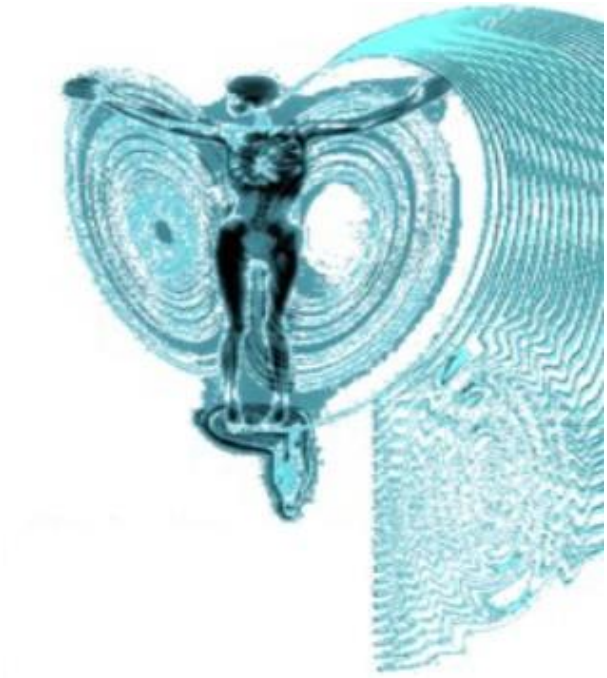
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of Biomedical Engineering

BIOPHYSICS



Working program educational disciplines (Syllabus)

Details educational disciplines

Level of higher education	First (bachelor's)
Field of knowledge	16 - Chemical and Bioengineering
Specialty	163 - Biomedical engineering
Educational program	Medical Engineering
Status disciplines	Normative
Form acquisition higher education	Full-time (offline)/ mixed/ online
Year of training, semester	2 course, spring semester
Course volume	5 ECTS credits / 150 hours (lectures 28 hours, practical 44 hours, self-study 78 hours)
Control/control measures	Exam, Calculation and graphic work (CGW), Module control work (MCW)
Class schedule	https://schedule.kpi.ua

Language of instruction: English

Information about the course lecturers/ teachers

Lectures: D.Sci., Prof. Orel V.E., e-mail: valeriiorel@gmail.com
Practical classes: D.Sci., Prof. Orel V.E., e-mail: valeriiorel@gmail.com

Placing course: https://classroom.google.com/c/NTI4NDU4MzU0MTk4?cjc=mluahse

Program educational disciplines

1. Description of educational disciplines, their goals, subject learning and teaching results

The main goal of the academic discipline "Biophysics" is the formation of students' ability to solve fundamental tasks and practical problems of physical and physicochemical properties concerning biology and medicine, applying basic theories, physical, physical-chemical and physical-mathematical methods and computer technologies. Teaching in the discipline " Biophysics " is carried out based on a student-centered approach and a strategy of interaction between the teacher and the student with the aim of students' assimilation of the material and the development of their practical skills.

The subject of study of the academic discipline " Biophysics " is the phenomena of living nature that occur on all levels its organizations, starting from quantum and molecular equal and ending with the biosphere as a whole; modern information technologies used in modeling medical and biological systems; bioelectromagnetic processes that arise during the functioning of cells and biological systems as a whole - that is, a complex of interconnected systems at different levels of the biological hierarchy, from which the basic components of biomedical engineering are formed to improve the results of the innovation process and the service system of clinical engineering and medical device manufacturing.

In accordance with educational and professional programs (EPP) the first "bachelor's" equal higher education, after studying the discipline, students must acquire the following **general competencies (EP put into effect by the Order of the Rector NON/434/2024 dated June 10, 2024):**

GC 1 - Ability to apply knowledge in practical situations
GC 5 - Ability to conduct research at an appropriate level.
GC 6 - Ability to search, process, and analyze information from various sources.

Special (professional) competencies (EP put into effect by the Rector's Order NON/434/2024 dated June 10, 2024):

PC 5 - Ability to apply physical, chemical, biological, and mathematical methods in the analysis and modeling of the functioning of living organisms and biotechnical systems.
PC 9 - Ability to identify, formulate, and solve engineering problems related to the interaction between living and non-living systems.

