Appendix to the working program

Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation

BANK OF ASSESSMENT TOOLS FOR DISCIPLINE

« MEDICAL PHYSICS »

Training program (specialty): **31.05.03 DENTISTRY**

Department: **MEDICAL BIOPHYSICS**

Mode of study: **FULL-TIME**

Nizhniy Novgorod
2021

1. Bank of assessment tools for the current monitoring of academic performance, mid-term assessment of students in the discipline / practice

This Bank of Assessment Tools (BAT) for the discipline " Medical physics " is an integral appendix to the working program of the discipline " Medical physics ". All the details of the approval submitted in the WPD for this discipline apply to this BAT.

(Banks of assessment tools allow us to evaluate the achievement of the planned results stated in the educational program.

Assessment tools are a bank of control tasks, as well as a description of forms and procedures designed to determine the quality of mastering study material by students.)

2. List of assessment tools

The following assessment tools are used to determine the quality of mastering the academic material by students in the discipline “Medical physics”:

No.	Assessment tool	Brief description of the assessment tool	Presentation of the assessment tool in the BAT
1.	Test №1 Test №2	A system of standardized tasks that allows you to automate the procedure of measuring the level of knowledge and skills of a student.	Bank of test tasks
2.	Situational tasks	A method of control that allows you to assess the criticality of thinking and the degree of the material comprehension, the ability to apply theoretical knowledge in practice.	List of tasks
3.	Individual survey	A control tool that allows you to assess the degree of comprehension of the material	List of questions
4.	Control work	A tool of checking the ability to apply acquired knowledge for solving problems of a certain type by topic or section	Set of control tasks in variants
5.	Colloquium	A tool of controlling the mastering of study materials of a topic, section or sections of a discipline, organized as a class in the form of an interview between a teacher and students.	Questions on topics/sections of the discipline

3. A list of competencies indicating the stages of their formation in the process of mastering the educational program and the types of evaluation tools

Code and formulation of competence*	Stage of competence formation	Controlled sections of the discipline	Assessment tools
UC-1 Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy.	Current	**Section 1.** *Biomechanics.*	Situational tasks Individual survey Control work

UC-1 Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy.	Current	**Section 2.** *Molecular physics, thermodynamics.*	Situational tasks Individual survey Control work Colloquium
UC-1 Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy.	Current	**Section 3.** *Electrical properties of organs and tissues of the human body, the effect of electromagnetic fields.*	Situational tasks Individual survey Control work
UC-1 Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy.	Current	**Section 4.** *Medical optics.*	
UC-1 Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy.	Current	**Section 5.** *Physical fundamentals of medical introscopy.*	
Credit		***All Sections***	***Credit Test***

4. The content of the assessment tools of entry, current control

Entry /current control is carried out by the discipline teacher when conducting classes in the form of: Test, Situational tasks, Individual survey, Control work, Colloquium.

4.1. Tasks for the assessment of competence "UC-1" *(the competence code):*

Situational tasks

Biomechanics.

1. What additional pressure should be applied to push the air bubble formed in the blood vessel, if one meniscus of the bubble has a radius of curvature equal to 1.5 mm, and the second to 2.5 mm?

2. Determine at what velocity the flow of blood in a vessel with a radius of 1 cm will become turbulent. The critical value of the Reynolds number is 1500.

3. In the aorta of a dog with a diameter of 1.5 cm, determine the average blood flow rate, considering the kinematic viscosity coefficient equal to $5 \cdot 10^{-6}$ m^2/s, and the Reynolds number equal to 4500. (The blood flow changes from laminar to turbulent.)

4. What is the mechanical work of the right ventricle of the heart, performed during active muscle activity, if the work of a single contraction of the heart is equal to 2.4 J?

5. What is the mechanical work of a single heart contraction, if the average static pressure in the aorta is 14,000 Pa, the shock volume of blood is $6 \cdot 10^{-5}$ m^3, and the blood velocity in the aorta is 0.8 m/s?

6. Determine the wavelength for the fundamental tone having a frequency of 440 Hz, if the velocity of sound in the air is 330 m/s.

7. Find the volume of a Newtonian fluid flowing through a system of rigid cylindrical tubes in 5 minutes (see Fig. 1), if the fluid current is laminar and the dynamic viscosity coefficient is 3.14 mPa·s, r_1=2mm, $r_2 = r_3 = r_4 = 1$ mm, l_1= 2 cm, $l_2 = l_3 = l_4 = 4$ mm. (r_1, r_2, r_3, r_4 are the radii of the tubes , l_1, l_2, l_3 , l_4 are their lengths, respectively), the pressure drop in this system was $2 \cdot 10^3$ Pa.

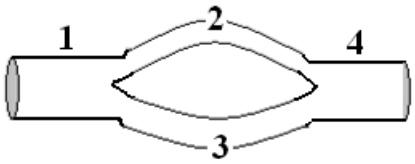

Fig. 1.

8. Find the hydraulic resistance of a rigid cylindrical tube with a diameter of 2 mm and a length of 10 cm, if there is a laminar flow of liquid through it, the viscosity coefficient of which is 0.7 mPa·s.

9. Determine at what velocity the flow of blood in a vessel with a radius of 1 cm will become turbulent. The critical value of the Reynolds number is 1500.

10. In the aorta of a dog with a diameter of 1.5 cm, determine the average blood flow rate, considering the kinematic viscosity coefficient equal to $5 \cdot 10^{-6}$ m^2/s, and the Reynolds number equal to 4500. (The blood flow changes from laminar to turbulent.)

11. The frequency range of the human ear ranges from 16 Hz to 16 kHz. Determine the long-wave range corresponding to the above – frequency, if the velocity of sound in the air is equal to 330 m/s. Find the appropriate ranges for water, whole blood, soft tissue, and bone.

