biological data.

2. Medical and biological physics.

SECTION 1. *Basics of mathematical processing of medical and biological data.*

Topic 1. Basics of differential calculation.

Differential of a single variable function. Partial derivatives and differentials of two or more variables. Full differential.

Topic 2. Basics of cumulative calculation.

Indefinite and defined integrals. Integration by replacing the variable and parts.

Topic 3. Concept of differential equations.

Differential equations of the first order with the variables that are separated. Linear, homogeneous second-order differential equations with sustainable coefficients. Methods for solving differential equations

Topic 4. Elements of probability theory. Addition theorem and multiplication of probabilities.

Topic 5. Elements of mathematical statistics

Mathematical expectation, variance, average square deviation. Laws of distribution of random variables. Confidence probabilities and confidence intervals. Functional and correlation dependence. Regression equation. Correlation coefficient.

SECTION 2. *Medical and biological physics.*

Topic 6. Basics of biomechanics.

The basic concepts of the mechanics of translational and rotational movements. The equation of movement, the laws of preservation. Elements of biomechanics. Human musculoskeletal system. Dynamic and statistical work of a person in different types of its activities. Ergometry. Methods and devices for measuring biomechanical characteristics.

Topic 7. Fluctuation processes in living organisms. Bioacoustics.

Unspoined, suffocating and forced fluctuations. Differential equations harmonic, different, forced oscillations and their solution. Decrement and logarithmic decrement of aternation. Resonance. Auto-stabbing. Relaxation fluctuations.

Wave processes and their characteristics. Wave equation. Differential wave equation. Energy flow. Vector Condition. Doppler effect.

Hearing physics. Objective and subjective sound characteristics. Intensity, intensity level, volume, their units. Threshold of audibility and pain.

Weber-Fechner's law. Biophysical bases of auditory sensation. Physical basis of audiometry. Audiograms and curves of the same volume.

Ultrasound and infrasonic. Sources and catchers of ultrasound and infrasonic. Features of the spread and biophysical basis of ultrasound and infrasoak action on biological tissues. The use of ultrasound in medicine.

Topic 8. Superficial phenomena. Definition of CPR. Gas emboliya.

Surface tension. Surface tension coefficient. Methods for determining it. Gas emboliya. Steam in biology and medicine.

Topic 9. Biomechanics of blood circulation. Elements of heart biomechanics.

Stationary flow of liquids. The equation of continuity and the Bernoulli equation. Linear and volumetric velocity. The main equation of fluid dynamics. The flow of binding liquids. Poisale formulas. Hydraulic resistance. Methods for measuring blood pressure and circulatory rate. Pulse waves.

Topic 10. Physical foundations of hemodynamics

Internal friction, viscosity. Newton's formula for internal friction. Newtonian and Non-Nyuton liquids. Methods and devices for measuring viscosity. Laminar and turbulent fluid. Reynolds number.

Topic 11. Thermodynamic method of studying medical and biological

Systems. Thermodynamics of open systems.

Thermodynamic method of studying medical and biological systems. The first and second laws of thermodynamics, entropy, thermodynamic potentials.

Thermodynamics of open systems near equilibrium (linear law for flows and thermodynamic forces, cross-transfer processes, entropy, stream conjugence, stationary state).

Thermodynamics of open systems far from equilibrium (ordering processes in physical, chemical and medical-biological systems, concepts about synergizing). The value of thermodynamics and synergism in the problem of environmental protection.

Topic 12. Structural elements of biological membranes

Passive and active transport of substances through membrane structures.

Фізичні властивості біомембран. Рідкокристалічний стан біомембран.

Dynamic properties of membranes. Fik equation. The permeability coefficient of the membrane for a certain substance. Nernst-Plank equation. Electrochemical potential. Active

transport, main types. Molecular organization of active transport on the example of Na^+-K^+ the pump. Conjugration of streams. Diffusion rate.

Topic 13. Membrane resting potentials. The potential of action.

The nature of the membrane potential of calm (equilibral potential of Rnst, diffusion potential, stationary potential of Goldman-Hodgkin-Katz).

The potential of action. Potential of action (PA) and the cause of its occurrence. The equivalent electrical circuit of the membrane. Hodgkin-Huxley's phenomenological equations. Hodgkin-Huxley equation for the process of spreading PAP in nerve fibers. Speed and face-to-face distribution of THE in axons.