The program learning outcomes after studying the discipline "Biophysics" are (EP was put into effect by the Order of the Rector NON/434/2024 dated June 10, 2024):

PLO 8 - Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology.
PLO 18 - Understanding of fundamental-applied, medical-physical, and physico-chemical principles governing the functioning of biological objects, as well as bioengineering fundamentals of technologies and equipment for researching human body processes.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of study according to the relevant educational program)

The discipline "Biophysics" has an interdisciplinary character. It integrates, according to its subject, knowledge from other academic disciplines: physics, biochemistry, mathematics, etc. According to the structural and logical scheme of the specialist training program, the discipline "Biophysics" is closely related to other disciplines of general and professional training: "Biomedical Mechanics", "Foundations clinical engineering and radiology", "Biothermodynamics" and mass transfer". Directly precedes the discipline "Physics".

Practical skills acquired and theoretical knowledge acquired while studying the academic discipline "Biophysics" can be used in further under time mastery academic disciplines:

- with cycle professional preparation (educational and professional program "Medical engineering"):
"Biomedical devices, devices and complexes".

- with selective disciplines (educational and professional program "Medical engineering"):
"Therapeutic medical machinery", "Development and operation of physiotherapy medical devices", "Treatment and diagnostic complexes on basis of biophotonic converters",
"Designing medical informational systems".
- undergraduate practices and at diploma design.

3. Content educational disciplines

Basic sections and topics, which will be considered in process study course:

Section 1. Basic principles and methods of biophysics. Molecular biophysics and biophysics of complex systems.

Topic 1.1. Subject and methods biophysics

Topic 1.2. Thermodynamics of biological processes

Topic 1.3. Molecular biophysics

Topic 1.4. Foundations mathematical biophysics

Topic 1.5. Biophysical foundations medical nanotechnology and nanodevices

Section 2. Biophysics of the human organism.

Topic 2.1. Physical foundations Hemodynamics

Topic 2.2. Bioacoustics

Topic 2.3. Photobiological processes. Physical foundations vision

Topic 2.4. Electromagnetic phenomena in alive systems. Biophysical aspects of exposure to electromagnetic radiation

Topic 2.5. Biomedical engineering and cancer

4. Educational materials and resources

Basic and additional literature (hereinafter referred to as literature) is used to prepare for lectures and practical classes, modular tests, calculation and graphic work, etc. Literature that must be used to master the discipline is processed by students independently from the application of internet resources, Google Classroom. In distance learning conditions, you can prepare using the literature posted in e-form on Google Classroom for the academic discipline.

Basic literature:

1. J. L. Nadeau. Introduction to experimental biophysics, second edition: biological methods for physical scientists. CRC Press, 2018. – p. 790.
2. D. S. Lee. Biological and medical physics, biomedical engineering: radiation and medicine, combining nuclear and nanomedicine. Springer, 2018. – p. 456.
3. R. Blossey. Computational biology: A statistical mechanics perspective. Second edition, CRC Press, 2019. – p. 301
4. Ben Greenebaum, Frank Barnes. Handbook of biological effects of electromagnetic fields. Vol 1. Fourth edition, CRC Press, 2019. – p. 651.
5. Ben Greenebaum, Frank Barnes. Handbook of biological effects of electromagnetic fields, Vol 2. Fourth edition, CRC Press, 2019. – p. 537.

Additional literature:

6. A. Kamenev. Field theory of non-equilibrium systems. Cambridge University Press, 2011. – p. 357
7. R. Glaser. Biophysics: An Introduction. Second edition, Springer, 2012. – p. 428.
8. J. F. Allemand, C. T. Mierke. Physics and biology: From molecules to life. World Scientific, 2014. – p. 200.
9. S. H. Strogatz, Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering. Second edition, CRC Press, 2015. – p. 532.
10. P. Kumar. Fundamentals and techniques of biophysics and molecular biology. Second edition, Pathfinder Publication, 2015. – p. 115.

Educational content

5. Method mastery educational disciplines (educational component)

Under time study educational material are applied next methods teaching:

Lectures are held using the explanatory and illustrative method, the problem-based presentation method, and the interactive method during lecture sessions, which is used to establish a dialogue with the audience.

Practical occupation with using:

1) A reproductive method, thanks to which students consolidate the studied theoretical material and learn to use it in specific tasks.

2) Partially searchable, or heuristic method, which teaches search faithful ways and problem-solving methods.

