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

Department
biomedical engineering

Medical physics

Working program of basic discipline (Syllabus)

Requisites for basic discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*16 Chemical and bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical engineering*
Discipline status	*Mandatory discipline*
Form of study	*full-time / day / mixed / remote*
Year of preparation, semester	*1 course, autumn semester*
The scope of discipline	*6 ECTS credit (180 hours)*
Semester control / control measures	*Modular Test Work, Home Control Work, Exam*
Lessons schedule	*Lectures (46 hours) - 3 lessons / 2 weeks, practical lessons (44 hours) - 3 lessons / 2 weeks (According to the schedule on the website http://rozklad.kpi.ua/)*
Language of instruction	*English*
Information about the course leader / teachers	***Lecturer:*** *PhD. physical and mathematical Sciences, Associate Professor, Andriy Vyacheslavovich Solomin, a.solomin@kpi.ua ; andr-sol@i.ua ; Phone 0509271063* ***Practical:*** *PhD. physical and mathematical Sciences, Associate Professor, Andriy Vyacheslavovich Solomin, a.solomin@kpi.ua ; andr-sol@i.ua ; Phone 0509271063*
Teacher profile	*https://intellect.kpi.ua/profile/sav231* *http://bmi.fbmi.kpi.ua/department/staff-department/*
Course placement	*Sikorsky (Moodle) https://do.ipo.kpi.ua/course/view.php?id=1605* *Individual video conference room Zoom 650 976 8233*

Curriculum of the discipline

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

The discipline "Medical Physics" belongs to the cycle of normative (mandatory) disciplines of the cycle of general training of masters. It is designed for students who have a bachelor's degree in engineering.
The discipline "Medical Physics" deals with the study of systems consisting of physical radiation, the human body (and its diseases), medical and diagnostic technologies, devices, drugs and materials, as well as the use of methods and tools of physics, mathematics and technology, physical radiation and devices for diagnosis, treatment and prevention of diseases.
"Medical physics" in a broad sense covers all medical applications of physical phenomena, i.e. the volume of topics can be compared with physics. But historically and in connection with the needs of the market it has happened that the discipline "Medical Physics" in the conventional narrow sense means medical radiation physics. It is the biomedical industry that needs specialists in this area in increasing numbers. This is due to the expansion of the range of relevant therapeutic and diagnostic medical equipment, the specifics of medical radiation physics, the complexity of the nature of physical processes, which requires engineering and physical qualification of specialists, and the importance of their basic competencies in biomedicine.

The purpose of the discipline

The main purpose of the discipline "Medical Physics" is the formation of students' ability to solve complex specialized problems of radiation and biological action of ionizing radiation, practical calculation of the activity of radiation sources, quantitative assessment of the effects of ionizing radiation with matter and the corresponding biological impact, therapeutic and diagnostic equipment and technical control of radiation safety of medical procedures.

Training in the discipline "Medical Physics" is carried out on the basis of student-centered approach and strategy of interaction between teacher and student in order for students to master the material and develop their practical skills.

As the discipline "Medical Physics" is considered difficult to learn and one that is developing very rapidly, as well as bearing in mind the requirements of industry standards and the specifics of medical and biological applications and significantly heterogeneous nature of general training, its teaching is guided by the following principles.

The methodical model of teaching the discipline is based on the use of active teaching methods. The organization is based on the following principles:

- the choice of teaching methods depending on the various factors influencing the organization of the educational process, the contingent of students;

- heuristic methods (methods of creating ideas, methods of solving creative problems, methods of activating creative thinking);

- active participation of students in the learning process;

- giving examples of the use of theoretical material to real practical situations;

- emphasizing the features of the subject in relation to the medical and biological aspects of use, interest in new developments and technologies;

- flexible and differentiated approach to each student, taking into account the degree of general training;

- forecasting the directions of technology development in the future.

During the study and for interaction with students, modern information-communication and network technologies are used, the corresponding online course in the Moodle system is developed and constantly improved.