12. The ultrasonic wave, with a frequency of 1 megahertz, is reflected from the surface of the heart valve, moving towards the propagation of the wave at a velocity of $6 \cdot 10^{-2}$ m/s. Determine the change in the frequency of vibrations in the reflected wave caused by the Doppler effect.

13. What is the surface tension of gasoline poured into a U-shaped capillary, if the radius of one knee is 1 mm, the second is 0.5 mm, and the difference in gasoline levels is 20 mm? (The shape of the menisci in the capillaries is considered spherical).

14. A bubble of air formed in the tube. Determine the additional pressure in the bubble if both menisci have the same radius of curvature equal to 1 mm.

15. The ultrasonic wave, with a frequency of 1.2 megahertz, is reflected from the surface of the heart valve, moving towards the propagation of the wave at a velocity of $5.8 \cdot 10^{-2}$ m/s. Determine the change in the frequency of vibrations in the reflected wave caused by the Doppler effect.

16. The ultrasonic wave, with a frequency of 1.1 megahertz, is reflected from the surface of the heart valve, moving towards the propagation of the wave at a velocity of $6.2 \cdot 10^{-2}$m/s. Determine the change in the frequency of vibrations in the reflected wave caused by the Doppler effect.

17. What is the mechanical work of the right ventricle of the heart, performed during active muscle activity, if the work of a single contraction of the heart is equal to 2.4 J?

18. What is the mechanical work of a single heart contraction, if the average static pressure in the aorta is 14,000 Pa, the shock volume of blood is $6 \cdot 10^{-5}$ m^3, and the blood velocity in the aorta is 0.8 m/s?

19. Determine the elongation, under the action of a force of 5 kN, of a rod made of steel Screw having a radius of 2 cm and a length of 50 cm. (Take the missing data from the table).

20. What are the elongation and relative deformation, under the action of a force of 7 kN, of an aluminum rod 0.5 m long having a radius of 1 cm?

21. Determine the change in the volume of a cube made of steel, if 2.6 · 106 J was spent on heating it.

22. Determine the change in the volume of a cube made of iron, if 3.4 · 106 J was spent on heating it.

23. Determine the change in the volume of a cube made of copper, if 4.2 · 106 J was spent on heating it.

24. What is the area of the sample made of dentin, which is compressed with a force of 1500 N. Consider the length of the sample equal to 3 mm, and its shortening equal to 0.015 mm. (Assume that the material under such loads obeys Hooke's law).

25. The press compresses an ebony cube having a face length of 3 mm. The compression force is equal to 2200 N. Determine the longitudinal and transverse deformations of this cube. Take the Poisson's ratio for the filling material equal to 0.3.

26. Determine by Brinell the hardness of a sample made of gold. The indenter is a steel ball; the load is 7355 N, and the diameter of the print is 2 mm. (Use units of kgf and H for the magnitude of the applied load).

27. Determine the Brinell hardness of a sample made of gold, if the test was carried out using a steel ball having a diameter of 10 mm at a load of 1764 N, and the ratio of the diameter of the imprint to the diameter of the ball (d / D) was 0.5. (Use units of kgf and H for the magnitude of the applied load).

28. Determine the Vickers hardness of a sample made of gold if the load applied to the diamond tip is equal to 294 N, and the arithmetic mean of both diagonals of the print after removing the load was 0.5 mm. (Use units of kgf and H for the magnitude of the applied load).

29. What is the Vickers hardness of a sample made of silver, if the load applied to the diamond indenter is 392 N, and the arithmetic mean of both diagonals of the print after removing the load was 0.4 mm?

30. Determine the hardness of hardened steel, if the test is performed on a Rockwell device on a scale with a diamond cone. The difference between the depth of the prints obtained from the indentation of the tip under preliminary and final loads is 0.08 mm.

31. Determine the hardness of a metal plate if the test is performed on a Rockwell device on A scale with a diamond cone. The difference between the depth of the prints obtained from the indentation of the tip under preliminary and final loads is 0.07 mm.

32. Considering the Knup hardness equal to 1000 kgf / mm2, find the depth of immersion of the indenter, as well as the force to be applied to the indenter if the length of its small diagonal is 20 microns. The answer should be given in system and non-system units.

33. Determine the hardness according to the Knoop of a sample made of plastic, if the length of the larger diagonal of the indenter is 60 microns. The answer should be given in system and non-system units.

34. Determine the length of the larger diagonal of the indenter and the depth of its immersion, if the hardness of the plastic sample determined by the Knoop was 25 kgf / mm2. The ratio of the diameter of the print to the diameter of the ball (d / D) should be equal to 0.4. (Use units of kgf and H for the magnitude of the applied load).

35. Considering the Shore hardness number of a gold sample equal to 30 kgf / mm2, find the force applied to a steel ball with a diameter of 10 mm when determining the hardness of this sample by the Brinell method, if HB = 6.5 HSh. The ratio of the diameter of the print to the diameter of the ball (d / D) should be equal to 0.5. (Use units of kgf and H for the magnitude of the applied load).

36. The Shore hardness number of the metal sample is 50 kgf/mm2. Find the force applied to a steel ball with a diameter of 10 mm when determining the hardness of this sample by the Brinell method, if HB = 7 HSh. The ratio of the diameter of the print to the diameter of the ball (d / D) should be equal to 0.5. (Use units of kgf and H for the magnitude of the applied load).

37. Determine the hardness of a sample made of gold by the Shore method, assuming that the Brinell hardness is equal to 7 HSh. The hardness test was carried out using a steel ball having a diameter of 5 mm at a load of 2650 kgf. The ratio of the diameter of the print to the diameter of the ball (d / D) should be equal to 0.5. (Use units of kgf and H for the magnitude of the applied load).

38. Find the hardness of a metal sample by the Shore method, assuming that the Brinell hardness is equal to 7 HSh. The hardness test was carried out using a steel ball having a diameter of 10 mm, with a load of 9121 kgf. The ratio of the diameter of the print to the diameter of the ball (d / D) should be equal to 0.4. (Use units of kgf and H for the magnitude of the applied load).