3) Interactive method, which is used during laboratory classes for involving students in problem-solving processes and the theoretical facts used for this purpose.

4) Presentation and discussion received results provides using problem-based and interactive learning methods.

5) Mathematical modeling.

Below given plan carrying out classes.

No.	Topic	Program learning outcomes	Control	Term implementation
1	**Tasks and methods biophysics. Compliance biological and physical concepts.** Part 1. Subject and tasks of biophysics; fundamental and applied, medical and physical and physical and chemical laws of functioning of biological objects. Part 2. Application of physical, chemical, biological and mathematical methods in analysis and modeling; identification of engineering problems of interaction between living and non-living systems.	PLO 18	Practical work 1	1st week
2	**Thermodynamics biological processes.** Part 1. The first and second laws of thermodynamics; enthalpy, entropy, free energy, and equilibrium in biological systems. Part 2. Analysis and modeling of heat and mass transfer in living organisms; formulation and solution of engineering problems in bioenergetics.	PLO 18	Practical work 2	2nd week
3	**Methods research structures biopolymers.** Part 1. Physical and chemical methods for analyzing the structure of biopolymers: transmission and scanning electron, atomic force microscopy. Part 2. Theoretical and practical approaches to the creation, calibration and control of laboratory and medical equipment for the study of biopolymers; bioengineering requirements for detectors and sensors.	PLO 8	Practical work 3	3rd week
4	**Interaction non-ionizing electromagnetic fields with organism.** Part 1. Biophysical mechanisms of interaction of EMF with tissues. Part 2. Analysis and modeling of the distribution of the specific absorption coefficient of electromagnetic energy in biological objects.	PLO 8 PLO 18	Practical work 4	4th week
5	**Molecular biophysics. Physics macromolecules. Physics Protein. DNA physics.** Part 1. Conformational transitions and intermolecular interactions in the functioning of biological objects. Part 2. Analysis and modeling of the stability and functions of proteins and DNA.	PLO 18	Practical work 5	5th week
6	**Photobiological processes.** Part 1. Light absorption by biomolecules. Photochemical and photobiological reactions. Luminescence: fluorescence and phosphorescence. Part 2. Optical methods and medical technology (photometry, pulse oximetry, laser/photodynamic technologies).	PLO 8 PLO 18	Practical work 6	6th week
7	**Physics of enzymes.** Part 1. Fundamentals of enzymatic catalysis: kinetics (Michaelis–Menten), energy barrier, factors determining catalytic activity. Part 2. Analysis and modeling of enzyme systems in living organisms; bioengineering applications (biosensors, bioreactors).	PLO 18	Practical work 7	7th week
8	**Module control work.** Part 1. Checking the assimilation of medical-physical and physico-chemical laws. Part 2. Solving problems to solve bioengineering problems of interaction between living and non-living systems (FC 5, FC 9).	PLO 8 PLO 18	Writing MCW	7th week
9	**Bioacoustics. Physics hearing.** Part 1. Physical characteristics of sound, wave propagation in media, acoustic impedance; biomechanics of the organ of hearing. Part 2. Analysis and modeling of acoustic processes in	PLO 18	Practical work 8	8th week