Program competencies

General competencies

GC 1	*Ability to abstract thinking, analysis and synthesis.*
GC 2	*Ability to search, process and analyze information from various sources.*
GC 3	*Ability to identify, pose and solve problems.*
GC 4	*Ability to work in a team.*
GC 5	*Ability to work in an international context.*

Special (professional) competencies:

PC 1	*Ability to solve complex problems of biomedical engineering using the methods of mathematics, natural and engineering sciences.*
PC 2	*Ability to develop a working hypothesis, plan and set experiments to test the hypothesis and achieve the engineering goal using appropriate technologies, technical means and tools.*
PC 3	*Ability to analyze complex medical engineering and bioengineering problems and formalize them to find quantitative solutions using modern mathematical methods and information technology.*
PC 5	*Ability to develop terms of reference for creation, as well as to model, evaluate, design and construct complex bioengineering and medical engineering systems and technologies.*
PC 6	*Ability to study biological and technical aspects of functioning and interaction of artificial biological and biotechnical systems.*

PC 8	*Ability to develop models and* perform *experiments aimed at solving problems related to human health, according to the specific needs of scientific research, to analyze, explain the results and evaluate the cost of research.*
PC 11	*Ability to develop, plan and apply mathematical methods in the analysis, modeling of the functioning of living organisms, systems and processes in biology and medicine.*
PC 12	*Ability to perform research and observations on the interaction of biological, natural and artificial systems (prostheses, artificial organs, etc.), to plan biotechnical tests of artificial prostheses and systems.*

Program learning outcomes:

PLO 1	*Understanding of fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of physiological and pathological processes of the person.*
PLO 2	*Understanding the principles of action of modern diagnostic equipment and display systems of biomedical information, the basis of appropriate software.*
PLO 3	*Possession of modern methods of scientific research software, construction of adequate theoretical models and methods of their substantiation.*
PLO 4	*Application of calculation methods and selection of classical and new designs of biomaterials, elements of devices and systems of medical appointment.*
PLO 7	*Possession of methods research, design and construction of objects of biomedical engineering, analysis and processing of experimental data.*
PLO 8	*Knowledge of general requirements for the conditions of engineering, technological and scientific projects.*
PLO 9	*Knowledge of the principles of development and modern problems of creating biocompatible materials in medical practice.*
PLO 13	*Knowledge of a foreign language to an extent sufficient for general and professional communication*

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

The discipline "Medical Physics" is interdisciplinary. It integrates according to its subject knowledge from other disciplines (bachelor's degree programs): physics, biophysics, biochemistry, radiation safety and dosimetry; biomedical devices, apparatus and complexes; devices for monitoring physiological parameters of a person, etc. According to the structural and logical scheme of the master's program, the discipline is closely related to other disciplines of general and professional training: "Biomedical information display systems", "Diagnostic and therapeutic methods in arrhythmology and electrophysiology" .

The acquired practical skills and acquired theoretical knowledge during the study of the discipline "Medical Physics" can be used in the future during the acquisition of disciplines:

- from selective disciplines (educational-professional program "Medical Engineering"): "Physiotherapeutic medical devices", "Electronic sensors and biochips", "Biophotonics and nanoelectronics", "Medical devices and technologies".

The acquired practical skills and acquired theoretical knowledge during the study of the discipline "Medical Physics" can be used in the future during the undergraduate practice, for the preparation of a master's thesis and in further practical work in the specialty.

Necessary skills

1. Knowledge and practical skills in solving problems in physics.

2. Possession of knowledge and methodology in biophysics.

3. Knowledge of the basics of clinical engineering and radiology.

3. The content of the discipline

The main sections and topics that will be considered in the process of studying the course:

Section 1. Introduction. Tasks, history and problems of medical physics. Rights and responsibilities of a medical physicist. Medical and physical deontology.

Topic 1.1. Subject and tasks of medical physics. The purpose of medical physics. Connection of medical physics with other subjects.

Topic 1.2. History of medical physics.

