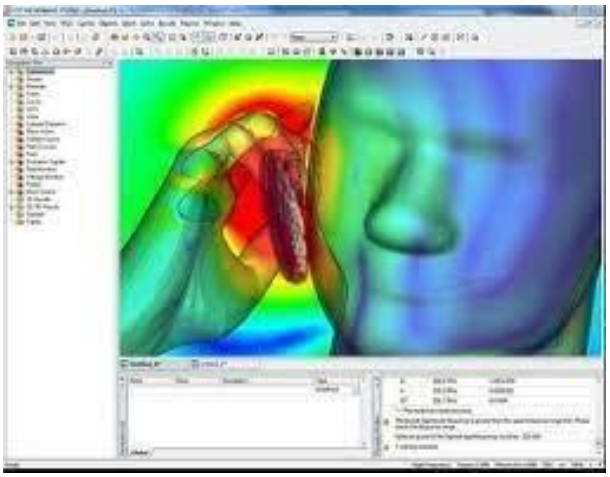
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-274] INTERACTION OF PHYSICAL FIELDS WITH BIOOBJECTS



Work program of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics and Telecommunications
Specialization	172 - Telecommunications and Radio Engineering
Educational program	All educational programs
Status of discipline	Elective (F-catalog)
Form of higher education	Full-time
Year of training, semester	Available for selection starting from the 4th year, fall semester
Course load	4 credits (Lectures 18 hours, Practical classes 36 hours, Laboratory work 36 hours, Independent work 66 hours)
Semester Control/control measures	Credit

Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian Information
about course coordinator / teachers	
Course location	https://classroom.google.com/c/NDA3NDIzNzk2ODky?cjc=6netjdf

Curriculum

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

The development of medical technology, in particular therapeutic and diagnostic devices and systems, involves the development and improvement of artificial sources of various physical fields, refinement of the mechanisms of their interaction with biological objects, and the use of the results obtained in the field of clinical medicine and ecology. The discipline "Interaction of physical fields with biological objects" belongs to the cycle of professional and practical training of students of the first (bachelor's) level of higher education in the specialty "Electronic Communications and Radio Engineering."

The aim *of teaching the discipline is to develop knowledge about the main characteristics of physical fields; their stages of action (physical, chemical, biological) on bio-objects; the consequences of such action and measures to protect against the undesirable effects of a particular physical field.*

The subject *of the discipline is the process of interaction of radiation (electromagnetic, acoustic, and ionizing) of natural and artificial origin with biological objects and methods of using the effects of this interaction in medical technology.*

As a result of training*, students develop general competencies;*

GC 1 Ability to think abstractly, analyze, and synthesize. GC 2 Ability to apply knowledge in practical situations. GC 7 Ability to learn and master modern knowledge; professional competencies:

PC 4 Ability to perform computer modeling of processes in biological objects under the influence of external and internal physical fields of various nature;

PC 20 Ability to select methods and means of information processing using intelligent technologies;

PC 23 Ability to select and apply specialized software tools for simulation modeling and design of biomedical equipment.

Studying the discipline "Interaction of physical fields with bio-objects" contributes to the achievement of the following program learning outcomes.

PLO 1 Analyze and make informed decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions.

PLO 4 Explain the results obtained from measurements in terms of their significance and relate them to the relevant theory.

PLO 7 Competently apply the terminology of the telecommunications and radio engineering industry.

PLO 13 Apply fundamental and applied sciences to analyze and develop processes occurring in biomedical telecommunications and radio engineering systems.

Within the framework of the above-defined general and professional competencies and program learning outcomes, students should:

be familiar with *the basic patterns of propagation of electromagnetic and acoustic waves and ionizing radiation in natural conditions and in biological objects; the physical characteristics of biological tissues in different ranges of electromagnetic and acoustic waves; u n d e r s t a n d the prospects for the development of technical systems in biomedical engineering and its interconnection with related fields;*

be able to *analyze the main trends in the development of biomedical engineering, identify its promising areas of research in the field of interaction of physical fields with biological objects and the possibilities of practical application of their results; use the principles of a systematic approach to analyze and synthesize biotechnical systems and technologies.*

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

Interdisciplinary connections are determined by the place of the discipline "Interaction of physical fields with bio-objects" in the training program for specialists in the field of electronics and telecommunications. It is based on the general training of students in physics and mathematics. The professional disciplines that precede its study are: "Electrodynamics and Radio Wave Propagation" and "Fundamentals of Metrology."

The discipline "Interaction of physical fields with bio-objects" provides for the study of disciplines of the first (bachelor's) level of higher education: "Introscopy of bio-objects and methods of bioinformation processing,"

"Design of biomedical equipment," "Certification of biomedical Equipment Certification."