Medical optics.

39. Find the resolution of the microscope when illuminating an object with light with a wavelength of 600 nm, if the angle of opening of the lens is 130°. Cedar oil (n=1.5) is used as an immersion medium.

40. Calculate the magnitude of maximum velocity of photoelectrons ejected from a metallic surface illuminated by a light beam, if the work function of the metal is 2.0 eV and wavelength of light is 320 nm.

41. Calculate the magnitude of maximum velocity of photoelectrons ejected from a metallic surface illuminated by a light beam, if the work function of the metal is 2.0 eV and wavelength of light is 530 nm.

42. Find the maximum wavelength of light, which is able to cause a photoelectric effect on a dielectric surface, if the work function of the metal is 4.75 eV.

43. Find the maximum wavelength of light, which is able to cause a photoelectric effect on a dielectric surface, if the work function of the metal is 4.50 eV.

44.Determine the transmittance and optical density of a substance that is illuminated by light with an intensity of I_o = 85 W / m^2. The substance, 2 cm thick, has a concentration of 0.1 M, and the molar index χ is 450.

45.What is the intensity of light transmitted through a layer of matter with a molar concentration

of 0.4 M and a thickness of 1 cm, if the molar index χ is 500, and the intensity of the incident radiation I0 = 100 W / m^2 ?

46. How many times is the intensity of blue light scattered by an ultra-small particle greater than the intensity of red light scattered by the same particle? (Take the wavelength of blue light as 470 nm, and the wavelength of red light as 650 nm.)

47. Determine the mass concentration of sugar in the solution, if the length of the cell is 20 cm, and the angle of rotation of the plane of polarization was equal to 2°. The specific rotation of sugar is taken to be equal to A = 0.5 [degrees$\cdot m^2 \cdot kg^{-1}$].

48. Determine the angle of rotation of the polarization plane, if the mass concentration of sugar c = 20 kg / m^3, the length of the tube *l* =10 cm. The specific rotation of sugar is taken to be equal to 0.4 deg $\cdot$ m^2/kg.

49. Find the intensity of the light coming out of the analyzer, if the intensity of the light incident on the polarizer I_o = 70 W / m^2, and the angle between the main planes of the polarizer and the analyzer φ= 45°.

50.The intensity of the light passed through the analyzer-polarizer system is 27 W/m^2. What is the intensity of the light incident on the polarizer, if the angle between the main planes of the polarizer and the analyzer φ = 30°?

Molecular physics, thermodynamics.

51. What is the absolute humidity of the air at a temperature of 50 ° C and a partial vapor pressure of 20 kPa in it?

52. Determine the absolute humidity of the air at a temperature of 30 ° C and a partial vapor pressure of 15 kPa in it.

53. What is the absolute humidity of the air at a temperature of 70 ° C and a partial vapor pressure of 28 kPa in it.

54. The relative humidity of the air is 85% at a temperature of 17 ° C. What is its absolute humidity?

55. Find the absolute humidity of the air if its relative humidity at a temperature of 27 ° C is 92%.

56. What is the change in entropy when 5 g of water with an initial temperature of 5 ° C evaporates?

57. What is the change in entropy when melting 3 kg of ice having an initial temperature of 0°C?

Electrical properties of organs and tissues of the human body, the effect of electromagnetic fields.

58.What is the DC power consumed for heating the soft tissue area? The soft tissues has the following dimensions: the cross-sectional area of the circuit is 10 cm^2, a depth is 5 mm, the resistivity of the living tissues is 2 Ohms×m. The current density is 10 mA / mm^2.

59.What is the DC power consumed for heating the soft tissue area? The soft tissues has the following dimensions: the cross-sectional area of the circuit is 10 cm^2, a depth is 5 mm, the resistivity of the living tissues is 2 Ohms×m. The current density is 10 mA / mm^2.

60. In a physiological experiment a tetanizing current (triangular-shaped pulses) was used. The

pulse length τ_i is 1 ms, and the frequency is 80 Hz. What is the duty cycle of the pulses Q, the period T of their repetition rate and the duration of the pause? Draw a signal waveform.

61. In a physiological experiment an exponential current was used. The pulse duration τ_i and is 20 ms, and the repetition frequency is 50 Hz. What is the duty cycle of the pulses Q and the period of their repetition? Draw a signal waveform.

62. Determine the impedance and phase shift between the sinusoidal current and the voltage in the gum tissues, if the capacitance of the circuit section through which the current flows is 6×10^{-9} Farad, the electrical resistance is 30 kOhms, and the cyclic frequency is 2000 Hz. Consider the resistance and capacitance connected in parallel.

63. Determine the impedance and phase shift between the sinusoidal current and the voltage in the gum tissues, if the capacitance of the circuit section through which the current flows is 3×10^{-9} Farad, the electrical resistance is 60 kOhms, and the circular frequency is 2000 Hz. Consider the resistance and capacitance included in series.

64. What is the impedance and phase shift between the sinusoidal current and the voltage in soft tissues, if the capacitance of the circuit section through which the current flows is 6×10^{-9} Farad, the electrical resistance is 100 kOhms, and the circular frequency is 3000 Hz. Consider the resistance and capacitance connected in parallel.

65. Calculate the impedance and phase shift between the sinusoidal electric current and voltage, if the total capacitance in the circuit is 5×10^{-9} Farad, the electrical resistance is 100 kOhms, and the cyclic frequency is 3000 Hz. Consider the resistance and capacitance included in series.

66. What is the amount of heat released in bone tissues during UHF therapy, if the amplitude of the electric component of the UHF electromagnetic field is equal to 2000 V/m, the capacitance of the therapeutic (Lc) circuit capacitor is 3 μF, the inductance of the inductor is 3×10^{-12} Henry. (The relative dielectric permittivity of bone tissues is taken to be equal to 7.6, and the angle of dielectric losses is 30°).

