Department of Biological and Medical Physics and Medical Informatics

Discipline "Medical and Biological Physics"

Specialties: 7.110101 – Medical care

7.110106 – Dentistry

WORKING CURRICULUM OF THE DISCIPLINE “MEDICAL AND BIOLOGICAL PHYSICS”

(Developed on the basis of the standard curriculum of 2010)

Module 1. The mathematical procession of medical and biological data.

Content modules:

Basics of the mathematical analysis.
Basics of the probability theory and mathematical statistics.

Module 2. Basics of biophysics.

Content modules:

Basics of biomechanics, bioacoustics, biorheology and hemodynamics.
Thermodynamics of biological systems.
Biophysics of membrane processes.

Module 3. Basics of medical physics.

Content modules:

Electrodynamics, its medical application. Basics of the medical apparatus.
Optical methods and their application in biology and medicine.
Quanto-mechanical methods of researches.
Radiation physics. Basics of dosimetry.

he structure preparation plan of the subject "Medical and biological physics" for students of medical faculties with the specialty "Medical care".

Structure of the educational discipline	Number of hours, out of them				Year of study	Types of control
	In total hours/ credits	Class hours		Independent work of a student		
		Lectures	Practical lessons			
	135/4,5	10	70	55	1	
Module 1 *Content modules 2* Final control of the module assimilation	46/1,5	6	22	18		Final test control. Control of practical skills
Module 2 *Content modules 3* Final control of the module assimilation	34/1	4	18	12		Final test control. Control of practical skills
Module 3 *Content modules 4* Final control of the module assimilation	55/2		30	25		Final test control. Control of practical skills

1 ECTS credit– 30 год. Classroom academic load – 66,7%, independent work of a student – 33,3%.

PROGRAM CONTENT

Module 1. Mathematical processing of medical-biological data.

Content module 1. Basics of the mathematical analysis.

Topic 1. Basics of the differential calculus.

The differential of a function of one variable. Partial derivatives and differentials of functions of two or more variables. Total differential. The usage of a differential in approximate calculations.

Topic 2. Basics of the integral calculus.

Indefinite and definite integrals. Integration by means of change of variables and by parts.

Topic 3. The notion about differential equations.

Differential equations of the first order with variables which are separated. Linear differential equations of the first order. Methods of solving differential equations.

C**ontent module 2.** Basics of the probability theory and mathematical statistics

Topic 4. Elements of the probability theory.

Theorems of addition and multiplication of probabilities. Formulas of Bernoulli, of the complete probability, of Bayes.

Topic 5. Random variables.

Discrete and continuous random variables. Numerical characteristics of random variables. Laws of distribution of random variables.

Topic 6. **Elements of the mathematical statistics.**

Selective evaluations of the statistical characteristics of the general population. The reliable interval for the mathematical expectation. The evaluation of the probability of the difference of two sample averages. Basics of the correlation and regression analysis.

Topic 7. The processing of measurement results.

Direct, indirect and compatible measurements. Errors.

Module 2. Basics of the biological physics.

Content module 3. Basics of biomechanics, bioacoustics, biorheology and hemodynamics.

Topic 8. Basics of mechanics and biomechanics.

Basic notions and laws of mechanics of the forward and rotary motions. Conservation laws. Basics of the material science. Hooke's Law. Young's modulus and Poisson ratio. Fluidity and relaxation of voltage.

Topic 9. Basics of hydrodynamics, biorheology and hemodynamics.

Ideal and real liquid. The Bernoulli equation and the continuity of the jet. Viscosity. Laminar and turbulent flow. Newton's formula for the viscous friction. Viscosimetry. Reynolds number. Poiseuille formulas. Hydraulic head. Basic notions of biorheology. The flow of viscous liquids. Rheological properties of blood. Shvedov-Binghan and Kesson models. Blood circulation in the circulatory system.

Topic 10. Mechanical vibrations and waves. Bioacoustics.

Undamped, damped and forced oscillations. The differential equation of harmonic, damped, forced oscillations and their solutions. The damping and logarithmic decrement. Resonance, vibration. Self-oscillations. Relaxation oscillations.

Wave processes and their characteristics. The wave equation. The differential wave equation. The flow of energy.