3. Contents of the academic discipline

Names of sections and topics	Number of hours				
	Total	including			
		Lectures	Practical (seminars)	Laboratory work	Ind. work
1	2	3	4	5	6
Chapter 1 Introduction to Biophysics and Bioenergetics					
Topic 1.1 Physical fields as environmental factors	3	2	0	0	1
Topic 1.2 Subject, research methods of biophysics	4	0	0	0	4
Topic 1.3 Human body systems	8	0	0	4	4
Topic 1.4 Thermodynamics of biophysical processes. Bioenergetics	3	2	0	0	1
Total for Section 1	18	4	0	4	10
Section 2 Fundamentals of electromagnetic field interaction with the human body					
Topic 2.1 The effect of static electric and magnetic fields on biological objects	12	4	0	4	4
Topic 2.2 Biological effects of radio frequency electromagnetic radiation on living organisms	22	2	0	16	4
Topic 2.3 Reaction of biological objects to optical range radiation	6	2	0	0	4
Topic 2.4 Interaction of laser radiation with biological objects. Laser devices for medical use	6	2	0	0	4
Total for Section 2	46	10	0	20	16
Section 3 The effect of ionizing radiation on living organisms					
Topic 3.1 The effect of X-ray radiation on biological objects	6	2	0	0	4
Topic 3.2 Interaction of penetrating radiation with human body tissues	10	0	0	4	6
Total for Section 3	16	2	0	4	10
Section 4 Influence of acoustic fields on biological objects					
Topic 4.1 Reaction of biological objects to sound oscillations and vibrations	8	0	0	4	4
Topic 4.2 Interaction of ultrasonic radiation with the human body	10	2	0	4	4
Total for Section 4	18	2	0	8	8
Modular test	2	0	0	0	2
Homework assignment	14	0	0	0	14
Credit	6	0	0	0	6
Total hours	120	18	0	36	66

4. Teaching materials and resources

Recommended reading

Basic

1. Grigorieva L.I., Tomilin Yu.A. Fundamentals of Biophysics and Biomechanics: Textbook. Black Sea State University named after Petro Mohyla. – Mykolaiv: Petro Mohyla Black Sea State University Publishing House, 2011. – 297 p.
2. Yanenko, O. P. Medical equipment for therapy and diagnostics [Electronic resource]: textbook / O. P. Yanenko, S. N. Peregudov, V. P. Kutsenko. – Kyiv: NTUU "KPI", 2013. – Title from screen. – Access: http://library.kpi.ua:8080/handle/123456789/2488. – Title from screen.

3. Fundamentals of the interaction of physical fields with biological objects [Text]: textbook / V. P. Oliinyk; National Aerospace University named after M. S. Zhukovsky "Kharkiv Aviation Institute." - Kharkiv: KhAI, 2020. - 71 p.
4. Grygorieva L. I. Ionizing radiation and its effect on the human body [Text]: textbook / L. I. Grygorieva, Yu. A. Tomilin, I. M. Rozhkov. – Mykolaiv: Petro Mohyla Black Sea National University Publishing House, 2008. – 137 p.
5. Mobile communications and human health: Information bulletin [Text] / [authors-compilers: Shtyl O. V., Protas S. V. – Kyiv: Ministry of Health of Ukraine Publishing House, 2008. – 21 p.
6. Calculation of the Dielectric Properties of Body Tissues [Electronic resource] // URL: http://niremf.ifac.cnr.it/tissprop/htmlclie/htmlclie.php (accessed: 10.10.2021).

Supplementary

7. M. E. Dzerzhinsky, N. V. Skrypnyk. General Cytology and Histology. Part 1. [Text]: textbook M. E. Dzerzhinsky, N. V. – Kyiv: Publishing and Printing Center "Kyiv University," 2006. – 273 p.
8. M. E. Dzerzhinsky, N. V. Skrypnyk. General Cytology and Histology. Part 1. [Text]: textbook M. E. Dzerzhinsky, N. V. – Kyiv: Publishing and Printing Center "Kyiv University", 2006. – 273 p.
9. Histology, Cytology, and Embryology. Atlas: Textbook. / O. Yu. Stepanenko, O. V. Miroshnichenko, L. O. Zaychenko, et al. — 2nd ed. — Kyiv: VSV "Medicine," 2020. — 152 p.
10. Electrodynamics and propagation of radio waves. Part 2. Radiation and propagation of electromagnetic waves: Textbook for university students / [Shokalo V. M., Pravda V. I., Usin V. A. et al.]; edited by V. M. Shokalo and V. I. Pravda – Kharkiv: KNURE; Collegium, 2010 – 435 p.
11. Thuéry Jacque. Microwaves: Industrial, Scientific, and Medical Applications [Text] / Jacque Thuéry. – Boston-London: Artech House Inc., 1992. – 675 p.
12. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz): ICNIRP (International Commission on Non-Ionizing Radiation Protection) Guidelines // Health Physics. - Vol. 74, No. 4. - April 1998. - P. 494-522.