67. Determine the amount of heat released in the fat layer with a relative permittivity of 8 in UHF therapy, if the angle of dielectric loss is 10°, the amplitude of the electric component of the UHF electromagnetic field is 3000 V/m. (For calculations, use a frequency equal to 40.5 MHz).

68. What is the amount of heat released in bone tissue during UHF therapy, if the relative permittivity of the tissue is 50, the angle of dielectric loss is 15°, the amplitude of the electric component of the electromagnetic field is 2500 V/m? (For calculations, use a frequency equal to 40.5 MHz).

69. Determine the amount of heat released during inductothermy in adipose tissue with a resistivity of 20 Ohms×m and in muscles with a resistivity of 2 Ohms×m. The cyclic frequency of the field oscillations is 13 MHz, the amplitude value of the magnetic induction is 0.01 T. The procedure takes 20 minutes. The results obtained should be compared with each other and analyzed. (The calculation is made according to the formula $q = t\times k\times\omega^2\times B^2_{max}/\rho$, the coefficient k is taken to be 3×10^{-7} m^2. Check the physical units of the result).

70. Determine the amount of heat released during inductothermy in dry skin with a resistivity of 10 Ohms×m and in blood with a resistivity of 2 Ohms×m. The cyclic frequency of the device used in the hospital is 13 MHz, the amplitude value of the magnetic induction is 0.01 T. The procedure takes 10 minutes. The results obtained should be compared with each other and analyzed. (The calculation is made according to the formula $q = t\times k\times\omega^2\times B^2_{max}/\rho$, the coefficient k is taken to be 2×10^{-7} m^2. Check the physical units of the result).

71. Considering the heart as a current dipole, determine the dipole moment of the heart. The distance between the source and the drain is 2 cm, and the current strength is 0.1 mA.

72. The value of the dipole moment of the current dipole is 2 mA×cm. What is the moment of the force acting on this dipole, if the angle between the direction of the dipole moment and the intensity of the external homogeneous electric field is 30°, and the intensity of this field is 50 mV/cm?

4.3. Questions for colloquiums *(the competence code UC-1,* GPC -1*):*

«Biomechanics. Study of elastic properties of bone tissue»

1. Stresses and deformations. Their types. Measures of deformations.
2. Laws of elastic deformation. Hooke's law, formula, graph. Limits of elasticity and strength.
3. Poisson's ratio. Its physical meaning, the formula of relative volume change. Examples of numerical values of the Poisson's ratio
4. Strength of materials under deformation conditions.
5. Static and dynamic loads. The concept of fatigue strength.
6. Physical properties of metals and alloys. Defects in structural materials.
7. Determination of the coefficient of linear thermal expansion. The influence of temperature, time factor, aggressive media and humidity on the characteristics of materials.
8. Mechanical methods of testing materials.

«*Biomechanics*»

1. Surface tension. Surfactants and surfactants. The phenomenon of capillarity. Gas embolism.
2. Phenomena of wetting, non-wetting, ideal wetting, edge angle. Hydrophilic and hydrophobic surfaces.
3. The equation of continuity of the jet. The Bernoulli equation. The Torricelli formula. Methods of measuring statistical, dynamic and total pressure.
4. The total pressure in the flow of the ideal liquid. A method for measuring static pressure and fluid flow velocity using pressure gauge tubes.
5. The concepts of stationary flow are laminar and turbulent flows. Lines, current surfaces (layers). Reynolds number. The critical value of the Reynolds number. Kinematic viscosity coefficient. Turbulence in the cardiovascular system.
6. Viscosity. Newton's formula. The viscosity coefficient. Newtonian and non-Newtonian fluids, examples. Blood flow rates in various departments of the Cardiovascular System (give a graph, explain qualitatively from the point of view of the continuity equation of the jet).
7. Laws of viscous fluid flow. Poiseuille formula, hydraulic resistance. The flow of viscous liquid through pipes (sequential and parallel connection of pipes). To draw an analogy with Ohm's law for a section of the chain.
8. Serial connection of the tubes, two conditions. Derive the formula for the hydraulic connection of series-connected tubes.
9. Parallel connection of the tubes, two conditions. Deduce the formula for the hydraulic connection of parallel connected tubes.
10. Methods for the determination of viscous liquid. Capillary method, Hess method, rotational viscometry. Types of viscometers, the principle of their operation. The concept of relative viscosity.
11. The phenomenon of a decrease in equivalent viscosity in small vessels. The Caisson equation. Theory of the cutting cylinder. "Coin column."
12. Stokes' law. Derive the formula for the viscosity of the liquid, the relationship of dynamic and kinematic viscosities.
13. Newton's equation. Newtonian and non-Newtonian fluids corresponding to their viscosities. Examples.
14. Describe the principle of pressure measurement by the "Korotkov Sounds" method.

15. Pulse waves, graphs of pressure fluctuations near the heart and in arterioles. Pulse wave length. Equation for pressure wave, pulse wave velocity

16. The work and power of the heart, the principle of operation of the artificial circulation apparatus.

«Molecular physics, thermodynamics»

1. Thermodynamics, basic concepts. The first law of thermodynamics. The second law of thermodynamics.

2. Reversible and irreversible processes. Carnot cycle. Thermodynamic efficiency.

3. Третий закон термодинамики. Приведенная теплота. Энтропия.

3. The third law of thermodynamics. Reduced heat. Entropy.

4. Open systems. Stationary state. The body as an open system.

5. Characteristics of thermal radiation. A completely black body. Kirchhoff's law. The spectrum of radiation of a completely black body.

6. The laws of blackbody radiation (Stefan-Boltzmann, Wine).

7. The body's thermal balance. The concept of thermography.

8. Problems on this topic.

«*Medical optics. Physical fundamentals of medical introscopy*.»