Objective and subjective sound characteristics. Intensity, a level of intensity, volume, their units. The threshold of sensitivity and pain. Weber-Fechner law. Biophysical basics of the auditory sensation. Physical principles of audiometry. Audiogram and curves of equal volume. Ultrasound and infrasound. Sources of ultrasound and infrasound. Features of distribution and the biophysical basis of ultrasound and infrasound on a biological tissue. The application of ultrasound in medicine.

Content module 4. Biological thermodynamics. Thermodynamics. Elements of molecular biophysics.

Content module 5. Biophysics of membranes.

Theme 12. Biophysics of membranes.

Structural elements of biological membranes. Physical properties of biomembranes. Liquid-crystalline status of biomembranes.

The passive transportation of substances through the membrane structure.

The Fick equation. The permeability coefficient of a membrane for the certain substance. The Nernst-Planck equation. Active transportation, basic types.

Resting and action potentials of membranes.

The nature of membrane resting potential. The Goldman-Hodgkin-Katz equation.

The action potential (AP) and the mechanisms of its occurrence. The speed and features of distribution of AP in axons.

Module 3. Basics of medical physics.

Content module 6. Electrodynamics. Basics of medical electronics.

Topic 13. Effects of electric currents or electromagnetic fields on biological objects. Magnetic phenomena. Elements of magnetobiology. (in 3 parts, including laboratory work)

Electrical properties of biological tissues and liquids. Constant electric current, its characteristics, the mechanism of action on biological tissues. Galvanization and medical electrophoresis. Pulsed electric current, its characteristics, the mechanism of action on biological tissues. The Du Bois-Reymond Law. Electrodiagnostics. The Weiss-Lapicque equation. Electrostimulation. Electric sleep. Electroanalgesia. Defibrillation. Alternating electric current, its characteristics, the mechanism of action on biological tissues. The Nernst law. Impedance of biological tissues. Rheography. Diathermy. Electrosurgery. The main characteristics of the electromagnetic field. Effects of electromagnetic fields on biological tissues. Inductothermy. UHF-therapy. Microwave and decimeter-wave therapy.

Magnetic field and its characteristics. Magnetic properties of substances. The Biot-Savart-Laplace law. Electromagnetic induction. Effects of magnetic fields on biological objects. Bio-magnetism.

Topic 14. Medical electronics. Physical and biophysical basics of rheography. (in 2 parts)

Tasks of medical electronics. The classification of the electronic medical equipment. The general scheme of control and diagnostic equipment. The general scheme of an apparatus for physical therapy. Electrodes and sensors. Amplifiers of electrical signals, their main characteristics. Devices of the display and registration of medical information. The electrical safety and reliability of electronic medical equipment. Capacitive properties of biological tissues. The electrical equivalent of biological tissues. The dependence of the tissue impedance on the current frequencies. Rheography.

Topic 15. The concept of electrography of organs and tissues. (in 2 parts)
Physical and biophysical basics of electrocardiography. The Einthoven model (biophysical interpretation of the electrocardiography).
Registration of medical information. Electrical safety and reliability of the electronic medical equipment.

Content module 7. Optical methods and their application in biology and medicine.

Topic 16. Elements of geometric optics. Optical refractometry. (in 2 parts)
Lenses. The optical system of an eye. Laws of light reflection and refraction. The complete light reflection. Refractometry.

Topic 17. Optical microscopy. Wave optics. The interaction of light and substance (in 2 parts)
Optical microscopy. Main features of a microscope. Special methods of the microscopy. The Bouguer law. Light absorption by solutions, the Bouguer-Lambert-Beer law. Concentration colorimetry.

Topic 18. Light polarization. (in 2 parts)
Light polarization. The Malus law. Optically active substances. Birefringence. Polarization at the light reflection and refraction. The Nicol prism. Concentration polarimetry.

Content module 8. Elements of quantum physics and its application in medicine.

Topic 19. Basic notions and laws of the quantum physics. Spectroscopy. Heat radiation of bodies, its characteristics.
Wave properties of microparticles, the de Broglie formula, wave function and its physical meaning, the Heisenberg uncertainty relation. The Schrödinger equation. A quantum-mechanical model of a hydrogen atom. Quantum numbers. Energy levels. The Pauli principle. The emission and absorption of light by atoms and molecules. Emission and absorption spectra. Spectrophotometry.
Absolutely black and gray bodies. The Kirchhoff's law. The laws of black body radiation, the Planck's radiation law, the Stefan-Boltzmann law, the Wien's displacement law. The heat radiation of a human's body. The notion about thermography.