Information resources

13. The Application Gallery features COMSOL Multiphysics® tutorial and demo app files. [Electronic resource]. – URL: https://www.comsol.com/models (accessed: 10.08.2024).
14. Standards and rules for protecting the population from the effects of electromagnetic radiation. [Electronic resource]. – URL: http://government.ru (accessed: 10.08.2024).
15. Nuclear and radiation safety. Scientific and technical journal [Electronic resource] // URL: https://nuclear-journal.com/index.php/journal (accessed: 10.08.2024).
16. Histology. The first Ukrainian-language histology resource. [Electronic resource] // URL: https://www.youtube.com/channel/UCbRpfENIEYCawGwYVqE_1EQ (accessed: 10.08.2024).
17. Biophysics. Molecular biophysics [Electronic resource] – URL: http://znaimo.com.ua/Біофізика. (accessed: 10.08.2024).
18. Microwaves101.com (Microwave Encyclopedia) [Electronic resource] // Access to the resource: https://www.microwaves101.com (date of access: 10.08.2024).
19. Medical acoustics (Wikiwand) [Electronic resource] // URL: https://www.wikiwand.com/uk/articles/Медична_акустика (accessed: 10.08.2024).

Educational content

5. Methodology for mastering the academic discipline (educational component)

Lectures

No	Lecture topic and list of key questions (list of teaching aids, references to literature, and assignments for independent study)
1	2
	SECTION 1 INTRODUCTION TO BIOPHYSICS AND BIOENERGETICS
1	**Topic 1.1 Physical fields as environmental factors** Key terms and definitions. Artificial and natural fields. Diversity of physical fields and their impact on biological objects. Structure of a biogeocenosis. Diagram of a global homeostatic system. Independent work assignment: review the lecture material and study the literature sources. Literature: [1, pp. 10-15,].
2	**Topic 1.4 Thermodynamics of biophysical processes. Bioenergetics** Fundamental concepts of classical thermodynamics and the equilibrium state of a system. Life as a thermodynamic process. Thermodynamics of biophysical processes. Steady state of a system. Laws of thermodynamics of biological systems. The relationship between entropy and information for biological systems. Energy exchange between a biosystem and the environment. The general nature of the reaction of a biological object to the action of a physical field. The organism as an open thermodynamic system. Criteria for achieving the stability of the steady state of biological systems. Independent work assignment: review the lecture material and study the literature sources. Literature: [1, pp. 35-48].
	CHAPTER 2 BASICS OF INTERACTION BETWEEN THE ELECTROMAGNETIC FIELD AND THE HUMAN BODY **HUMAN**
3	**Topic 2.1 The effect of static electric and magnetic fields on biological objects** Artificial and natural sources of electromagnetic fields. Electromagnetic field, spectrum of electromagnetic oscillations. The effect of electrostatic fields on biological objects. The effect of of electric currents. The effect of magnetic fields on biological objects. The effect of an alternating electric field Independent work assignment: review the lecture material; analyze the dependence of the reaction of biological objects on the frequency of radio waves. Pay attention to the process of radiation absorption by different cell structures and their damage. Literature: [2, pp. 8-39].
4	**Topic 2.1 Fundamentals of magnetic resonance imaging** Microscopic (quantum) mechanism of magnetic fields. Larmor frequency. Zeeman effect. Nuclear magnetic resonance (NMR). Relaxation processes. Principles of MRI. Independent work assignment: review the lecture material and study the literature sources. Literature: [2, pp. 97-102, 160-177].
5	**Topic 2.2 Biological effects of radio frequency electromagnetic radiation on living organisms** Model of electromagnetic waves. Their main properties. Range of electromagnetic waves. Electrical properties of living tissue. Biological aspects of electromagnetic fields. Thermal and non-thermal effects of electromagnetic radiation on biological objects at the cellular and molecular levels. Characteristics of radio wave parameters that are most widely used in modern medical devices. General methods and principles of protecting living organisms from the effects of electromagnetic waves. Thermal and non-thermal effects of electromagnetic irradiation on biological objects. Negative effects of electromagnetic radiation on living organisms. Dosimetry of high and ultra-high radio frequencies. Independent work assignment: review the lecture material and study the literature sources. Literature: [2, pp. 50-82].