1. Geometric and wave optics. Coherence of waves. Forced radiation. Features of laser radiation. The structure and principle of operation of the laser.

2. The device of a biological microscope. Image construction in the lens, eyepiece and microscope. Derivation of the formula for linear magnification of lenses and microscopes. Characteristics of images.

3. The basic positions of Abbe's theory. Characteristics of the microscope: useful and useless magnification. Resolution and resolution distance (resolution limit). The formula of the resolution of the microscope.

4. Immersion lens. The course of the rays. The aperture angle. Numerical aperture. Advantages and purposes of using immersion.

5. Ultraviolet microscopy. Features, advantages, disadvantages.

6. Electron microscopy. The structure of an electron microscope, the structure of magnetic lenses.

7. The course of the rays in an electron microscope. The resolution limit of the electron microscope.

8. Ultramicroscopy. The course of the rays. The dark field method. Rayleigh's law.

9. Phase contrast method.

10. Polarizing microscope. Optical scheme and structure of the microscope. Use when working with histological samples.

11. The laws of refraction and reflection of light. The concept of total internal reflection. Limit angle of total reflection, limit angle of refraction.

12. The course of the rays in the optical fiber. Fiber optics and its use in medicine. Light guides. Endoscopes.

13. The optical system of the eye, its features. Accommodation. The distance of the best vision. The angle of view. The smallest angle of view. Visual acuity. Disadvantages of the optical system of the eye and their elimination. The concept of aberrations.

14. Physical fundamentals of radiology. The use of X-ray radiation in medicine. The structure of the massive anode of X-ray tubes.

15.Physical fundamentals of medical tomography. Computed tomography.

16. Problems on this topic.

4.4. Tasks (assessment tools) for the credit *(the competence code UC-1, GPC -1):*

CARD № 1

1. Subjective characteristics of sound, their connection with objective ones.
2. Stresses and deformations. Their types. Measures of deformations.
3. Determine the mass concentration of sugar in the solution, if the length of the cell is 20 cm, and the angle of rotation of the plane of polarization was equal to 2°. The specific rotation of sugar is taken to be equal to A = 0.5 [degrees·m^2 · kg^{-1}].

CARD № 2

1. The Weber-Fechner law (verbal formulation, formula, explanation; values of the audibility limit and the pain limit).
2. Ohm's law for alternating current and voltage. The total resistance (impedance) in electrical circuits containing capacitive and resistive components. The dependence of the impedance on the frequency of the current.
3. Determine by Brinell the hardness of a sample made of gold. The indenter is a steel ball; the load is 7355 N, and the diameter of the print is 2 mm. (Use units of kgf and H for the magnitude of the applied load).

CARD № 3

1. Audiogram. Audiometry. Graphs, explanations.
2. Medical polarimetry. Optical activity of substances. The structure and principle of operation of the polarimeter-saccharimeter.
3. Determine the Vickers hardness of a sample made of gold if the load applied to the diamond tip is equal to 294 N, and the arithmetic mean of both diagonals of the print after removing the load was 0.5 mm. (Use units of kgf and H for the magnitude of the applied load).

CARD № 4

1. Physical foundations of the Korotkov sound method. Physical foundations of hemodynamics.
2. Laws of elastic deformation. Hooke's law, formula, graph. Limits of elasticity and strength.
3. The intensity of the light passed through the analyzer-polarizer system is 27 W/m^2. What is the intensity of the light incident on the polarizer, if the angle between the main planes of the polarizer and the analyzer $\varphi = 30°$?

CARD № 5

1. Features of blood flow through large vessels, medium and small vessels, capillaries;
blood flow during vasoconstriction, sound effects.
2. Physical fundamentals of medical tomography. Computed tomography.
3. Determine the Brinell hardness of a sample made of gold, if the test was carried out using a steel ball having a diameter of 10 mm at a load of 1764 N, and the ratio of the diameter of the imprint to the diameter of the ball (d / D) was 0.5. (Use units of kgf and H for the magnitude of the applied load).

CARD № 6

1. Natural and polarized light. Methods of obtaining polarized light. Double refraction. Malus' law. Brewster's law. Nicolas's prism.

2. Poisson's ratio. Its physical meaning, the formula of relative volume change. Examples of numerical values of the Poisson's ratio.
3. What is the impedance and phase shift between the sinusoidal current and the voltage in soft tissues, if the capacitance of the circuit section through which the current flows is $6 \cdot 10^{-9}$ Farad, the electrical resistance is 100 kOhm, and the circular frequency is 3000 Hz. Consider the resistance and capacitance connected in parallel.

CARD № 7
1. Medical polarimetry. Optical activity of substances (examples of optically active tissues in the human body. The structure and principle of operation of the polarimeter-saccharimeter.
2. Strength of materials under deformation conditions.
3. Determine the impedance and phase shift between the sinusoidal current and the voltage in the gum tissues, if the capacitance of the circuit section through which the current flows is $3 \cdot 10^{-9}$ Farad, the electrical resistance is 60 kOhm, and the circular frequency is 2000 Hz. Consider the resistance and capacitance included in series.

CARD № 8
1. The effect of the UHF electromagnetic field on dielectric conductors. Low-frequency therapy.
2. Mechanical methods of testing materials.
3. The intensity of the light passed through the analyzer-polarizer system is 27 W/m^2. What is the intensity of the light incident on the polarizer, if the angle between the main planes of the polarizer and the analyzer $\varphi = 30°$?

CARD № 9
1. Impedance measurement. The impedance of living tissues.
2. Natural and polarized light. Methods of obtaining polarized light. Double refraction. Malus' law. Brewster's law. Nicolas's prism.
3. Determine the hardness of hardened steel, if the test is performed on a Rockwell device on a scale with a diamond cone. The difference between the depth of the prints obtained from the indentation of the tip under preliminary and final loads is 0.08 mm.