	tissues; bioengineering problems of interaction in diagnostic techniques (audiometry, ultrasonography).			
10	**Calculation and graphic work.** Part 1. Calculation and modeling of selected biophysical processes/parameters using physical, chemical, biological and mathematical methods. Part 2. Formulation of a bioengineering problem and presentation of results (graphs, tables, conclusions).	PLO 8 PLO 18	Design and sending CGW	8th week
11	**Bioenergy.** Part 1. Energy metabolism in the cell: oxidative phosphorylation, electron transport in the respiratory chain; physicochemical laws of energy conversion. Part 2. Analysis and modeling of energy processes in living organisms.	PLO 18	Practical work 10	9th week
12	**Nanotechnology and nanorobots.** Part 1. Nanomaterials and nanoparticles: physical and chemical methods of synthesis and characterization; interaction with biological objects. Part 2. Theoretical and practical approaches to the creation and control of biomedical nanodevices/nanorobots; identification and solution of bioengineering problems of diagnostics and treatment of malignant neoplasms.	PLO 8	Practical work 11	10th week
13	**Physics membranes.** Part 1. Structure of biomembranes; diffusion, osmosis, active/passive transport. Part 2. Analysis and modeling of electrochemical and mechanochemical processes in membranes.	PLO 18	Practical work 12	11th week
14	**Physics muscular abbreviation and mechanochemical processes.** Part 1. Biomechanics of contraction: actin-myosin interaction, conversion of chemical energy into mechanical energy, viscoelastic properties of tissues. Part 2. Modeling of mechanochemical processes for solving bioengineering problems.	PLO 18	Practical work 13	12th week
15	**Free radicals.** Part 1. Formation of reactive oxygen/nitrogen species, oxidation chain reactions; physicochemical patterns of oxidative stress. Part 2. Methods of analysis and modeling of free radical oxidation processes in living organisms; bioengineering aspects of the influence of external factors.	PLO 18	Practical work 14	13th week
16	**Biomedical engineering and cancer.** Part 1. Biophysical mechanisms of carcinogenesis. Part 2. Theoretical and practical approaches to the creation and control of medical equipment in oncological practice (visualization, therapy); identification and solution of biomedical problems of controlled interaction of nanomaterials with tissues of the human body.	PLO 8	Practical work 15	14th week
17	**Hemodynamics.** Part 1. Fundamentals of circulatory hydrodynamics: laminar/turbulent flow, viscosity, Poiseuille's law, vascular compliance. Part 2. Analysis and modeling of hemodynamic parameters, measurement methods (Doppler imaging).	PLO 18	Practical work 16	15th week

Platform remote teaching:

For better assimilation of the subject material during distance learning, it is used electronic mail, platform remote teaching "Sikorsky" based on systems Google Classroom and platform for carrying out online meetings Google Meet and ZOOM, which allow you to:

- simplifies placing methodical recommendations, educational materials, literature, etc.
- is carried out reverse connection from students of educational tasks and the content of the academic discipline.

- are being checked and are evaluated completed task.
- is underway accounting implementation students plan educational disciplines, adherence to the schedule for submitting educational/individual assignments and their evaluation

6. Independent work student

Types of independent work *(preparation for classroom lessons, calculations based on primary data obtained in laboratory classes, solving problems, writing an essay, performing calculation work, completing homework tests, etc.):*

No.	Types of work submitted for independent processing	Number hours of self-study work
1	Review of lecture material and study of questions assigned for independent work	22
2	Preparation for practical classes	18
3	Preparation for the modular control work	4
4	Performing calculation and graphic work	4
5	Exam preparation	30
	Total	78

Distribution of hours of independent work of students by educational content topics

No.	Titles of topics and questions to be studied independently and references to educational literature	Number of hours of self-study work
1	**Non-equilibrium thermodynamic approaches in bioenergetics and metabolism:** redox transformations as a source of free energy; directionality of processes and equilibrium; assessment of the efficiency of energy transformations in the cell [3,6,7,8,9].	3
2	**Transport of electroneutral and charged particles through biomembranes:** Fick's laws and diffusion flow; electrodiffusion (Nernst–Planck equation); Nernst potential; prerequisites for the formation of membrane potential; Goldmann equation; RC - equivalent membrane models. [1,6,7,8]	3
3	**Biopotential recording:** sources of bioelectric potentials; differential measurement and the role of electrodes; bioimpedance and its frequency dependence; noise components and artifacts [1,7,10].	3
4	**Acoustic methods in biomedical diagnostics and analysis of ultrasound signals:** reflection/attraction/absorption coefficients; Doppler measurements (physical content, errors); spectral and time-frequency analysis of signals; signal-to-noise ratio [1,8,9].	3
5	**Rheological models of biofluids and elements of hydrodynamic calculation of blood flow:** Reynolds number; Poiseuille's law and hydraulic resistance; non-Newtonian viscosity models (qualitatively); pulsatile flow (Womersley criterion); basic approaches to mathematical modeling of hemodynamics [3,7,8,9].	3
6	**Optical phenomena in biotissues and spectroscopic methods: absorption**, scattering, luminescence: the Bouguer–Lambert–Beer law; absorption and scattering coefficients and their effect on measurements; fluorescence (quantum yield, quenching) [1,7,8,10].	3
7	**Interaction of ionizing radiation with matter and the basics of dosimetry:** dose values and protection principles [2,7].	4
	Together	**22**

One of the main types of semester control during the mastering of the academic discipline "Biophysics" is the execution of CGW . CGW is performed in accordance with the requirements, within the period specified by the teacher.