6	**Topic 2.3 Reaction of biological objects to radiation in the optical range** Basic information on physical optics. The effect of radiation in the optical range on biological objects. Spectral composition of solar radiation. Radiation from the Earth's surface and the environment. Artificial sources of infrared radiation. The place of the infrared spectrum among other types of radiation. The reaction of human skin to infrared radiation. The effect of infrared radiation on the central nervous and cardiovascular systems and the human organs of vision. The propagation of ultraviolet radiation in the Earth's atmosphere. Absorption and scattering of ultraviolet rays by natural and artificial materials. The biological effect of ultraviolet rays (at the molecular level). The skin's reaction to ultraviolet radiation. Independent work assignment: review the lecture material and study the literature sources. Literature: [3, pp. 50-82].
7	**Topic 2.4 Interaction of laser radiation with biological objects** The effect of laser radiation on biological objects. Physical processes that occur when laser radiation is generated. The difference between laser beams and ordinary natural and artificial beams. The power and wavelength of laser radiation sources. The effect of laser radiation on biological objects (coagulation of biological tissues; physiological and biological changes in cells and tissues). Independent work assignment: review the lecture material and study the literature sources. Literature: [3, pp. 50-82].
	CHAPTER 3 THE EFFECT OF IONIZING RADIATION ON LIVING ORGANISMS
8	**Topic 3.1 The effect of X-ray radiation on biological objects** The place of X-rays in the spectrum of electromagnetic oscillations. Natural and artificial sources of X-ray radiation. The effect of X-rays of varying intensity on biological objects, their use in modern medicine. Protection of living organisms from X-ray radiation. Independent work assignment: review the lecture material; determine the cause of X-ray radiation and name its types; analyze the effect of X-ray radiation on biological objects of different classes; consider the principles of operation of artificial sources of X-ray radiation and their biomedical application. Literature: [4, pp. 142-165, 171-186].
	CHAPTER 4 THE EFFECT OF ACOUSTIC FIELDS ON BIOLOGICAL OBJECTS
9	**Topic 4.2 Interaction of ultrasonic radiation with the human body** Ultrasound and its biological effect on the functions of a living organism. Propagation of ultrasonic waves in biological environments. Properties and characteristics of biological tissues and organs. Artificial sources of ultrasonic radiation, their main characteristics and features of application. The use of ultrasonic effects in modern medical devices. Ultrasonic diagnostics. The main types of ultrasonic scanners and their operating modes. Independent work assignment: review the lecture material; examine the peculiarities of the propagation of ultrasonic waves in biological media; study the principle of operation of ultrasound devices and their application in the biomedical field; classify ultrasonic scanners and their operating modes; examine the principles of operation of ultrasonic tomography devices. Literature: [3, pp. 82-99].

Laboratory classes

The main purpose of the laboratory classes:

- *to test the theoretical knowledge acquired in practice;*
- *to acquire skills in working with measuring instruments and equipment;*
- *to study experimental methods for determining the characteristics of physical fields and bio- objects, as well as evaluating the results of their interaction;*
- *to study methods for calculating the main indicators of effects caused by the interaction of physical fields and bio-objects;*
- *mastering methods and software tools for modeling the interaction of physical fields and biological objects;*
- *acquiring skills in analyzing research results.*

No.	Name of the lesson topic, tasks, and references to literature	Number lecture hours
1	2	3
	Topic 1.3 **Human body systems**	
1	**Study** of **the electrical parameters** of **the human skin surface during electrostimulation** Independent work assignment: review the material for independent study in Topic 2.1 and prepare for the laboratory work; write a report on the work and prepare answers to the test questions.	4
	Topic 2.1 **The effect of static electric and magnetic fields on biological objects**	
2	**Determination of the distribution of the electrostatic field in human biological tissue** Independent work assignment: review the material from the practical session, familiarize yourself with the principles of the COMSOL Multiphysics package [13] and model building in the program environment. Consider the propagation of an electrostatic field in human tissue. Use information resource 13 to select the electrical parameters of biological tissue. Download the model "Electrical Signals in a Heart" (https://www.comsol.ru/model/electrical-signals-in-a-heart-981). Determine the distribution of electrical potentials in the heart muscle. Present the simulation results and conclusions.	4
	Topic 2.2 **Biological effects of radio frequency electromagnetic radiation on living organisms**	
3	**Specific absorption rate (SAR) in the human brain** Task: download the model "Specific Absorption Rate (SAR) in the Human Brain" (https://www.comsol.ru/model/specific-absorption-rate-sar-in-the-human-brain-2190) [13]. Determine the distribution of the temperature of the human brain heated by microwave radiation. Present the simulation results and conclusions. References: [4, pp. 3-20].	4
4	**Calculation of specific absorption rate (SAR) using the COMSOL Multiphysics package** Task: familiarize yourself with the material of Lecture 3. Download the model "SAR of a Human Head Next to a Wi-Fi Antenna" (https://www.comsol.ru/model/sar-of-a-human-head-next-to-a-wi-fi-antenna-71721) [13]. Perform calculations of the distribution of specific microwave power absorbed in the human head. Present the results of the calculations. Draw conclusions. References: [4, pp. 3-20];	4
5	**Microwave heating of a tumor** Task: download the model "Microwave Heating of a Cancer Tumor" (https://www.comsol.ru/model/microwave-heating-of-a-cancer-tumor-30) [13]. Determine the distribution of the heating temperature of the tumor and normal tissue by microwave radiation. Present the simulation results and draw conclusions about the medical application of microwave radiation. References: [4, pp. 3-20]; [5].	4
6	**Radiometric method for studying thermal fields of biological objects** Independent work assignment: review the material from Lecture 7 and prepare for the lab ; write a report on the work and prepare answers to the test questions.	4
	Topic 3.2 **Interaction of penetrating radiation with human body tissues**	
7	**Assessment of the level of radioactive contamination of the environment and analysis of its impact on humans** Independent work assignment: prepare for the lab work using the material from the methodological recommendations and lecture 8, as well as the material for independent study on topic 3.1; complete the experimental part of the work; prepare a report and prepare answers to the control questions.	4
	Topic 4.1 **Reaction of biological objects to sound waves and vibrations**	
8	**Research into the characteristics of acoustic waves in human biological tissues** Task: download the Head and Torso Simulator Acoustics model (https://www.comsol.ru/model/head-and-torso-simulator-acoustics-74381) [13]. Determine the distribution of acoustic vibration intensity in the human head and body. Present the simulation results and draw conclusions. References: [2, pp. 77-90].	4
	Topic 4.2 **Interaction of ultrasonic radiation with the human body**	
9	**Study of the propagation of high-intensity ultrasonic vibrations in a human phantom** Task: download the model "High-Intensity Focused Ultrasound (HIFU) Propagation Through a Tissue Phantom" (https://www.comsol.ru/model/high-intensity-focused-ultrasound-hifu-propagation-through-a-tissue-phantom-90191) [13]. Determine the characteristics of the distribution of ultrasonic waves in human tissue. Present the simulation results and draw conclusions about the use of high-intensity ultrasound radiation in clinical medicine. References: [2, pp. 95-111].	4

