List of Topics (Questions) for the Final Examination in Medical Biophysics, Biometrics and Computer Technology

Medical Biophysics

1. Molecular biophysics, basic terms and laws. Elementary particles, atom, electron shell, quantum numbers, Pauli exclusion principle.
2. Atomic nucleus, binding energy, mass defect, nuclear magnetic moment, magnetic resonance, nuclear magneton, gyromagnetic ratio.
7. Molecular properties of solids, types of crystals, plasma.
8. Changes of state, Gibbs’s phase rule, the triple point of water.
10. Liquids - phenomena at the interface of phases: the surface tension, surface tension measurement, adsorption, adsorption measurement.
12. Liquids - viscosity, viscosity measurement, fluid flow (real, ideal), basic laws.
15. Colligative properties of solutions, Raoult's law, ebullioscopy, Cryoscopy.
16. Colligative properties of solutions, osmosis, osmotic pressure, Pfeffer experiment, Van't Hoff law, regulation of osmosis.
17. Water and living organisms, water balance and distribution.
18. The transport mechanism of substances through the biological membranes, movement of substances in the body.
19. Stability of systems, homeostatic curve. Regulatory circuits (feedbacks), quality of a control loop (e.g. glycemic curve).
21. Structure and physical properties of biological membranes. Active and passive membrane transport.
25. The origin (source), course and propagation of the action potential. The electrical model of the cell membrane.
30. The laws of geometrical optics. The law of light reflection and light refraction.
33. Effect of infrared, visible and ultraviolet radiation on the organism.
34. Biophysics of vision: the eye, the optical path, visual cortex, visual perception (delay of visual perception).
35. The optical system of the eye.
38. Optical imaging - reflection and refraction. Lens equation, types of lenses. The basic points of the optical system. Eyeglasses. Contact lenses.
39. Biophysics of vision, a scheme of the cross section of the retina.
40. Biophysics of rods and cones. Purkynje effect, mesopic, scotopic, and photopic vision. Adaptation to light and darkness.
41. Photochemical interpretation of the vision.
42. Resolution limit of the eye, visual acuity. Snellen and Jaeger eye chart.
43. The visual field of the eye. Perimetry. The principle of spatial perception.
44. The perception of colors, the trichromatic theory, the theory of complementary colors. Color vision deficiencies.
45. Microscope, optical system and its properties.
46. The methods of the light microscopy. The phase contrast. UV microscopy, infrared microscopy, interference microscopy, fluorescence microscopy, polarized light microscopy.
48. Spectral optical methods. Spectrometer, atomic absorption spectroscopy, spectral devices based on the measurement of emissions.
49. Fluorescent methods. Fluorometry.
50. Nephelometry and turbidimetry.
51. Refractometry, polarimetry.
52. Basic characteristics of sound: height, color (timbre), intensity, intensity level, and loudness level. Hearing field.
55. Electrical phenomena accompanying the irritation of the hearing organ, formation of the action potentials.
56. Methods of testing hearing losses. The basic types of hearing impairment.
60. Laminar and turbulent flow. Reynolds number. The effect of viscosity on the flow of fluids. Examples.
61. Biophysics of blood circulation, model of blood circulation at rest and during exercise.
62. Blood pressure. The mechanism of systolic and diastolic blood pressure formation. Pressure curve, mean (effective) blood pressure.
64. Function of the cardiac pump. Starling's principle and Laplace law. Cardiac volumes, ejection fraction, cardiac output, cardiac index.
65. Work and power of the heart. Factors affecting systemic arterial blood pressure. Preload, contractility, afterload.
66. Arterial hemodynamics. The courses of DV, EDV, SV, cardiac fiber shortening. The mechanical properties of blood vessels and blood.
67. Direct and indirect measurement of blood pressure, accuracy of the measurement, various types (approaches) of the measurement.
69. Henry's law, examples. Mechanics of breathing, inspiration and expiration
70. Lung volumes and capacities.
71. The viscoelastic properties of the lung and the chest, breathing resistance.
72. Distribution of gases in the body and their partial pressures, the exchange of respiratory gases via alveolocapillary membrane and its structure.
73. Spontaneous breathing. Artificial ventilation.
74. Methods of spirometry. Spirometry with closed and open circuit.
75. Restrictive and obstructive ventilation disorders. Basic characteristics and clinical examples.
76. Electric current in a gas, vacuum, electric current in electrolytes (Faraday's law). Utilization in medicine.
78. Electrostatic field, basic laws. Coulomb's law, the effect of relative permittivity on the membrane ion permeability.
79. Principle of ECG. Excitation and heart conduction system. The electric field of the heart. Einthoven triangle.
81. Vectorcardiography, phonocardiography, other methods of measuring the heart activity.
82. Electroencephalography, localization and characterization of the basic activities, their ontogenesis, evoked potentials. Electromyography, types of electrodes.
83. Conduction of the electrical current in the body, the speed of propagation, transmission at synapses. Laws of excitability, I (t) curve, rheobasis and chronaxie.
84. Effects of electric current on the body, the measurement of skin impedance.
85. Iontophoresis and galvanizing, electrotherapy by alternating and intermittent currents (TENS, MENS, HVPS, LVPS, IFC). Electrostimulation, electro-shock, high-frequency therapy. High-frequency electrotherapy.
88. Physical properties of ultrasound. Sources of ultrasonic waves - mechanical, piezoelectric, magnetostrictive and their use. Describe the characteristics of ultrasonic field.
89. The physical parameters describing the characteristics of the ultrasonic field and the environment in which it is spreading. The absorption of ultrasound energy. Reflection and refraction of ultrasonic waves.
90. The principle of ultrasound imaging, imaging modes. Types of ultrasonic probes.
91. Doppler effect. Doppler ultrasound systems, principles and applications in medicine.
94. Nuclear magnetic resonance tomography. Larmor frequency, the principle of resonance phenomena, relaxation times. Applications in medicine.
95. Origin and types of X-ray radiation and its properties.
97. X-ray imaging methods.
102. Methods of nuclear medicine. SPECT, PET. Principle of positron emission tomography.
103. The basic dosimetric quantities. Personal dosimetry. Effects of ionizing radiation on the body.
104. Radiotherapy
105. Effect of heat and cold on the body. Thermometry. Temperature measurement of the body core, skin temperature measurement, temperature measurement of internal organs. Temperature measurement. Thermometers, thermography, thermal imaging.
106. Interaction of laser radiation with skin. Types of lasers used in medicine.
109. Biomechanics of bones and joints. Testing of mechanical properties, the load curve.
110. Mechanical characteristics: elasticity, strength, thermal expansion, shape memory.
111. The thermal expansion, thermal conductivity of solids.
112. Measurement of physical quantities - measurement errors, measurement accuracy. Processing of measurement results.
113. Comparative method of an emitter activity measurement, calculation of the linear attenuation coefficient from given values of a beta radiation absorption.
114. Method of a beta radiation absorption curve measurement.
115. Function of the Geiger-Müller counter and its basic parameters.
116. Spectrophotometric measurement of a solution concentration, physical characteristics of the light.
117. Measurement of viscosity with the Stokes viscosimeter.
118. Measurement of the liquid surface tension.
119. Measurement of the skin impedance, and its real (resistance) and imaginary (capacity) component.
120. Measurement of the body temperature, difference between the digital thermistor and mercury thermometer.
121. Measurement of the blood flow velocity in arteries using ultrasound.
122. ECG recording, main leads, ECG trace waves, calculation of the heart rate from the given record, construction of the electric heart axis from the given ECG record.
123. Principle of distance (thickness) measurement of anatomical structures by ultrasound.
124. Ophthalmoscopy.
126. Determination of unknown radioactive emitter using the nuclear differential energy.
127. Audiometry, audiogram, air and bone conduction examination, the reason of dB scale usage.
128. Short Increment Sensitivity Index - recruitment measurement of hearing.
129. Examination of the visual field with automated perimeter.
130. Foetal age estimation by ultrasound scanning, methods of scanning, used frequencies.
131. Stochastic and deterministic effects of ionizing radiation.
132. Electretinography.