Topic 14. Radioactivity, main types and properties.

Theme 14. Radioactivity, main types and properties. Dosimetry of ionizing radiation.

Law of radioactive decay. Half-life. Activity, units of activity. Ionizing radiation, properties and basic mechanisms of interaction with biological objects. Protection against ionizing radiation. Physical and biophysical problems associated with the Chornobyl accident.

Dosimetry of ionizing radiation. Exposure and absorbed doses. Equivalent biological dose. Dose power. Units of doses and dose capacities.

Topic 15. Practical skills.

Structure of the discipline

<table>
<tr><th>Topic</th><th>Lectures</th><th>Seminars</th><th>СРС, в т.ч., індивідуальна</th></tr>
<tr><td colspan="5">UNIT 1. BASICS OF HIGHER MATHEMATICS AND BIOLOGICAL PHYSICS</td></tr>
<tr><td colspan="5">SECTION 1. Basics of mathematical processing of medical and biological data</td></tr>
<tr><td>1. Basics of differential calculation.</td><td rowspan="5">2</td><td>2</td><td>3</td><td></td></tr>
<tr><td>2. Basics of cumulative calculation.</td><td>2</td><td>3</td><td rowspan="12">Individual work - review of scientific literature or experimental research</td></tr>
<tr><td>3. Concept of differential equations.</td><td>2</td><td>3</td></tr>
<tr><td>4. Elements of probability theory. Addition theorem and multiplication of probabilities.</td><td>2</td><td>3</td></tr>
<tr><td>5. Elements of mathematical statistics.</td><td>2</td><td>3</td></tr>
<tr><td colspan="4">SECTION 2. Biological physics</td></tr>
<tr><td>6. Fundamentals of biomechanics.</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>7. Fluctuation processes in living organisms. Bioacoustics.</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>8. Surface phenomena. Definition of CPR. Gas emboliya.</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>9. Biomechanics of blood circulation. Elements of biomechanics</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>10. Physical foundations of hemodynamics</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>11. Thermodynamic method of studying medical and biological systems. Thermodynamics of open systems.</td><td>1</td><td>2</td><td>3</td></tr>
</table>

12. Structural elements of biological membranes. Passive and active transport of substances through membrane structures.	2	2	3	
13. Membrane dormant potentials. The potential of action.	2	2	3	
14. Radioactivity, main types and properties. Dosimetry of ionizing radiation.	3	2	3	
15. FINAL TEST	-	2	3	
Total – 30 hours Credits ECTS – 3	**15**	**30**	**45**	
Total – 30 hours Credits ECTS – 3	**15**	**30**	**45**	

1. Contents of the course

1.1. Lecture plan

№	TOPIC	Number of hours
1.	**Topic 1.** *Basics of differential calculation*. Elements of mathematical statistics. 1) Differential of a single variable function. 2) Partial derivatives and differentials of two or more variables. Full differential. 3) Elements of mathematical statistics.	**2**
2.	**Topic 2.** Basics of biomechanics. Fluctuation processes in living organisms. Bioacoustics. 1) Basic concepts of mechanics of translational and rotational movements. The equation of movement, the laws of preservation. Elements of biomechanics. Human musculoskeletal system. 2) Ergometry. Methods and devices for measuring biomechanical characteristics. 3) Uninhaected, suffocating and forced oscillations. Differential equations harmonic, different, forced oscillations and their solution. Wave processes and their characteristics. Wave equation. Differential wave equation. Energy flow. Hearing physics. Objective and subjective sound characteristics.	**2**
3.	**Topic 3.** Superficial phenomena. Definition of CPR. Gas emboliya. Biomechanics of blood circulation. Elements of biomechanics 1) Surface tension. Surface tension coefficient. Methods for determining it. Gas emboliya. South Africa in biology and medicine. 2) Stationary flow of liquids. The equation of continuity and the Bernoulli equation. Linear and volumetric velocity. The main equation of fluid dynamics. 3) Flow of binding liquids. Poisale formulas. Hydraulic resistance.	**2**