CARD № 10
1. Physical fundamentals of radiology. The use of X-ray radiation in medicine.
2. Determination of the coefficient of linear thermal expansion. The influence of temperature, time factor, aggressive media and humidity on the characteristics of materials.
3. Find the intensity of the light coming out of the analyzer, if the intensity of the light incident on the polarizer I_o = 70 W / m^2, and the angle between the main planes of the polarizer and the analyzer φ= 45°.

5. The content of the assessment tools of mid-term assessment

Mid-term assessment is carried out in the form of a credit.

5.1 The list of control tasks and other materials necessary for the assessment of knowledge, skills and work experience.

5.1.1. Questions for the discipline exam
FSES are not provided

5.1.2. Questions for the credit in the discipline “Biophysics”
https://sdo.pimunn.net/mod/resource/view.php?id=205162 – PHYSICS

Question	Competence code (according

	to the WPD)
1. DEFORMATION IS CALLED ELASTIC, WHICH, WHEN REMOVING THE MECHANICAL TENSION CAUSING DEFORMATION, 1) completely disappears and the body regains its volume and shape 2) partially disappears, but the body regains its volume 3) partially disappears and the body regains its length 4) partially disappears and the body regains its thickness	UC-1
2. DEFORMATION IS CALLED PLASTIC, WHICH, AFTER REMOVING MECHANICAL TENSION CAUSING THIS DEFORMATION, 1) is preserved completely, or partially 2) completely disappears and the body regains its volume and shape 3) partially disappears and the body regains its length 4) partially disappears and the body regains its volume	UC-1
3. PLASTIC MATERIALS ARE 1) stainless steel, rubber 2) copper, gold, brass 3) tungsten, cobalt, porcelain 4) tantalum, mercury, cements	UC-1
4. FRAGILITY IS MANIFESTED IN 1) destruction of bodies with significant deformations 2) preservation of the body volume with minor deformations 3) partial preservation of volume with significant deformations 4) destruction of bodies with minor deformations	UC-1
5. HIGHLY ELASTIC MATERIAL IS CHARACTERIZED BY 1) high modulus of elasticity and low deformation 2) inability to withstand heavy loads to rupture 3) low modulus of elasticity and large deformation 4) partial preservation of volume by the body with insignificant deformations	UC-1
6. RELATIVE DEFORMATION IS 1) a product of a change in any size of a body, under the influence of mechanical stress, and an initial size 2) a ratio of changes in any body size, under the influence of mechanical stress, to the initial value of a given size 3) a ratio of changes in any body size, under the influence of mechanical stress, to the elasticity modulus 4) a ratio of changes in any body size, under the influence of mechanical stress, to the original area	UC-1
7. HOOK'S LAW DEFINES THE FOLLOWING KIND OF DEPENDENCE BETWEEN NORMAL TENSION AND RELATIVE DEFORMATION 1) linear 2) logarithmic 3) exponential 4) sinusoidal	UC-1
8. ELASTIC RELATIVE DEFORMATION IS 1) inversely proportional to normal tensile stress or compression 2) directly proportional to the Student's coefficient 3) inversely proportional to Poisson's ratio 4) directly proportional to normal tensile stress or compression	UC-1
9. ELASTICITY LIMIT IS 1) normal mechanical stress at which deformation remains elastic 2) normal mechanical stress at which deformation ceases to be elastic 3) normal mechanical stress at which deformation ceases to change the longitudinal dimension of a sample 4) significant stress at which deformation ceases change the lateral dimension	UC-1

of a sample	
10. NORMAL TENSION IS A VALUE DEPENDING ON THE DEFORMING FORCE WHICH ACTS ON A UNIT OF THE AREA OF THE BODY CROSS-SECTION, IN THE DIRECTION 1) perpendicular to this area 2) parallel to this square 3) at an angle of 45 ° to this area 4) at an angle of 30 ° to this area	UC-1
11. MATERIAL FATIGUE IS 1) material resistance under a large cycle of loads 2) no fracture and crack propagation 3) destruction through the gradual formation of cracks and breaking the internal structure of material 4) destruction when heating	UC-1
12. A CHANGE AT THE MOMENT OF DEFORMATIONS OCCURRING IN A SAMPLE IN CASE OF PERMANENT MECHANICAL LOAD IS 1) fragility, 2) elasticity 3) creep 4) strength	UC-1
13. THE STRENGTH LIMIT IS MECHANICAL TENSION, ABOVE WHICH 1) a sample loses its plasticity 2) destruction of a loaded sample occurs 3) a sample becomes brittle 4) there is transition of elastic deformation into plastic one	UC-1
14. THE YIELD LIMIT IS MECHANICAL TENSION ABOVE WHICH 1) a sample loses its plasticity 2) destruction of a loaded sample occurs 3) a sample becomes brittle 4) there is transition of elastic deformation into plastic one	UC-1
15. A MEASURE OF THE SAMPLE RESISTANCE TO CHANGING ITS GEOMETRIC DIMENSIONS IN CASE OF NORMAL MECHANICAL TENSION IS 1) Young's modulus 2) Student's coefficient 3) Poisson's ratio 4) a viscosity coefficient	UC-1
16. A MEASURE OF CHANGING TRANSVERSE GEOMETRIC DIMENSIONS IN CASE OF NORMAL MECHANICAL TENSION IS 1) Young's modulus 2) Student's coefficient 3) Poisson's ratio 4) a viscosity coefficient	UC-1
17. POISSON'S COFFICIENT OF THE ABSOLUTELY ELASTIC SUBSTANCE (MECHANICAL PROPERTIES OF WATER CLOSE TO SUCH PROPERTIES) EQUALS 1) 0 2) 0,5 3) 1 4) π	UC-1
18. POISSON'S COFFICIENT OF THE ABSOLUTELY FRAGILE SUBSTANCE EQUALS 1) 0 2) 0.5	UC-1