6. Independent work of the student

During the semester, students study the following topics.

No	Title of the topic for independent study	Number hours Ind.work
1	2	3
1	**Topic 1.2. Subject and methods of biophysics research** Independent work assignment: consider the following questions. Subject, research methods, history of biophysics development. Modeling of mechanical and physical phenomena in biological systems. Literature: [1, pp. 10-34].	4
2	**Topic 1.3. Systems of the human body** Independent work assignment: consider the following questions. The study of cells. Cellular and non-cellular structures of the human body. Cell membrane, cytoplasm, and cytoplasmic organelles. Structure and functions of the nucleus. Cell reproduction. Structure and functions of the cell membrane. Biological role of water. Biophysics of proteins. Biotissues. Main systems of the human body. Literature: [1, pp. 53-72].	2
3	**Topic 2.1 The effect of static electric and magnetic fields on biological objects** Independent work assignment: consider the following questions. Electromagnetic field, spectrum of electromagnetic oscillations. The effect of electrostatic fields on biological objects. The effect of electric currents. The effect of magnetic fields on biological objects. The effect of low-frequency alternating electric current. Literature: [2, pp. 16-30].	2
4	**Topic 2.3 Reaction of biological objects to radiation in the optical range** Independent work assignment: consider the following questions. Concepts of photobiology and photomedicine. Medical applications of IR radiation. Vitamin-forming effect of ultraviolet rays. Erythemal and bactericidal effects of UV radiation. Air sterilization with ultraviolet rays. Negative effects on the human body caused by exposure to large amounts of ultraviolet radiation. Skin and eye diseases. The use of UV rays in human diagnosis, prevention, and treatment. References: [2, pp. 35-42, 54-57].	3
5	**Topic 2.4 Interaction of laser radiation with biological objects. Laser devices for medical use** Independent work assignment: consider the following questions. Physical processes that occur when laser radiation is generated. The difference between laser beams and ordinary natural and artificial beams. Biophysical and biochemical processes that occur in living organisms under the influence of laser radiation. The use of lasers in modern medicine. References: [2, pp. 264-270].	3
6	**Topic 3.1 The effect of X-ray radiation on biological objects** Independent work assignment: consider the following questions. Natural and artificial sources of X-ray radiation. Its effect on biological objects at the cellular and molecular levels. Comparative sensitivity of different organisms to X-rays. The role of low doses of radiation. The use of X-rays in modern medicine, determining the radiation dose of living objects. Radiation ecology. Literature: [3, pp. 117-125].	3

7	**Topic 3.2 Interaction of penetrating radiation with human body tissues** Independent work assignment: consider the following questions. Natural and artificial sources of penetrating radiation. The physical nature of α, β particles, neutrons, and γ rays as ionizing radiation. Their effect on biological objects at the cellular and molecular levels. Comparative radiosensitivity of different organisms. Radiation sickness and chemical protection against it. The role of low doses of radiation. The use of penetrating radiation in modern medicine, determination of radiation doses and the degree of contamination of living and non-living objects with radioactive substances. Radiation ecology. Literature: [3, pp. 117-125, 165-168].	4

8	**Topic 4.1 The reaction of biological objects to sound waves and vibrations** Independent work assignment: consider the following questions. The acoustic field as an environmental factor. Physical characteristics of acoustic waves. Acoustic properties of biological tissues. Physical and physicochemical effects of the field on biological objects. Cavitation, its physicochemical manifestation. Literature: [2, pp. 100-112].	2

In addition, students complete the independent work assignments listed in section 5, as well as in the methodological recommendations for practical and laboratory classes in accordance with the academic calendar.
During the semester, students must complete a home assignment (HA). The approximate topics for the HA are listed in Appendix 9.