Biometrics
1. Classification of statistics and basic statistical terms. Types of data and charts.
3. Evaluation of the diagnostic screening methods. ROC analysis.
4. Measure of central value (arithmetic mean, median, mode). Measure of variability (variation range, variance and standard deviation, coefficient of variation, percentiles and quartile).
5. The probability of random event. The rules for calculating probabilities. Total probability theorem.
6. Theoretical models of distributions: uniform, binomial, Poisson, normal (Gaussian), standard normal, exponential.
7. Statistical decision. Hypothesis testing. Errors in hypothesis testing.
8. Parametric tests (Student's t-test: one-tailed, paired and two-tailed).
10. Analysis of variance (ANOVA).

Computer Technology
1. Classical Information Theory, Shannon’s Formula for Uncertainty
2. Binary number system, bits and bytes
3. Representation of Characters, ASCII
4. Computer Memory, Data Mining
5. Basic Types of Software, system software, operating systems, programming software, application software
6. Personal Computers: desktop computers, laptops, tablets, PDAs,
7. Von Neumann Architecture, Components of Personal Computer
8. Internet - Electronic information resources, electronic mail, antivirus protection principles
9. Essentials of image analysis

The exam enrollment must be strictly carried out via STAG (university study system).
Prior to the enrollment, each student must be granted course credits for both the winter and summer practical training.
During examination, the student must not leave the room.
Calculators, mobile phones or other electronic devices are prohibited. No bags, books or other study materials can be placed on a desk.
Each student has to prove his identify with an actual ID card (passport is highly recommended, the student’s book is not acceptable because of easy photo removal).