3) 1 4) π	
19. THE STRENGTH LIMIT UNDER CONTINUOUS LOADING 1) decreases 2) rises 3) remains constant 4) decreases and then increases	UC-1
20. THE RATE OF STEADY MOTION OF AN ION IN A VISCOUS MEDIUM IS DETERMINED BY ITS 1) by weight 2) electric charge 3) mobility 4) radius	UC-1
21. CELL MEMBRANES HAVE 1) high dielectric constant 2) high specific electric power 3) high specific electrical inductance 4) high specific electrical capacity	UC-1
22. THE AUDIBLE SOUND FREQUENCY RANGE IS 1) 1.6 Hz - 16 Hz 2) 16 Hz - 16 MHz 3) 16 Hz - 16 kHz 4) 16 kHz - 16 MHz	UC-1
23. UNITS "W/M^2" MEASURE THE FOLLOWING ENERGY CHARACTERISTIC OF THE SOUND 1) strength 2) a flow 3) amplitude 4) intensity	UC-1
24. THE ULTRASOUND IS 1) electrical oscillation with a frequency higher than a sound 2) mechanical oscillation and waves with a frequency of less than 16 Hz 3) mechanical oscillation and waves with a frequency of more than 16 kHz 4) mechanical oscillation of molecules of a medium	UC-1
25. WHEN A TEMPERATURE REDUCES, THE VISCOSITY OF A LIQUID 1) decreases 2) increases 3) remains unchanged 4) grows quadratically	UC-1
26. UHF OSCILLATION FREQUENCY IS 1) 3 ÷ 30 MHz 2) 30 ÷ 300 MHz 3) 300 MHz ÷ 30 GHz 4) 30 GHz ÷ 3000 GHz	UC-1
27. THE CALIBRATION VOLTAGE USED IN THE ELECTROCARDIOGRAPH IS 1) 1 mV (milliVolt) 2) 1 V (Volt) 3) 1 kV (kiloVolt) 4) 1 MV (MegaVolt)	UC-1
28. THE ELECTRIC DIPOLE IS 1) a system of two bipolar electrical terminals in a conductive environment 2) a system of two bipolar electrical terminals in a dielectric medium 3) a system of two oppositely polar electric charges located in a conductive	UC-1

environment 4) a system of two oppositely polar electric charges located in a dielectric medium	
29. WITH AN INCREASE IN TEMPERATURE, A RATE OF THE THERMAL MOTION OF MOLECULES 1) decreases 2) increases 3) does not change 4) varies with viscosity	UC-1
30. IT IS KNOWN THAT BLOOD IS A NON-NEWTONIAN LIQUID. THIS IS EXPLAINED BY THE FACT THAT 1) blood cells vary in shape and size 2) blood cells move chaotically 3) blood plasma has high viscosity 4) blood corpuscles form aggregations	UC-1
31. THE SPECIFIC FEATURES OF LASER RADIATION ARE 1) monochromaticity, spectrum saturation, beam narrowness 2) monochromaticity, unidirectionality, high spectral density 3) monochromaticity, divergence, polarization 4) monochromaticity, brightness, rigidity	UC-1
32. LIGHT IS 1) an ultrasonic wave 2) a mechanical wave 3) heat radiation 4) electromagnetic radiation	UC-1
33. PHYSICAL BASIS FOR A LIVING TISSUE RHEOGRAPHY METHOD IS 1) a spectral analysis and registration of heart murmurs 2) registration of a magnetic field of the body's biocurrents 3) registration of changes in tissue impedance in the process of cardiac activities 4) measurement of tissue resistance to the direct current	UC-1
34. THE ESSENCE OF THE METHOD OF MICROWAVE THERAPY CONSISTS OF 1) heating tissues using a high-frequency magnetic field 2) heating tissues using ultra-high frequency electric field 3) heating tissues using a microwave electromagnetic range 4) heating tissues using electromagnetic waves of a EHF- range	UC-1
35. THE RATIO OF ENERGY TRANSFERRED TO THE ELEMENT OF AN IRRADIATED SUBSTANCE TO A MASS OF THIS ELEMENT IS CALLED 1) an absorbed dose 2) an exposure dose 3) an equivalent dose 4) a dose rate	UC-1
36. THE UNIT OF MEASUREMENT OF AN EQUIVALENT DOSE IN THE SI SYSTEM IS 1) gray 2) rad 3) X-ray 4) sievert 5) Cl / kg	UC-1
37. UHF OSCILLATION FREQUENCY IS 1) 3 ÷ 30 MHz 2) 30 ÷ 300 MHz 3) 300 MHz ÷ 30 GHz	UC-1

4) 30 GHz ÷ 3000 GHz	
38.THE RED LIGHT HAS WAVE LENGTHS IN THE RANGE OF 1) 380 - 730 mm 2) 620 - 700 microns 3) 620 - 700 nm 4) 380 - 730 cm	UC-1