	Methods for measuring blood pressure and circulatory rate. Pulse waves.	
4.	**Topic 4.** Physical basis of hemodynamics. Thermodynamic method of studying medical and biological systems. Thermodynamics of open systems. 1) Internal friction, viscosity. Newton's formula for internal friction. Newtonian and Non-Nyuton liquids. Methods and devices for measuring viscosity. Laminar and turbulent fluid. Reynolds' number. 2) Thermodynamic method of studying medical and biological systems. The first and second laws of thermodynamics, entropy, thermodynamic potentials. 3) Thermodynamics of open systems near equilibrium (linear law for flows and thermodynamic forces, cross-transfer processes, entropy, contributing flows, stationary state).	**2**
5.	**Topic 5.** Structural elements of biological membranes.. 1) The physical properties of biomembrane. Liquid crystal condition of biomembrane. Dynamic properties of membranes. Fik equation. The permeability coefficient of the membrane for a certain substance. Nernst-Plank equation. Electrochemical potential. 2) The nature of the membrane potential of calm (equilibrance potential of Rnst, diffusion potential, stationary potential of Goldman-Hodgkin-Katz).	**2**
6.	**Topic 6.** Passive and active transport of substances through membrane structures. Membrane resting potentials. The potential of action. 1) Potential action. Potential of action (PA) and the cause of its occurrence. The equivalent electrical circuit of the membrane. Hodgkin-Huxley's phenomenological equations. Hodgkin-Huxley equation for the process of spreading PAP in nerve fibers. 2) Speed and features of the spread of TDs in axons.	**2**
7.	**Topic 7.** Radioactivity, main types and properties. 1) Law of radioactive decay. Half-life. Activity, units of activity. Ionizing radiation, properties and basic mechanisms of interaction with biological objects. 2) Protection against ionizing radiation. Physical and biophysical problems associated with the Chornobyl accident.	**2**
8.	**Topic 8.** Dosimetry of ionizing radiation. 1) Dosimetry of ionizing radiation. Exposure and absorbed doses. Equivalent biological dose. 2) Dose power. Units of doses and dose capacities.	**1**
TOTAL		**15**

1.2. Plan of seminars

№	TOPIC	Number of hours
1.	**Topic 1.** Basics of differential calculation.	2
2.	**Topic 2.** Basics of cumulative calculation.	2
3.	**Topic 3.** Elements of probability theory. Addition theorem and multiplication of probabilities.	2

4.	**Topic 4.** Elements of mathematical statistics.	2
	Розділ 2. Біологічна фізика	2
5.	**Topic 5.** Mechanical properties of biological tissues. Jung module.	2
6.	**Topic 6.** Biophysicals of muscle contractions. Ergometry dynamometry.	2
7.	**Topic 7.** Oscillations and waves. Sound, infrascies and ultrasound. Acoustic methods in medicine.	2
8.	**Topic 8.** Biophysicals of the organs of hearing. Audiometry.	2
9.	**Topic 9.** Superficial phenomena. Definition of CPR. Gas emboliya.	2
10.	**Topic 10.** Biomechanics of blood circulation. Elements of biomechanics	2
11.	**Topic 11.** Physical foundations of hemodynamics	2
12.	**Topic 12.** Thermodynamic method of studying medical and biological systems.	2
13.	**Topic 13.** Membrane resting potentials. The potential of action.	2
14.	**Topic 14.** Radioactivity, main types and properties. Dosimetry of ionizing radiation.	
15.	**FINAL TEST BASED ON UNIT 1**	2
РАЗОМ		**30**

1.3. Task for independent study

№	TOPIC	Number of hours
1	Preparation for practical classes (theoretical training, practical skills processing)	**42**
2	Self-study of topics that are not included in the plan of classroom classes (the list is attached)	
3	Preparation for the final test	**3**
TOTAL		**35**

1. To improve the skills of finding derivatives of simple and complex functions, differential of the function of one variable, partial derivatives, differentials of the function of two or more variables and a complete differential by doing homework. Study the issue of scalar function gradient.
2. Improve integration skills by replacing variables and parts by doing homework. Study of the geometrical content of a certain integral. Mastering the skills of calculating the area of different shapes.
3. Improve the skills of solving differential equations by doing homework. Study the solution of the Bernoulli equation and the Lagrange equation. Acquire the idea of linear differential equations of higher orders with sustainable coefficients.