Topic 20. Luminescence. Elements of photobiology. Electronic microscope.
Luminescence. The main types of photobiological processes. Stages of photobiological processes. The concept of an electronic microscope

Topic 21. Resonance methods of quantum mechanics. Induced radiation.
Resonance methods of quantum mechanics. Nuclear magnetic resonance, electron paramagnetic resonance, their application in medicine (NMR tomography, etc.). Lasers.

Topic 22. Photometry. Energy photometric values. The level of sensation. Relative

spectral luminous efficiency of monochromatic radiation. Luminocity coefficient. Luminous flux. Luminous intensity. Lightness. Emittance. Brightness.

Content module 9. Ionizing radiation. Basics of dosimetry.

Topic 23. X-ray radiation.

Types of ionizing radiations. Continuous and characteristic X-ray radiation. Mechanisms and laws of interaction of X-rays with the substance. Protection against X-ray radiation. The application of use of X-ray radiation in medicine.

Topic 24. Radioactivity. Ionizing radiation and its dosimetry. Elements of radiobiology.

Radioactivity. Ionizing radiation and its interaction with the substance and its application in medicine. Dosimetry.

The approximate structure of the test credit – *module 1:* ***The mathematical procession of medical-biological data.***

Topic	Lectures	Practical classes	Independent work of a student	Individual work
Content module 1. Basics of the mathematical analysis				
1. Basics of the differential calculation.	0	2	2	
2. Basics of the integral calculation.	–	2	2	
3. The notion about differential equations.	–	2	3	
Content module 2. Basics of the probability theory and of the mathematical statistics.				
4. Elements of the probability theory.	2	4	3	
5. Random values.	2	4	3	
6. Elements of the mathematical statistics. Laboratory work.	2	4	2	
7. The procession of the results measurements		2	3	
Hours in total – 46	6	22	18	
ECTS credits– 1,5				
	Classwork – 61%		Independent work of a student - 39%	

The approximate structure of the test credit – *module 2****: Basics of biological physics.***

Topic	Lectures	Practical classes	Independent work of a student	Individual work
Content module 3. Basics of biomechanics, bioacoustics, biorheology and hemodynamics.				
8. Basics of mechanics and biomechanics.		2	4	
9. Basics of hydrodynamics, biorheology and hemodynamics. Laboratory work.		4		
10. Mechanical fluctuations and waves. Bioacoustics. Laboratory work. Ultrasound and infrasound. Laboratory work.	2	6	2	
Content module 4. Thermodynamics of open biological systems. Elements of molecular biophysics				
11. Biological thermodynamics. Elements of molecular biophysics.		2		
Content module 5. Biophysics of membranes.				
12. Biophysics of membranes.		2		
Hours in total - 34	4	18	12	
ECTS credits– 1,0	Classwork – 65%		**Independent work of a student–** 35%	

The approximate structure of the test credit – *module 3****: Basics of medical physics.***

Topic	Lectures	Practical classes	Independent work of a student	Individual work
Content module 6. Electrodynamics. Basics of medical electronics.				
13. The influence of electric currents and electromagnetic fields on biological objects. Magnetic phenomena. Elements of magnetobiology.		4	2	
14. Medical electronics. Physical and biophysical basics of rheography.		4		
15. The notion about electrography of organs and tissues.		2	6	
Content module 7. Optical methods and their application in medicine and biology**.**				
16. Elements of geometric optics. Optical refractometry.	6	2	6	
17. Optical miscroscopy. Wave optics. The interaction of light and substance.		2		
18. Light polarization. Laboratory work.		2		
Content module 8. Elements of quantum physics and its application in medicine.				
19. Main notions and laws of quantum physics. Spectroscopy. Heat radiation, its characteristics.	4	2	2	
20. Luminescence. Elements of photobiology. Electronic microscope		2	4	
21. Resonance methods of quantum mechanics. Induced radiation.		2	1	
22. Photometry.		**2**	**2**	
Content module 9. Ionizing radiation. Basics of dosiometry.				
23. X-ray radiation.	4	2		
24. Radioactivity. Ionizing radiation and its dosiometry. Elements of radiobiology.		2	6	
Hours in total – 55		30	25	