The main goal of CGW is to solve a practical problem using theoretical material learned in lectures and independently, and practical skills obtained in practical classes. A student can write a computational and graphical work only on a topic agreed with the teacher.

Policy and CONTROL

7. Policy educational disciplines (educational component)

7.1 Incentives points

Incentives points		Violation terms deadline*	
Criterion	**Gravimetric mark**	**Criterion**	***% decrease assessments***
Improve practical works	1 mark (for each practical work)	Untimely execution and submission of MCW	From -10% to -20% for the task (depends on term delivery)
Taking distance courses on topics agreed upon with teachers	5 points	Untimely execution and submission of CGW	From -10% to -20% for the task (depends on term delivery)
Preparation of a scientific paper for participation in a student scientific paper competition	10 points	Late execution tests	From -10% to -20% for the task (depends on term implementation)
Writing theses, articles, participation in international, all-Ukrainian and/or other events or competitions on the subject educational disciplines	5 points	Late execution abstracts	From -10% to -20% for the task (depends on the delivery date)

* If control West was missed with respectable reasons (disease, which confirmed reference established sample) – Violation of deadlines does not apply.

However, according to position https://osvita.kpi.ua/node/37 clause 2.7, sum incentive/ penalty points cannot exceed 10% of the rating scale.

7.2 Regulations visiting classes

Attendance at lectures is not mandatory. Attendance at practical classes is desirable, as they include writing express control papers/tests, and also defense of practical papers.

System evaluation oriented on receiving points by activity student, and as well as completing tasks that can develop practical skills and abilities.

7.3. Regulations implementation individual task

Main target CGW – solution practical tasks with using learned on lectures and independently theoretical material, and practical skills obtained in practical work. A student can write a CGW only on a topic agreed with the teacher.

Approximate subject computational and graphic works:

No.	Topic
1	Analyze side effects biomedical effects actions non-ionizing electromagnetic fields.
2	Calculate parameters and quantities non-ionizing electromagnetic fields, which can cause side effects biomedical effects.
3	Analyze side effects biomedical effects actions ionizing radiation.
4	To bring parameters and quantities ionizing irradiation, which can cause side effects biomedical effects.
5	Analyze side effects biomedical effects actions acoustic waves.

6	Calculate parameters and quantities acoustic waves, which call side effects biomedical effects.
7	Analyze side effects biomedical effects actions mechanical vibration influence.
8	Calculate parameters and values for mechanical vibration influence, which can cause side effects biomedical effects.

* Student maybe perform and another topic computational and graphic works by own desire, agreed with the teacher.

The title page of the calculation and graphic work should have the following content: name of the university; name of the faculty; name of the department; name of the specialty, name of the educational and professional programs, name educational disciplines; topic computational and graphic work; student's last name and first name, course, academic group number, year.

The title page is followed by a detailed plan (table of contents) of the calculation and graphic work, which should include an introduction, sections of the main content (the main topics studied), their subdivisions (if necessary), a conclusion, and a list of sources used. The table of contents indicates the page numbers of the beginning of each question on the right. Each section begins on a new page.

The total volume of computational and graphical work, depending on the chosen topic, can vary from 15 to 25 pages of the main text (as agreed with the teacher). The volume of computational and graphical work works is determined skilled student succinctly and simultaneously comprehensively explain and analyze the obtained data in the IBM SPSS Statistics package.

Mandatory requirement: clear reference to sources of information. All figures, facts, opinions of scientists, quotes, formulas must have link in in the form of [2, with. 54] (first figure means the number of the source in the list of references given at the end of the creative work, and the second digit is the page number in this source). It is advisable to use tables, diagrams, graphs, charts, etc. The list of sources used (at least 10 sources) is drawn up in accordance with the current rules. If information taken with networks Internet, necessary, as and for regular literature, indicate the author, the title of the article, and then provide the address of the website on the Internet.

Calculation and graphic work are evaluated according to the following criteria: logicality of the plan; completeness and depth of disclosure of the topic; reliability of the data obtained; reflection of practical materials and results calculations; correctness formulation of conclusions the results and obtained; design; justification of the student's own opinion on this issue in the form of a conclusion.

Deadline for submitting calculation and graphic work for review: 11th week of study.