Topic 1.3. Rights and responsibilities of a medical physicist. Medical and physical deontology.

Section 2. Bioacoustics.

Topic 2.1. The main characteristics of auditory sensation. Parameters of sound measurements.

Topic 2.2. Sound research methods in medicine.

Topic 2.3. Components of impedance. Reflection of sound waves. Reverberation.

Section 3. Ultrasound and its application in medicine.

Topic 3.1. Ultrasound in medicine. Ultrasound physics.

Topic 3.2. Piezoelectric effect.

Topic 3.3. Acoustic resistance, its effect on the passage of ultrasound. Attenuation of ultrasound in biological tissues.

Section 4. Hemodynamic processes and blood circulation.

Topic 4.1. Rheological and hemodynamic parameters of blood.

Topic 4.2. Frank's model. Pulse wave. Transfer of substances in the capillary network.

Topic 4.3. Methods and devices for measuring blood pressure.

Section 5. Thermodynamics and diffusion processes.

Topic 5.1. Features of biological objects as thermodynamic systems.

Topic 5.2. The first law of thermodynamics in the bioenvironment.

Topic 5.3. The second law of thermodynamics for open environments.

Topic 5.4. Chemical and electrochemical potentials. Standard free energy.

Topic 5.5. Entropy growth. Dissipative function. Conjugate processes.

Topic 5.6. Criteria for achieving stability and achieving steady state. The body as an open system.

Section 6. Physical features of biological membranes. Metabolism and energy in membranes.

Topic 6.1. The structure of the functioning of the membranes.

Topic 6.2. Artificial membrane structures.

Topic 6.3. Membrane parameters. Phase transitions.

Section 7. Electro- and magnetodynamic processes in biological nature.

Topic 7.1. Electric and magnetic fields of man. Physical bases of electrocardiography.

Topic 7.2. Membrane theory of the origin of potentials in biocells.

Topic 7.3. Conduction functions.

Topic 7.4. Magnetic properties of body tissues. Physical foundations of magnetobiology.

Section 8. Electromagnetic oscillations and waves in biomedicine.

Topic 8.1. Electromagnetic fields in biomedicine. Features of different frequency ranges.

Topic 8.2. Physical principles of quantitative description of electromagnetic phenomena.

Topic 8.3. Diagnosis using electromagnetic radiation of different frequency ranges.

Topic 8.4. Therapy using electromagnetic radiation.

Section 9. Thermal radiation in technical and biological environments.

Topic 9.1. Parameters and characteristics of thermal radiation. Laws of black body radiation.

Topic 9.2. Heat transfer of an organism. The concept of thermography.

Topic 9.3. Infrared radiation and its application in medicine.

Topic 9.4. Ultraviolet radiation and its application in medicine.

Section 10. Elements of nuclear physics. Physical models of the atomic nucleus. Radioactivity. Law of radioactive decay.

Topic 10.1. Composition and structure of the nucleus. Nuclear forces and physical models of the nucleus. Defect of mass and binding energy of the nucleus.

Topic 10.2. Radioactivity. Law of radioactive decay.
Topic 10.3. Types of ionizing radiation and their characteristics.

Section 11. Dosimetry. Quantitative characteristics of radioactive radiation and the extent of its effect on the body. Radiation safety when using ionizing radiation in medicine.

Topic 11.1. The concept of exposure, absorbed, equivalent and effective equivalent radiation doses. Units of measurement.
Topic 11.2. Dosimetry methods.
Topic 11.3. Radiation safety standards in Ukraine.

Section 12. Types and mechanisms of radioactive decay. Schemes of radioactive decay. Radionuclides as sources of ionizing radiation.

Topic 12.1. Types and mechanisms of radioactive decay. Schemes of radioactive decay.
Topic 12.2. Radionuclides used in nuclear medicine. Methods of obtaining radionuclides.
Topic 12.3. Radioisotope generator. Physical characteristics of radioisotopes.