4. Improve the skills of using add and multiply probability theory to solve problems by doing homework.Удосконалити навички знаходження числових характеристик випадкових вели-чин шляхом виконання домашнього завдання.
5. Learn to use methods of mathematical statistics to solve problems of a medical and biological nature. Learn the methods of nonparametric statistics.
6. Familiarize yourself with the methods of processing the results of compatible measurements
7. Elements of biomechanics. Human musculoskeletal system. Dynamic and statistical work of a person in different types of its activities. Ergometry. Methods and devices for measuring biomechanical characteristics. Deformation properties of biological tissues.
8. Vector Condition. Doppler effect.
9. Hygienic rationing of noise, infrascence, vibration levels.
10. Study of elastic properties of biological tissues
11. Investigation of the properties of the surface layer of liquid.

Common problems to solve

1. "Quiet water breaks the shores" (Folk saying). Why is the speed faster in places where the river narrows? Why do "calm water" break the shores?

2. Athlete weighing t = 70 kg jumps vertically upwards, squatting before jumping at a distance S = 30 cm. What muscular effort of the legs must develop an athlete to jump to a height of h = 60 cm? What is the repulsion time from the ground? What power N does the athlete develop when pushing? What energy is spent on the jump? Consider the movement of the center of mass of the athlete in the phase of repulsion equally accelerated.

3. From a horizontally placed medical syringe with a diameter of d = 1.5 cm is squeezed saline with a force of F = 10 N. Find the flow rate of fluids from the tip of the syringe. The density of physiological solution ρ = 103 kg / m3. Where is the greater velocity of the fluid: in the syringe barrel or in the bed of the tip? Justify the answer.

4. At rest, $V_1 \approx 85$ ml of blood per second is ejected through the aorta with a diameter of d = 2.2 cm. The average velocity of blood through the capillary of a large circle is of the order of υ = 0.3 mm / s in the tissue, which is at rest. Find the cross-sectional area of the open capillary bed. Explain why the rate of blood in the capillaries is much slower than the rate of blood in the arteries.

5. Who does not know that a horse, having fallen from a height of three or four elbows, breaks its legs, while the dog remains unharmed, if it falls with eight to ten elbows, as well as a cricket that falls from the top of the tower, or an ant that falls to the ground at least from the lunar surface." (Galileo Galilei). Why do insects, falling from a great height, remain intact, and large animals die?

5. Who does not know that a horse, having fallen from a height of three or four elbows, breaks its legs, while the dog remains unharmed, if it falls with eight to ten elbows, as well as a cricket that falls from the top of the tower, or an ant that falls to the ground at least from the lunar surface." (Galileo Galilei). Why do insects, falling from a great height, remain intact, and large animals die?

"Quiet water breaks the shores" (Folk saying). Why is the speed faster in places where the river narrows? Why do "calm water" break the shores?

1.4. Ensuring the educational process

1. Multimedia projectors, computers, screens for multimedia presentations, lecture presentations, discipline directories, descriptions of laboratory works.

2. Demonstration screens, laptops, equipment of the laboratory of medical and biological physics, files in Power Point and Word with tasks for practical and final classes.

3. Examination tickets

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5. Exam
List of questions for the exam

1. Differential of a function of one variable. Partial derivatives and differentials of functions of two or more variables. Full differential.
2. Undefined and defined integrals.
3. Differential equations 1 order Classification of phenomena. Probability of random phenomena, probability-adding theorem.
4. Probability multiplication theorem for independent random phenomena, conditional probability, probability multiplication theorem for dependent random phenomena.
5. Distribution of random phenomena, mathematical expectation, dispersion, mean quadratic deviation.
6. Basic laws of distribution of random variables (normal law, Poisson distribution, binomial distribution, etc.).
7. Deformations, their types . Elasticity and plasticity. Hook's law. Jung module. Poisson coefficient. Deformation properties of biological tissues.
8. Surface tension. Surface tension coefficient and methods of its determination. Gas emboliya.
9. Internal friction. Viscosity. Newton's formula for internal friction. Newtonian and Non-Nyuton liquids. Viscosity of blood.
10. Stationary flow of liquids. Continuity equation. Linear and volumetric velocity. The main equation of fluid dynamics.
11. Laminar and turbulent flow. Reynolds' number. Bernoulli equation. The flow of binding liquids. Poisale formula. Hydraulic resistance.
12. The main provisions of equilibrium thermodynamics. entropy. The Bolzman principle. The value of thermodynamics in the problem of environmental protection.
13. The main provisions of non-essential thermodynamics (linear law, production of entropy, contributing flows). Stationary state of open systems. Prigozhin's theorem.
14. Structural organization of biological membranes. The physical properties of biomembrane. Liquid crystal condition of biomembrane. Dynamic properties of membranes.
15. Passive transport of substances through membrane structures. Fik equation. Diffusion rate. Nernst-Plank equation. Electrochemical gradient and potential. Theorella equation.
16. Active transport, main types. Molecular organization of active transport on the example of the K-Na-pump. Conjugration of streams.
17. The nature of the membrane dormant potential (Nernst's equilibrium potentials for various ions, diffusion potential, Donnan potential).
18. The nature of the membrane dormant potential (stationary potential goldman-Hodgkin-