ECTS credits– 2				
	Classwork – 55%		Independent work of a student – 45%	

SUBJECT PLAN OF THE DISCIPLINE

№	T O P I C	Number of hours
	Subject plan of lectures of Module 1	
1	Elements of the probabilistic theory.	2
2	Random values.	2
3	Basics of mathematical statistics.	2
I N	**T O T A L**	**6**
	Subject plan of lectures of Module 2	
4	Basics of biorheology and hemodynamics. Membranes. Mechanism of the substance transportation through membrane cells. Biopotentials.	2
5	Bioacoustics.	2
I N	**T O T A L**	**6**

SUBJECT PLAN OF PRACTICAL LESSONS

№	T O P I C	Number of hours
	Subject plan of practical lessons from Module 1	
1	Basics of the differential calculus (a differential, partial derivatives, total differential, the usage of differentials in approximate calculations).	2
2	**Basics of the integral calculus (**indefinite and definite integrals, methods of integration).	2
3	Differential equations (linear equations of the first order)	2
4, 5	Elements of the probability theory	2
6, 7	Random values.	2
8	Basics of mathematical statistics.	2
9	The study of the correlation dependency between random values.	2
10	The processing of measurement results.	2
11	Test work in higher mathematics (the final control of knowledge of Module 1).	2
IN	**T O T A L**	**18**

Subject plan of practical lessons from Module 2

12	Biomechanics. Basics of material science.	2
13	Mechanical fluctuations and waves	2
14	Bioacoustics (seminar).	2
15	The definition of spectral characteristics of the hearing aid of a person on the threshold of sensitivity(laboratory work).	2
16	Basics of biorheology and hemodynamics (seminar).	2
17	The definition of the liquid viscosity by Ostwald and Hess viscometers (laboratory work).	2
18	Biological thermodynamics. Macromolecule biophysics.	2
19	The transportation of substances via cell membranes. Biopotential (seminar).	2
20	The control of practical skills (the final control of knowledge of Module 2).	2
IN	**T O T A L**	**18**

Subject plan of practical lessons from Module 3

№.	**Name of the lesson**	**Number of hours**
21	The influence of electrical currents and electromagnetic fields on biological objects. Magnetic phenomena. The elements of magnetobiology (seminar, part 1).	2
22	The influence of electrical currents and electromagnetic fields on biological objects. Magnetic phenomena. The elements of magnetobiology (seminar, seminar, part 2).	2
23 24	1. Medical electronics (seminar). 2. The study of electrical properties of biological tissues (laboratory work).	2
25 26	1. The physical basics of electrocardiography (seminar). 2. The study of the cardiograph operation (laboratory work).	2
27	The definition of ions mobility by means of electrophoresis. The definition of the operation of an apparatus for UHF-therapy (laboratory work).	2
28 29	1. Optics (seminar, part 1 «Eye»). 2. The determination of the solutions concentration by means of a refractometer (laboratory work).	2
30 31	1. Optics (seminar, part 2 «Microscope»). 2. Photometry.	2
32 33	1. Polarization 2. The determination of the solutions concentrations by means of a concentration saccharometer (laboratory work).	2
34	Basic notions and laws of quantum physics. Spectroscopy. Heat radiation of bodies, its characteristics.	2
35	Luminescence. Elements of photobiology. Electronic microscope.	2
36	Resonance methods of quantum mechanics. Induced radiation	2
37	Photometry	2
38	Ionizing radition. (seminar).	2

№.	Name of the lesson	Number of hours
39	Dosimetry (seminar).	2
40	The control of practical skills (the final control of knowledge of Module 3).	2
I N T O T A L		**30**
IN TOTAL		**70**