Chapter 13. Non-radioactive ionizing radiation photon generation. X-ray tube, linear accelerator.

Topic 13.1. X-ray formation. Spectral and azimuth distribution of bremsstrahlung intensity.
Topic 13.2. Characteristic radiation. Mosley's law.
Topic 13.3. Structure and characteristics of the X-ray tube.
Topic 13.4. Linear accelerator, principle of operation, types, characteristics.

Section 14. Interaction of radiation with matter. Mechanisms of interaction of electrons and photon radiation with matter.

Topic 14.1. Elastic scattering of electrons, excitation, ionization, bremsstrahlung by the interaction of electrons with matter.
Topic 14.2. Interaction of photons with matter: coherent scattering, photoelectric effect, compton effect, creation of electron-positron pairs.

Section 15. Types and mechanisms of interaction of neutrons and heavy charged particles with matter.

Topic 15.1. Interaction of neutrons with matter: elastic and inelastic scattering, radiation capture with radiation of charged particles and gamma quanta, fission of nuclei.
Topic 15.2. Interaction of heavy charged particles with matter: elastic scattering, excitation, ionization, generation of bremsstrahlung.

Section 16 Quantum-mechanical bases of explanation of microparticle interaction phenomena.

Topic 16.1. The wave nature of the phenomena of the microworld. Wave function.
Topic 16.2. Schrödinger's equation and its consequences.
Topic 16.3. Discrete energy states of atoms and nuclei and transitions between them – the basis of modern applications of medical physics, MRI technologies, lasers, radioactive sources of gamma radiation, etc.
Topic 16.4. The current state – paradoxes and prospects for the use of quantum mechanical effects.

Chapter 17. Biological effects of ionizing radiation. Principles of radiation therapy.

Topic 17.1. Molecular-cellular mechanisms of radiation exposure.
Topic 17.2. Radiation and chemical DNA damage. Repair of DNA and other molecules in the cell. Oxygen effect.
Topic 17.3. Basics of radiation therapy.

Section 18. Methods of radiation therapy.

Topic 18.1. Remote or external radiotherapy, brachytherapy, nuclear medicine or radioisotope therapy.
Topic 18.2. Surface, orthovolt therapy, telegamma therapy, intraoperative radiotherapy, distance heavy particle therapy, distance megavoltage X-therapy.
Topic 18.3. Interstitial, intracavitary, application brachytherapy.

Section 19. Principles of quantitative radiobiology and target theory.

Topic 19.1. The nature of exponential dose dependences of cell survival.
Topic 19.2. Principles of target theory. Unique and massive cell structures.
Topic 19.3. Multi-impact targets.

Section 20. Hardware of radiation therapy.

Topic 20.1. Methods of radiation therapy. Tomotherapy.

Topic 20.2. Radiation therapy planning.
Topic 20.3. Devices for radiation therapy.

Chapter 21. Detectors of ionizing radiation, their types, principles of operation and application.

Topic 21.1. Trace detectors.
Topic 21.2. Ionization, scintillation, semiconductor, photoemulsion detectors.
Topic 21.3. Dosimeters, radiometers.
Topic 21.4. Physical principles of action and application.

Section 22. Radiosurgery and radiotherapy. Stereotactic surgery. Gamma knife. Linear accelerator.

Topic 22.1. Radiosurgery and radiotherapy – common and differences, current trends.
Topic 22.2. Stereotactic surgery and radiosurgery. Hardware.
Topic 22.3. Gamma knife.
Topic 22.4. Linear accelerator.

Section 23. Structure and principle of operation of the CyberKnife.

Topic 23.1. Structure and principle of operation of a CyberKnife. Comparative analysis with other means of radiotherapy and radiosurgery.
Topic 23.2. Image management system. Comparative position tracking method. Synchronization method. Predicting the patient's movements.
Topic 23.3. Advantages and prospects of using heavily charged particles in radiosurgery.