Katz, conditions of stationaryness, the main equations of electrodisfusion of ions in a stationary state, permeability of the membrane for ions at rest).

19. Potential action (PA). The hypothesis of the emergence of THE. The equivalent electrical circuit of the membrane. Phenomenological Hodgkin-Huxley equations. The concept of vorotni ion currents.
20. Spreading the potential of action in biological membranes. Telegraph equation. Speed of potential spread. Features of the spread of the potential of action in myelin fiber.
21. Uninhammed and forced oscillations, differential equations and their solution. Resonance. Auto-stabbing.
22. Suffocating oscillations. Differential equation of different oscillations, its solution. Coefficient of atermation, decrement and logarithmic decrement.
23. Mechanical waves. Wave equation. Energy flow. Vector Condition.
24. Acoustics. Physical characteristics of sound. Hearing physics, auditory sensation characteristics. Weber-Fechner's law.
25. Audiometry. Intensity scale and volume scale of sound, unit. Thresholds of audibility and pain. Audiogram.
26. Ultrasound. The main properties and features of the spread of ultrasound. Infrasonic, physical characteristics of infrasonic. The effect of ultrasound and infrascation on biological tissues and human organs.
27. Radioactivity. Types of radioactivity. Basic law of radioactive decay. Half-life. Activity, units of activity.
28. Ionizing radiation and its types. Interaction of ionizing radiation with substance. Protection against ionizing radiation. Biophysical bases of interaction of ionizing radiation with biological tissues.
29. Dosimetry of ionizing radiation. Exposure and absorbed doses. Biological action of radiation, biological equivalent dose. Dose power. Units of doses and dose capacities.

«0» exam variant

Petro Mohyla Black Sea National University

Level of higher education - master

Area of knowledge: 22 Health

Specialty 222 Medicine

Course - Medical and Biological Physics

Option № 0

1. Uninhammed and forced oscillations, differential equations and their solution. Resonance. Auto-stabbing. - maximum number of points - 30

2. Dosimetry of ionizing radiation. Exposure and absorbed doses. Biological action of radiation, biological equivalent dose. Dose power. Units of doses and dose capacities - maximum number of points – 30

3. Classification of phenomena. Probability of random phenomena, probability-adding theorem - maximum number of points – 20.

Approved at the meeting of the Department of "Medical Biology and Chemistry, Microbiology, Physiology, Pathophysiology and Pharmacology", the protocol № ___ from "__" _____ 2021.

The head of the department _____ is professor Korolova O.V.

Examiner _____ is Professor Chuyko G.P.

Final control work

1. At rest through the aorta with a diameter of d = 2.2 cm $V_1 \approx 85$ ml of blood per second is ejected. The average velocity of blood through the capillary of a large circle is of the order of 0.3 mm / s in the tissue, which is at rest. Find the cross-sectional area of the open capillary bed. Explain why the velocity of blood in the capillaries is much slower than the velocity of blood in the arteries.
2. 2. A capillary with a diameter of the inner channel d = 1.2 mm is lowered into the blood plasma to a very small depth. What is the mass of plasma entering the capillary if its density ρ = 1.03 g / cm3, and the surface tension σ = 73 mN / m?
3. 3. Which environments of the body have the best electrical conductivity:
   A) air in the lungs; C) adipose tissue; C) muscle tissue; D) bone tissue; E) body fluids (blood, lymph, etc.).
4. Find the derivative $$y = \frac{x^4 - 8x^2}{2\left(x^2 - 4\right)}.$$
5. Conductometry is:
   A) the method of introduction into the body through the skin of ions of the drug by means of galvanic current;
   B) method of therapeutic action on the body with direct current of low voltage (60-80 V) and low current (50 mA);
   C) directed motion of microparticles dispersed in a liquid medium under the action of an electric field;
   D) the movement of fluid through capillaries, diaphragm slits or through deposits of small particles under the action of an electric field;
   E) method of research and analysis, which is based on measuring the electrical conductivity of any liquid media (including biological ones).