Subject plan of practical lessons from Module 3

SUBJECT PLAN OF THE INDEPENDENT (INDIVIDUAL) WORK OF STUDENTS

№	TOPIC	Кількість годин
	Subject plan of the independent (individual) work of students upon Module 1	
1	To improve skills of finding the derivatives of simple and composite functions, a function differential of one variable, partial derivatives, function differentials of two and more variables and the total differential by means of doing the homework. The study of the scalar function gradient .	7
2	To improve the skills of integration by means of the variable change and by parts by means of doing the homework. The study of geometrical content of the defined integral. Mastering the skills of calculation of squares of different figures.	
3	To improve the skills of solving differential equations by means of doing the homework. To study the matters of solutions of the Bernoulli and Lagrange equations. To obtain the image about linear differential equations of higher order with constant coefficients.	
4	To improve the skills of applying theorems of probability addition and multiplication by means of doing the homework.	3
5	To improve the skills of finding numerical characteristics of random variables by means of doing the homework	5 3
6	To learn how to use the methods of mathematical statistics for solving tasks of biomedical nature. To master the methods of nonparametric statistics.	
7	To get acquainted with the methods of processing the results of joint measurements	
	I N T O T A L	**18**
	Subject plan of the independent (individual) work of students upon Module 2	
8	Elements of biomechanics. Human's musculoskeletal system. Dynamical and statistical work of a person at different types of activities. Ergometry. Methods and devices for measuring biomechanical characteristics. Deformation properties of biological tissues.	4
9	The Umov vector. The doppler effect.	2
10	Hygienic rationing of levels of noise, infrasound, vibration.	6
I N T O T A L		**12**

Subject plan of the independent (individual) work of students upon Module 3

11	The concept of electroencephalography and other electrographic methods	2
12	The Umov-Pointing vector. The concept of bias current. The electrostatic field of high voltage. Franklinization. Hygienic regulation of electric and magnetic fields	2
13	Metrological health service.	6
14	Basic notions and formulas of wave optics.	2
15	Light scattering. Nephelometry. Light dispersion.	4
16	Basic notions of radiobiology and radiation medicine.	1
17	Hygienic regulation of photometric values.	2
18	Photoeffect and its application in medicine.	6
I N T O T A L		**25**
	I N T O T A L	**55**

The distribution of points assigned to students

№	Module (current testing)	Quantity of points
	Module 1	
1	**Content module 1**	
	Topic 1	12
	Topic2	12
	Topic 3	12
2	**Content module 2**	
	Topic 4	24
	Topic 5	24
	Topic6	24
	Topic 7	12
	Content modules in total	120
	Independent (individual) work of students	-
	I N T O T A L	120
	Final control of the module assimilation	80
	Sum of points for the study of Module 1 I N T O T A L	**200**
	Module 2	
3	**Content module 3**	
	Topic 8	15
	Topic 9	30
	Topic 10	45
4	**Content module 4**	
	Topic 11	15
5	**Content module 5**	
	Topic 12	15

	Content modules in total	120
	Independent (individual) work of students	-
	I N T O T A L	120
	Final control of the module assimilation	80
	Sum of points for the study of Module 2 I N T O T A L	**200**

	Module 3	
6	**Content module 6**	
	Topic 13	12
	Topic 14	6
	Topic 15	12
	Topic 16	6
	Topic 17	6
7	**Content module 7**	
	Topic 18	12
	Topic 19	6
	Topic 20	12
	Topic 21	6
8	**Content module** 8	
	Topic 22	6
	Topic 23	6
9	**Content module 9**	
	Topic 24	6
	Topic 25	6
	Topic 26	6
	Topic 27	6
	Content modules in total	114
	Independent (individual) work of students	6
	I N T O T A L	120
	Final control of the module assimilation	80
	Sum of points for the study of Module 3 I N T O T A L	**200**
	Sum of points for the study of the discipline I N T O T A L	**600**

The distribution of points assigned for students from the Medical-Biological Faculty
(135 hours, 4,5 credits)

For Module 1: grade "5" is converted into 12 points;
"4" – into 10 points;
"3" – into 7 points;
"2" – into 0 points.

For Module 2: grade "5" is converted into 15 points;
"4" – into 12 points;
"3" – into 9 points;

"2" – into 0 points.

For Module 3: grade " 5" is converted into 8 points;
"4" – into 7 points;
"3" – into 5 points ;
"2" – into 0 points.

Additionally 8 points are given for the execution of the individual work

The minimal quantity of points which a student must obtain *for the module control*:

The unified scale of points for students

ECTS grade	Qunatity of points
A	180-200
B	160-179
C	150-159
D	130-149
E	120-129
Fx	Repetitive task
F	Obligatory repetitive course of study

ESTS grade is converted into the 4-point grading scale in the following way:

ESTS grade	Grade by the 4-point grading scale
A	5
B,C	4
D,E	3
Fx, F	2