4. Training materials and resources

Basic literature

1. *S.A.Kane, B.A.Gelman. Introduction to physics in modern medicine. – CRC Press, 2020. – 451p. https://filesdo.com/c95b99865e5baaf3?pt=sWZC7w3iXfv0xrU0PMIPkAIcqxtaxCJ04uOGSVSXSlq%3D*
2. *Daniel Jirák, František Vítek. Basics of medical physics. – Prague: Charles University Karolinum Press, 2017. – 224p. https://filesdo.com/bed116e92eb7a7ed?pt=B85tfibMhupqC%2BfPl2YKxMXf4%2Bmtw3rvEjDh8UID9ro%3D*
3. *J.D.Bronzino. The Biomedical Engineering Handbook. – USA: Taylor & Francis Group, 2006. – 1404p. https://www.academia.edu/42026274/The_Biomedical_Engineering_Handbook_Third_Edition_Biomedical_Engineering_Fundamentals*

Additional literature:

4. *Терещенко М.Ф. Біофізика: підручник / М.Ф.Терещенко, Г.С.Тимчик, І.О.Яковенко. - Київ: КПІ ім. Ігоря Сікорського, Вид-во «Політехніка», 2019. – 444 с. // https://ela.kpi.ua/bitstream/123456789/27589/1/Biophysics.pdf*
5. *Ремизов А. Н. Медицинская и биологическая физика : Учеб. по физике для студ. мед. вузов / А.Н. Ремизов, А.Г. Максина, А.Я. Потапенко / 4 изд., перераб. и доп. - М. : Дрофа, 2003. - 560 с. // https://www.booksmed.com/biologiya/843-medicinskaya-i-biologicheskaya-fizika-remizov.html*
6. *Костылев В.А., Наркевич Б.Я. Медицинская физика. М.: Медицина, 2008. - 464с. // https://www.studmed.ru/kostylev-va-narkevich-bya-medicinskaya-fizika_68630f2838e.html*
7. *Гродзинський Д. М. Радіобіологія. - К. : Либідь, 2001 - 448 с. //*
8. *http://www.twirpx.com/file/839255/*
9. *Мухин К.М. Экспериментальная ядерная физика: Учеб. для вузов. – М.: Энергоатомиздат, 1993. - 376с. // http://nuclphys.sinp.msu.ru/books/np/mukhin1_1.htm*

Information resources

10. *Sikorsky Platform - https://do.ipo.kpi.ua/course/view.php?id=1605*
11. *http://info-library.com.ua/books-text-4072.html*
12. *http://www.twirpx.com*

Educational content

5. Methods of mastering the discipline (educational component)

№ s / n	Topic	Program learning outcomes	The main tasks	
			Control measure	Term implementation
1.	Introduction. Tasks, history and problems of medical physics. Rights and responsibilities of a medical physicist. Medical and physical deontology	PLO 1, 13	Practical work 1	1st week
2.	Bioacoustics	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 2	2nd week
3.	Ultrasound and its application in medicine	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 3	2nd week
4.	Hemodynamic processes and blood circulation	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 4	3rd week
5.	Thermodynamics and diffusion processes	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 5	4th week
6.	Physical features of biological membranes. Metabolism and energy in membranes	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 6	4th week
7.	Electro - and magnetodynamic processes in biological nature	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 7	5th week
8.	Electromagnetic oscillations and waves in biomedicine	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 8	6th week
9.	Thermal radiation in technical and biological environments	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 9	6th week
10.	Elements of nuclear physics. Physical models of the atomic nucleus. Radioactivity. Law of radioactive decay	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 10	7th week
11.	Dosimetry. Quantitative characteristics of radioactive radiation and the extent of its effect on the body. Radiation safety when using ionizing radiation in medicine	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 11	8th week
12.	Types and mechanisms of radioactive decay. Schemes of radioactive decay. Radionuclides as sources of ionizing radiation	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 12	8th week
13.	Non-radioactive ionizing radiation photon generation. X-ray tube, linear accelerator	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 13	9th week
14.	Interaction of radiation with matter. Mechanisms of interaction of electrons and photon radiation with matter	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 14	10th week
15.	Types and mechanisms of interaction of neutrons and heavy charged particles with matter	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 15	10th week
16.	Quantum-mechanical bases of explanation of ***microparticle interaction phenomena***	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 16	11st week