Evaluation system and tools for diagnosing learning outcomes

Control methods

• Survey (testing of theoretical knowledge and practical skills).

• Test control.

• Writing a review of scientific literature (abstracts), performing individual tasks, their defense.

Current control. Testing in practical classes of theoretical knowledge and the acquisition of practical skills, as well as the results of independent work of students. Supervised by teachers according to the specific purpose of the curriculum. Assessment of the level of students' training is carried out by: surveying students, solving and analyzing physical problems, test tasks, interpreting the results of experimental and laboratory research, monitoring the acquisition of practical skills.

Intermediate control. Checking the possibility of students using the theoretical knowledge and practical skills on all topics studied, as well as the results of independent work of students. Carried out in the last lesson by section by passing practical skills, solving physical problems and testing.

The final test is carried out at the end of the study of all topics of the block at the last test of the semester.

In order to assess the learning outcomes of the entire discipline "Medical and Biological Physics" is the final control in the form of an exam.

Students who have attended all lectures, classroom classes, completed full-time independent work and scored at least 70 points in the course of study are admitted to the intermediate final control (attestation) and final control (exam). in the fall semester.

Only students who have passed both final tests in the discipline are allowed to take the exam.

Distribution of points received by students

In the autumn semester, a positive assessment in each practical session can be from 5 to 6 points. A score below 3 points means "unsatisfactory", the lesson is not credited and is subject to practice in the prescribed manner.

At the RCC, a student can get a maximum of 40 points. Control is considered credited if the student scored at least 30 points.

Assessment of student performance	
Topic 1	5
Topic 2	5
Topic 3	5
Topic 4	5
Topic 5	6
Topic 6	6
Topic 7	6
Topic 8	6
Topic 9	6
Topic 10	6
Topic 11	6
Topic 12	6
Topic 13	6
Topic 14	6
Together for the semester	80
Final control work	40
Total	120
Exam	80
Total	200

Criteria for assessing knowledge

A grade of 5-6 points in the autumn semester (A on the ECTS scale and 5 on the national scale) the student's answer is evaluated if it demonstrates deep knowledge of all theoretical positions and ability to apply theoretical material for practical analysis and has no inaccuracies.

A grade of 4 points in the autumn semester (B and C on the ECTS scale and 4 on the national scale) is answered if it shows knowledge of all theoretical provisions, the ability to apply them in practice, but some fundamental inaccuracies are allowed.

A grade of 3 points in the autumn semester (D and E on the ECTS scale and 3 on the national scale) evaluates the student's response, provided that he knows the main theoretical provisions and can use them in practice.

7. Recommended sources of information

7.1. Basic

1. Medical and biological physics: texbook for the students of higher medical establishments of the IV accred. level / Edited by Alexander V. Chalyi. - Third edition. – Vinnytsia : Nova Knyga, 2017. – 480 p.

2. Korovina L. D. Biophysics with beginnings of mathematical analysis and statistics. Extended course of lectures. – Vol. 1. Bases of mathematical analysis, probability theory and mathematical statistics. Biomechanics. / L. D. Korovina. – Poltava, 2017. – 127 p.

7.2. Secondary

1. Compendium of Medical Physics, Medical Technology and Biophysics for students, physicians and researchers. Nico A.M. Schellart. – Department of Biomedical Engineering and Physics Academic Medical Center University of Amsterdam.– Amsterdam.– 2009 (electronic book).

2. Roland Glaser. Biophysics: An Introduction. – 2010.

3. Philip Nelson. Biological Physics (Updated Edition). – 2007.

4. Paul Davidovits. Physics in Biology and Medicine, Third Edition (Complementary Science). – 2007.

5. Bengt Nölting. Methods in Modern Biophysics. – 2009.

6. Biological Physics. Energy, Information, Life. Philip Nelson, (Freeman and Company, New York, 2004).

7. Biological thermodynamics. Donald T. Haynie (Cambridge University Press, 2001).

7.3. Information resources

http://www.umsa.edu.ua/kaf_biophisik.html.