Theoretical Questions for the test	
Question	Competence code (according to the WPD)
1. Stresses and deformations. Their types. Measures of deformations.	
2. Laws of elastic deformation. Hooke's law, formula, graph. Limits of elasticity and strength.	
3. Poisson's ratio. Its physical meaning, the formula of relative volume change. Examples of numerical values of the Poisson's ratio.	
4. Strength of materials under deformation conditions.	
5. Static and dynamic loads. The concept of fatigue strength.	
6. Physical properties of metals and alloys. Defects in structural materials.	
7. Determination of the coefficient of linear thermal expansion. The influence of temperature, time factor, aggressive media and humidity on the characteristics of materials.	
8. Mechanical methods of testing materials.	
9. Surface tension. Surfactants and surfactants. The phenomenon of capillarity. Gas embolism.	UC-1
10. Phenomena of wetting, non-wetting, ideal wetting, edge angle. Hydrophilic and hydrophobic surfaces.	UC-1
11.The equation of continuity of the jet. The Bernoulli equation. The Torricelli formula. Methods of measuring statistical, dynamic and total pressure.	UC-1
12. The total pressure in the flow of the ideal liquid. A method for measuring static pressure and fluid flow velocity using pressure gauge tubes.	UC-1
13. The concepts of stationary flow are laminar and turbulent flows. Lines, current surfaces (layers). Reynolds number. The critical value of the Reynolds number. Kinematic viscosity coefficient. Turbulence in the cardiovascular system.	UC-1
14. Viscosity. Newton's formula. The viscosity coefficient. Newtonian and non-Newtonian fluids, examples. Blood flow rates in various departments of the Cardiovascular System (give a graph, explain qualitatively from the point of view of the continuity equation of the jet).	UC-1
15. Laws of viscous fluid flow. Poiseuille formula, hydraulic resistance. The flow of viscous liquid through pipes (sequential and parallel connection of pipes). To draw an analogy with Ohm's law for a section of the chain.	UC-1
16. Serial and Parallel connections of the tubes, two conditions. Derive the formula for the hydraulic connection of series-connected tubes and parallel connected tubes.	UC-1
17. The phenomenon of a decrease in equivalent viscosity in small vessels. The Caisson equation. Theory of the cutting cylinder. "Coin column."	UC-1
18. Newton's equation. Newtonian and non-Newtonian fluids corresponding to	UC-1

their viscosities. Examples.	
18. Describe the principle of pressure measurement by the "Korotkov Sounds" method.	UC-1
19. The work and power of the heart, the principle of operation of the artificial circulation apparatus.	UC-1
20. Thermodynamics, basic concepts. The first law of thermodynamics. The second law of thermodynamics.	UC-1
21. The third law of thermodynamics. Reduced heat. Entropy.	UC-1
22. Open systems. Stationary state. The body as an open system.	UC-1
23. Characteristics of thermal radiation. A completely black body. Kirchhoff's law. The spectrum of radiation of a completely black body.	UC-1
24. The laws of blackbody radiation (Stefan-Boltzmann, Wine). The body's thermal balance.	UC-1
25. Geometric and wave optics. Coherence of waves. Forced radiation. Features of laser radiation. The structure and principle of operation of the laser.	UC-1
26. The device of a biological microscope. Image construction in the lens, eyepiece and microscope. Derivation of the formula for linear magnification of lenses and microscopes. Characteristics of images.	UC-1
27. The basic positions of Abbe's theory. Characteristics of the microscope: useful and useless magnification. Resolution and resolution distance (resolution limit). The formula of the resolution of the microscope.	UC-1
28. Immersion lens. The course of the rays. The aperture angle. Numerical aperture. Advantages and purposes of using immersion.	UC-1
29. Ultraviolet microscopy. Features, advantages, disadvantages.	UC-1
30. Electron microscopy. The structure of an electron microscope, the structure of magnetic lenses. The course of the rays in an electron microscope. The resolution limit of the electron microscope.	UC-1
31. Ultramicroscopy. The course of the rays. The dark field method. Rayleigh's law.	UC-1
32. Phase contrast method.	UC-1
33. Polarizing microscope. Optical scheme and structure of the microscope. Use when working with histological samples.	UC-1
34. The laws of refraction and reflection of light. The concept of total internal reflection. Limit angle of total reflection, limit angle of refraction.	UC-1
35. The course of the rays in the optical fiber. Fiber optics and its use in medicine. Light guides. Endoscopes.	UC-1
36. The optical system of the eye, its features. Accommodation. The distance of the best vision. The angle of view. The smallest angle of view. Visual acuity. Disadvantages of the optical system of the eye and their elimination. The concept of aberrations.	UC-1
37. Types of luminescence. Stokes' law for photoluminescence.	UC-1
38. Chemiluminescence, mechanisms of its generation, application in biomedical analysis.	UC-1
39. Passive electrical properties of living tissues. Impedance measurement. The impedance of living tissues.	UC-1
40. External low-frequency EMF of tissues, organs, biophysical fundamentals of electrocardiography.	UC-1
41. Interaction of the electrical component of the electromagnetic field with the body: biological effect of high-frequency EMF (diathermy, darsonvalization, inductothermy, laser therapy, UHF therapy, microwave therapy).	UC-1
42. Physical fundamentals of radiology. The use of X-ray radiation in medicine.	UC-1
43. Physical fundamentals of medical tomography. The structure of the massive anode of X-ray tubes. Computed tomography.	UC-1

5.1.3. The subject of term papers *(if provided by the curriculum)*
FSES are not provided

6. Criteria for evaluating learning outcomes

For the credit

Learning outcomes	**Evaluation criteria**	
	Not passed	**Passed**
Completeness of knowledge	The level of knowledge is below the minimum requirements. There were bad mistakes.	The level of knowledge in the volume corresponding to the training program. Minor mistakes may be made
Availability of skills	Basic skills are not demonstrated when solving standard tasks. There were bad mistakes.	Basic skills are demonstrated. Typical tasks have been solved, all tasks have been completed. Minor mistakes may be made.
Availability of skills (possession of experience)	Basic skills are not demonstrated when solving standard tasks. There were bad mistakes.	Basic skills in solving standard tasks are demonstrated. Minor mistakes may be made.
Motivation (personal attitude)	Educational activity and motivation are poorly expressed, there is no willingness to solve the tasks qualitatively	Educational activity and motivation are manifested, readiness to perform assigned tasks is demonstrated.
Characteristics of competence formation*	The competence is not fully formed. The available knowledge and skills are not enough to solve practical (professional) tasks. Repeated training is required	The competence developed meets the requirements. The available knowledge, skills and motivation are generally sufficient to solve practical (professional) tasks.
The level of competence formation*	Low	Medium/High

For testing:

Mark "5" (Excellent) - points (100-90%)
Mark"4" (Good) - points (89-80%)
Mark "3" (Satisfactory) - points (79-70%)

Less than 70% – Unsatisfactory – Mark "2"

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