Policy and control

7. Academic discipline (educational component) policy

Class attendance rules
Laboratory classes are mandatory to attend and complete assignments. In case of absence, the work must be made up either during consultation hours or with other groups by prior agreement with the instructor.
If a student misses a lecture or practical class, they must complete the assigned tasks and have an interview with the teacher on the material covered in the missed class. The interview is conducted during scheduled consultations. Lecture and practical class materials with assignments are posted on Google Classroom, which students will have access to at the beginning of the semester.
Admission to laboratory classes and defense of the report on the work performed
Before laboratory work, students undergo an interview with the teacher, based on the results of which a decision is made on their admission to the work.
The defense of the report on the laboratory work is held during the next scheduled laboratory class. The grade that the student receives for the laboratory class consists of the points received during the admission and defense.
The number of points is specified in the rating system (item 8).
Defense of the home control work (HCW)
The defense of the HTA takes place during consultations according to the schedule in the last two weeks of the semester or, by prior agreement with the teacher, at another time. The grade for the HTA has two components: for the explanatory note and for the answers during the defense. The final grade is announced during the defense.
DCR is assessed in accordance with p.8.
Incentive and penalty points and academic integrity policy *The most active students, in particular those who perform exemplary tasks based on the course materials, can receive from 1 to 10 points to their semester rating.*
Penalty points are applied if a student submits someone else's work as their own. In this case, they must redo the assignment.
Deadline and resit policy
The dates for the defense of coursework, exams, and resits are determined by the schedule approved by the dean of the faculty.

8. Types of control and rating system for assessing learning outcomes

Before the second assessment, students complete a modular control work (MCW). The MCW assignment consists of questions that are included in the semester control (clause 9), with the exception of those that were not covered in class.
The curriculum for the discipline "Interaction of Physical Fields with Bio-Objects" provides for the following rating system for assessing student performance.
A student's grade consists of points (on a 100-point scale) that they receive for:

1. *ongoing assessment of lecture material mastery (an average of 5 answers per student);*
2. *assessment of the student's independent work (according to item 6);*
3. *answers in practical classes (an average of 10 answers per student);*
4. *completion and defense of laboratory work;*
5. *homework assignments (DKR);*
6. *answers during the exam.*

The number of points and assessment criteria are determined as follows.

Rating (weighted) point system and assessment criteria

1. *Current control (independent study of topics, item 6 of the syllabus)*
   Weighted score – 2.
   The maximum number of points for 9 lectures is: 2 points × 8 = 16 points.

Assessment criteria:

– complete answer ..... 2 points;
– satisfactory answer..... 1 point;
– Unsatisfactory answer..... 0 points.

2. *Laboratory work*

Weighting score – 5. The maximum number of points for all laboratory work is: 5 points × 9 = 45 points.
Each laboratory work is assessed on the following criteria:

a) preparedness for work:
– fluency in theoretical material, availability of a prepared protocol..... 2 points;
– unpreparedness for laboratory work (failure) .....0 points;
b) defense of the work:
– complete answer during defense ..... 3 points;
– satisfactory response during defense .....2 points;
– incomplete answer during defense.....1 point;
– work defended on another day .....0 points.

3. *Modular control work (MCW)*

Weighting score – 15.
Assessment criteria:

– complete answer to the question..... 13 to 15 points;
– discussion of the topic with minor errors..... 8 to 12 points;
– sufficient coverage of the topic, significant errors, poor quality of work..... 4 to 7 points;
– incomplete or superficial answers, poor presentation of the work.....1 to 3 points;
– all answers are incorrect .....0 points.

4. *Homework assignment (HZA)*

Weighting – 24 points.
Assessment criteria:

– complete disclosure of the topic of the task and mastery of it with reflection of one's own position and appropriate formatting of the work 21 to 24 points;
– sufficient coverage of the topic with minor errors. 16 to 20 points;
– sufficient coverage of the topic, errors, poor quality of the work .....7 to 15 points;
– incomplete or superficial coverage of the topic, poor quality of the work of the work from 1 to 6 points;
– the topic is not covered, the task is not completed ..... 0 points.

5. *Penalty points for:*

– not being admitted to laboratory work due to unsatisfactory initial assessment. .. - 1 point;

– absence from a lecture, practical or laboratory class without a valid reason…….. -1 point;

– late (more than a week) completion of coursework…….. -2 points.

The total number of penalty points shall not exceed Rs = 10 points.

Calculation of the semester rating

The maximum possible points for control measures (items 1-5) during the semester are:

R = 16 + 45 + 24 + 15 = 100 points.

Conditions for a positive interim assessment

– To receive a "pass" on the first interim assessment (week 8), the student must score at least 16 points ("ideal" student – 32 points).

– To receive a "pass" on the second interim assessment (week 14), the student must earn at least 32 points (an "ideal" student earns 64 points).

The maximum number of points is 100. A prerequisite for admission to the exam is the completion of all laboratory work and HCW.

To receive a credit for the credit module "automatically," you must have a rating of at least 60 points and have all laboratory work and HCWs credited.

Students who have a rating of less than 60 points at the end of the semester, as well as those who want to improve their grade, take a final exam. In this case, the points for the final exam and laboratory work should be added to the points for the test, and this rating is final. The test consists of three questions from different sections of the work program from the list provided in the methodological recommendations for completing the credit module.