Calculation and graphic work are not checked for plagiarism but must meet the requirements of academic virtue. In case of academic misconduct, the work is cancelled and not checked.

7.4. Policy extreme terms and rearrangements

Missed control measures (defense of practical works) must be completed in the following classes, provided that they are completed by an assignment that is scheduled for the current lesson or during consultations.

Omission writing module control works, and express control is not being worked out.

Calculation and graphic work, which are served upon verification with a violation, are evaluated with a decreasing number of weight points.

7.5. Procedure appeal results control events

Students have the opportunity to raise any question which concerns procedures control measures and expect it to be reviewed according to pre-defined procedures.

The student has the right to appeal the results of the control measure in accordance with the approved regulations on appeals at Igor Sikorsky Kyiv Polytechnic Institute (approved by order No. NON/128/2021 from 20.05.2021 (r.) - https://osvita.kpi.ua/index.php/node/182

7.6. Remote teaching

Remote teaching is happening through the Platform remote teaching "Sikorsky".

Distance learning through additional online courses on certain topics is allowed. by conditions coordination from students. In case a small number of students wish to take an online course on a certain topic, studying the material through such courses is allowed, but students must complete all tasks provided for in the academic discipline.

List courses offered by the teacher after detecting the desired students (since the bank of available courses is updated almost every month).

The student provides a document confirming completion of the distance learning course (in case of completing the full course) or provides completed laboratory assignments from the distance learning course, and upon passing the oral interviews with the teacher, topics can receive grades for the control measures provided for the topics studied.

7.7. Teaching foreign in the language

Teaching in English in the language is carried out only for foreign students.

By desire students, allowed study material by with help English-language online courses on topics that correspond to the topics of specific classes.

7.8. University Policy

Academic Integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code .

Norms ethical behavior

The norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More information: https://kpi.ua/code .

8. Types control and rating system evaluation results teaching (ERT)

No.	Control	%	Mark	Number	Total
1.	Express survey / notetaking abstract	20	4	5	20
2.	Tests	10	5	2	10
3.	Module control work	15	15	1	15
4.	Calculation and graphic work	15	15	1	15
5.	Exam	40	40	1	40
	Total				100

In order to receive the highest rating, the student must: complete and submit the following documents in a timely manner: CGW; on time perform MCW and express control / test task.

A student may appeal a teacher's grade by submitting a complaint to the teacher no later than the day after the student is informed of the grade. The complaint will be considered according to the procedures established by the university.

Admission requirements for semester control: availability not Less 40 points and implementation of MCW and CGW.

Table compliance rated points assessments by university scale

Number points	Score
100- 95	Excellent
94- 85	Very good
84- 75	Good
74- 65	Satisfactory
64- 60	Enough
Less 60	Unsatisfactory
Not completed conditions admission	No admitted

9. Additional information with disciplines (educational component)

A list of questions for preparing for the module test, as well as for preparing for the exam, is provided in Appendix 1.

Distance learning through additional online courses on a specific topic is permitted subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material through such courses is permitted, but students must complete all tasks provided for in the academic discipline.

List courses offered by the teacher after detection students' wishes (because the bank of available courses is updated almost every month).

The student provides a document confirming completion of the distance learning course (in case of completing the full course) or provides completed practical tasks from the distance learning course and, subject to passing an oral interview with the teacher on the topics covered, can receive grades for the control measures provided for the topics studied (express control / test tasks, practical work).

Inclusive teaching included.

Appendix 1 to the syllabus discipline "Biophysics"

List questions for preparation to modular control work, and also for preparation to exam