For each question, the student can receive points according to the assessment system:

– "excellent," complete answer (at least 90% of the required information)…….. 9-10 points;

– "good," sufficiently complete answer (at least 75% of the required information). …… 7-8 points;

– "satisfactory," incomplete answer (at least 60% of the required information).. 5-6 points;

– "sufficient," incomplete answer (at least 50% of the required information) 3-4 points;

– "unsatisfactory," unsatisfactory answer (less than 50% of the required information)... 0-2 points.

The sum of the student's points in the case of receiving a credit for the credit module "automatically", or the sum of points for DCR, laboratory work and credit control work should be transformed into a credit grade according to the table:

Table of correspondence between rating points and grades on the university scale

Number of points	**Grade**
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient

Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

List of questions for semester assessment

1. *Explain the meaning of the term "physical fields." Give examples of artificial and natural fields.*
2. *Explain how the properties of electromagnetic waves depend on their wavelength.*
3. *Name the individual regions of the electromagnetic radiation spectrum.*
4. *Explain the overall effect of solar radiation on the human body.*
5. *Describe the range of electromagnetic waves that are longer than infrared radiation.*
6. *What are the main properties of radio waves? What determines the range of radio waves?*
7. *Describe the ranges into which radio waves are divided in radio engineering.*
8. *Describe the effect of radio waves of different lengths and powers on living organisms.*
9. *Name ways to protect the population from constant and variable electromagnetic fields.*
10. *Describe the attenuation of electromagnetic fields by materials.*
11. *What is the difference between laser and ordinary visible radiation?*
12. *Explain spatial and temporal coherence.*
13. *What is wave polarization? Types of polarization.*
14. *Explain the concept of inversion population of energy levels of atoms (molecules) of a substance.*
15. *Gas lasers, their main characteristics and features.*
16. *Solid-state lasers, their main characteristics and features.*
17. *The effect of laser radiation on living organisms.*
18. *Name the main parameters of the Sun as a star and as the main natural source of radiant energy on Earth.*
19. *Explain the effect of solar radiation on the properties of the Earth's atmosphere.*
20. *Explain the effect of the Earth's atmosphere on the change in the spectrum of electromagnetic radiation oscillations as it passes to the Earth's surface.*
21. *Show the dependence of solar radiation on the latitude of the area.*
22. *What proportion of the Sun's total radiation is infrared radiation?*
23. *What is scattered solar radiation? The role of scattered radiation in the overall balance of solar radiation.*
24. *What environmental parameters improve human "thermal comfort"?*
25. *Name the main artificial sources of infrared radiation.*
26. *Draw and explain a graph showing the dependence of infrared radiation transmission on wavelength for certain parts of the human body.*
27. *What part of the energy of IR radiation is transmitted and reflected by human skin?*
28. *Human skin as a source of its own radiation.*
29. *What proportion of a person's own heat loss is due to radiation, convection, and evaporation?*
30. *The biological effect of infrared radiation on living organisms.*
31. *List the parts of the human body that are affected by infrared radiation.*
32. *The Sun is the main source of visible light on Earth.*
33. *How does average illumination depend on the Sun's altitude above the horizon?*
34. *What is direct and scattered or diffuse illumination?*
35. *The effect of snow cover and various types of clouds on the apparent illumination of the Sun.*
36. *The biological effect of the light part of the Sun's radiation spectrum.*
37. *The effect of visible rays on the human nervous and muscular systems, depending on their wavelength.*
38. *The spectral composition of UV radiation that reaches the Earth.*
39. *What factors influence the composition of UV radiation on the Earth's surface?*
40. *Determine the unit of erythemal action of ultraviolet rays. What is the average amount of radiation required to cause erythema?*
41. *What are microerythema and microbacteria?*
43. *The effect of scattered ultraviolet radiation on the erythemal effect.*
44. *The effect of atmospheric conditions on the reduction of ultraviolet radiation.*
45. *How can the effect of UV radiation on the human body be increased (decreased)?*

46. *Describe the groups into which artificial sources of ultraviolet radiation are divided.*
47. *Name the methods of generating ultraviolet radiation. Describe the main artificial sources of ultraviolet radiation.*
48. *Explain the formation of ozone in the Earth's atmosphere under the influence of ultraviolet rays. At what altitude is the main ozone layer located?*
49. *Explain the effect of ultraviolet radiation on the ionization of air and other environments.*
50. *What processes occur in the human body under the influence of ultraviolet rays? Explain the occurrence of erythema and pigmentation on human skin.*
51. *Show the dependence of skin reflection and transparency on the wavelength of ultraviolet radiation.*
52. *Explain the effect of ultraviolet radiation, which results in the formation of vitamin D in the human body. The role of vitamin D in the body's vital functions.*
53. *Explain the effect of ultraviolet rays on certain bacteria.*
54. *Damage to individual human organs by ultraviolet radiation.*
55. *How X-rays interact with matter. What physical processes lead to their attenuation?*
56. *According to what law does the intensity of X-rays change as they propagate in biological tissues?*
57. *What is the Hounsfield scale and the HU unit of measurement?*
58. *What are the main requirements for penetrating radiation used in medicine?*
59. *Name natural and artificial sources of X-ray radiation.*
60. *The effect of X-rays on biological objects.*
61. *Means of protecting living organisms from the negative effects of X-rays.*
62. *In which fields of medicine is X-ray radiation used?*
63. *Explain the principles of classical computed tomography.*
64. *Describe α-, 6-, and γ-particles. Name the sources of their origin.*
65. *In which case does radioactive decay produce a neutron flux?*
66. *What does the presence of neutrons in the flow of elementary particles indicate?*
67. *Describe the penetrating effect of α-, b-particles, neutrons, and γ-rays in different environments.*
68. *The effect of radiation on biological objects.*
69. *What is an acoustic field? List its main characteristics.*
70. *Explain the nature and physical characteristics of acoustic waves.*
71. *Describe the acoustic properties of human biological tissues and name the factors that affect them.*
72. *Physical and physicochemical effects of acoustic radiation on biological objects.*
73. *Explain the phenomenon of cavitation and give examples of its biomedical applications.*
74. *What are the main parameters of biological tissues in ultrasound diagnostics?*
75. *How is the coefficient of reflection of ultrasonic waves from the boundary between two media determined?*
76. *What are the coefficients of absorption, scattering, and attenuation of ultrasonic waves?*
77. *What is the essence of the Doppler effect? What physiological indicators of a person can be recorded using the Doppler method?*
78. *Name the methods of ultrasonic sonar. Which of them is more common?*
79. *Explain the principle of operation of an ultrasonic diagnostic device.*
80. *What are the criteria for classifying modern ultrasonic scanners?*
81. *Give a definition of a cell as an elementary living system. General structure and its main elements.*
82. *The cell as the basic structural and functional unit of tissue. Name the main components of the cell and their morphological and functional characteristics.*
83. *The cell cycle. Its stages, morpho-functional characteristics. Features of the cell cycle in cells of different species.*
84. *The nucleus, its importance in cell life. Main components. Nuclear-cytoplasmic ratios as an indicator of a person's functional state.*
85. *Tissue as one of the levels of organization of living organisms. The concept of cell populations.*
86. *Name the main types of tissues in the human body and their morphological and functional characteristics.*
87. *Name the main systems of the human body, give their structural-functional and morpho-functional characteristics.*
88. *Describe the organs of the central nervous system and give a general morphological and functional description. The structure of white and gray matter.*
89. *Explain the mechanism of nerve impulse transmission.*

90. *Red and yellow bone marrow.*
91. *Provide a morpho-functional description of the endocrine system.*
92. *Functional characteristics of the cardiovascular system and blood-forming organs.*

Approximate topics for the final exam

No	Topic
1	Calculation of the design parameters of electromagnetic screens when working with sources of non-ionizing radiation. Task options: • frequency range (high, ultra-high, extremely high frequencies); • screen material, intensity of electromagnetic radiation sources.
2	Calculation of the design parameters of electromagnetic screens when working with sources of non-ionizing radiation. Task options: • frequency range (high, ultra-high, extremely high frequencies); • screen material, intensity of electromagnetic radiation sources.
3	Calculation of radio frequency radiation reflection and absorption coefficients by biological media. Task options: • frequencies (high, ultra-high, extremely high frequencies); • type of biological medium (blood, skin, muscle, bone, etc.).
4	Calculation of the absorption coefficient of laser radiation by biological tissues. Task options: • type of biological tissue (blood, skin, muscle, bone, etc.); • wavelength of laser radiation.
5	Calculation of the main characteristics of an artificial source of ultraviolet radiation for biomedical applications. Task options: • mercury arc lamps for medical use of various types and power ratings.
6	Determination of the thickness of protective screens when working with sources of ionizing radiation. Task options: • type of ionizing radiation source (flow of α-, β-particles, neutrons, or γ-rays); • intensity of particle or radiation flux.
7	Calculation of the characteristics of ultrasound propagation in biological tissues. Task options: type of biological environment in which ultrasonic radiation propagates (muscles, bones, glands, other internal organs).

Description of material, technical, and informational support for the discipline

Laboratory classes involving the use of software
are held in computer classrooms (402-17, 404-17), which have 18 workstations with installed programs. Methodological recommendations for practical tasks have been developed and are available on Google Classroom.
Laboratory classes are held in the training laboratory (301-17) and with models for performing the tasks specified in paragraph 5. Methodological recommendations for the tasks are posted on Google Classroom.
Laboratory work in the discipline "Interaction of physical fields with bio-objects" is carried out in a computer classroom on modern computers in the COMSOL Multiphysics software environment (demo version). The classroom is equipped with 12 computers, which allows each student to work independently. The computer lab also has a large screen on which the instructor demonstrates and explains how to perform more complex tasks. However, it is not prohibited to perform tasks on your own laptops if it is more convenient for students; for this purpose, there are specially designated seats without computers in the classroom.
The working program of the academic discipline (syllabus):

Compiled by Peregudov S. M.;
Approved by the PRE Department (Minutes No. 06/2024 dated 06/27/2024)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2024 dated 28.06.2024)