1. Define place medical biophysics in natural science.
2. Analyze main sections biophysics.
3. Justify conformity biological and physical concepts.
4. To bring main methods research biophysics.
5. Explain in Why consists of X-ray structural analysis biopolymers.
6. Explain in Why consists of electronic paramagnetic resonance biopolymers.
7. Model Volterra trays or equation predator- prey.
8. Manifestations self-similarity biological objects. Features quasi-fractal forms in living organisms.
9. Calculation fractal dimensions.
10. Concept deterministic chaos. Basic properties dynamic chaos medical and biological systems.
11. Application methods nonlinear speakers for assessments biophysical processes.
12. Application two-choice t-test Student for checks similarities or differences of independent samples.
13. Application of the U-criterion Mann-Whitney for assessing differences between two samples.
14. Thermodynamics medical and biological processes – subject and terminology.
15. To bring first law thermodynamics.
16. Analyze effects transformation energy in organism.
17. To bring Law Hess. What such thermodynamic potential?
18. To bring second law thermodynamics.
19. Justify statistical nature entropy.
20. Analyze construction and principle works respiratory calorimeter.
21. What such dissipative structures? Theorem Prigogine. Changes entropy in in the process of life.
22. Heat balance organism, ways heat exchange.
23. To bring types of connections and interactions in biologically important molecules.
24. Explain features structures squirrel.
25. Analyze spatial organization proteins.
26. Dates assessment closed ring forms DNA.
27. Justify principle works and scheme nanomotor.
28. To bring composition biological membranes.
29. Biological functions membranes.
30. To bring structure membranes.
31. Analyze elastic properties membranes.
32. Analyze phase transitions in lipid Bishari biomembrane.
33. Explain flexoelectric effects in membranes. Pathology biomembrane.
34. Analyze free radicals' reactions monovalent way restoration oxygen.
35. Analyze free radical peroxide oxidation lipids.
36. Biological dosimetry.
37. Justify physical effects enzyme-substrate interactions.
38. Justify models enzymatic catalysis.
39. Dates assessment electronic-conformational interactions.
40. Analyze effects oxidizing phosphorylation.
41. Justify chemical concept oxidizing phosphorylation
42. Chemiosmotic combination respiratory chains.
43. Justify conformational oxidative theory phosphorylation.
44. To bring and to justify electric and magnetic properties fabrics organism.
45. Analyze properties electromagnetic fields radio waves. General idea.
46. Justify non-thermal effects electromagnetic fields radio waves.
47. To bring magnetic principles management chemical reactions.

48. Justify thermal effects electromagnetic radio wave fields
49. Resting biopotential of a cell. What are the ratios of relative permeabilities of different ions for a cell at rest?
50. Biopotential actions. Characteristics biopotential actions.
51. Structure and function potential-dependent sodium channel.
52. Features generations and dissemination receptor potential photoreceptor cell (using the example of a rod).
53. Analyze photobiological processes. General idea.
54. Analyze patterns absorption light biosystems.
55. Analyze intramolecular processes exchange energy.
56. Formulate definition phenomena luminescence.
57. Justify intermolecular transfer energy in photobiological processes.
58. Explain biophysical foundations vision.
59. Explain features colored vision.
60. Explain foundations physicists hearing.
61. Analyze auditory apparatus human.
62. Noise and its value in medicine.
63. Vocal apparatus human.
64. To bring structure muscles.
65. Justify mechanical properties muscles.
66. Analyze mechanochemical processes.
67. Justify theory muscular abbreviation.
68. Analyze physical patterns movement blood in large and small vessels.
69. Justify the concept of "heart" like a pump."
70. Explain features hemodynamics in pathological processes.

Appendix 2 to syllabus with disciplines "Biophysics"

Program learning outcomes (extended form)

As a result of studying the academic discipline "Biophysics", students will be able to:

Learning outcomes		Relevance of learning outcomes to competencies in the educational and professional program	
		General competencies (**soft skills**)	Special competences (**professional**)
PLO 8	Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology	*Ability to apply knowledge in practical situations*	*Ability to apply physical, chemical, biological, and mathematical methods in the analysis and modeling of the functioning of living organisms and biotechnical systems*
PLO 18	Understanding of fundamental-applied, medical-physical, and physico-chemical principles governing the functioning of biological objects, as well as bioengineering fundamentals of technologies and equipment for researching human body processes	*Ability to conduct research at an appropriate level.* *Ability to search, process, and analyze information from various sources*	*Ability to identify, formulate, and solve engineering problems related to the interaction between living and non-living systems*

Description logistical and informational software disciplines

The main methods are conversation, independent work and work in groups, visual methods learning, practical exercises. To activate cognitive activity, problem-based learning methods, trap tasks, discussions, game and interactive methods, project methods, etc. are used. Individual, pair and group forms of learning, as well as game forms of conducting classes are relevant.

Working program educational disciplines (syllabus):
Compiled Orel V.E.
Approved by department BME (protocol No. 16 from 21/06/2024)
Approved by methodical by the commission faculty BME (protocol No. 9 from 26/06/2024)