№ s / n	Topic	Program learning outcomes	The main tasks	
			Control measure	Term implementation
17.	Biological effects of ionizing radiation. Principles of radiation therapy	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 17	12nd week
18.	Methods of radiation therapy	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 18	12nd week
19.	Principles of quantitative radiobiology and target theory	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 19	13rd week
20.	Hardware of radiation therapy	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 20	14th week
21.	Detectors of ionizing radiation, their types, principles of operation and application	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 20	14th week
22.	Radiosurgery and radiotherapy. Stereotactic surgery. Gamma knife. Linear accelerator	PLO 1, 2, 3, 4, 7, 8, 9, 13	Practical work 21	15th week
23.	Structure and principle of operation of the CyberKnife	PLO 1, 2, 3, 4, 7, 8, 9, 13	MCR	16th week
24.	Modular control work	PLO 1-9, 15, 24, 25	Writing MCR	16th week
25.	Home control work	PLO 1, 2, 3, 4, 7, 8, 9, 13	Registration and submission of work	17-18th week

Distance learning platform:

For more effective communication in order to understand the structure of the discipline "Medical Physics" and master the material used e-mail, telegram channel, distance learning platform "Sikorsky" based on KPI-Telecom Moodle system and service for online meetings Zoom, whereby:

- *increases the efficiency of communication with students, provides convenient feedback;*
- *simplifies the placement, access and exchange of educational material;*
- *students' learning tasks are evaluated;*
- *student activity is analyzed.*

6. Independent student work

The following types of independent work are planned: preparation for classroom classes, solving problems of practical work and preparation of reports, preparation for modular control work, performance of home control work, preparation for exam. A total of 88 hours are planned for independent work.

One of the main types of semester control during the mastering of the discipline "Medical Physics" is the performance of home control work (HCW). HCW is performed in accordance with the requirements, within the period specified by the teacher.

It aims to master the ability to identify current issues; additional, in-depth study and practical awareness of certain sections of the curriculum; development of skills of independent work with scientific literature.

The main purpose of homework is to solve a practical problem using the material learned in lectures and independently, and practical skills acquired in practical classes.

The student can write HCW only on the subject agreed with the teacher.

Approximate topics of home control work:

1. Physical and technical bases of computer tomography.

2. Mathematical bases of computer tomography.

3. Design and radiotherapy capabilities of a linear accelerator.
4. Design and radiotherapy capabilities of the cyber knife.
5. Rights and responsibilities of medical physicists and engineers in radiology departments.
6. Radiobiological bases of radiation therapy.
7. Physical and technical bases of positron emission tomography.
8. Physical and technical principles of ionizing radiation dosimetry.
9. Design and radiotherapeutic capabilities of isotopic devices.
10. Principles of radiation protection during medical irradiation.
11. Radiation safety standards (on the basis of normative documents).
12. Medical and biological side effects of ionizing radiation.
13. Analyze the design of a hybrid device PET / CT.
14. Analyze the design of a hybrid PET / MRI machine.
15. Analyze the design of a hybrid CT / MRI machine.
16. The principle of operation and design of ionization dosimeters.
17. The principle of operation and design of semiconductor dosimeters.
18. The principle of operation and design of scintillation dosimeters.

Students can also suggest and agree with the teacher their topic

The title page of the homework should have the following content: the name of the university; name of the faculty; name of department; name of specialty, name of educational-professional program, registration number, name of academic discipline; topic of home control work; surname and name of the student, course, number of the academic group, year.
The title page is followed by a detailed plan (content) of homework, which should highlight the introduction, sections of the main content, conclusion, list of sources used. The table of contents on the right indicates the page numbers at the beginning of each section. Each section begins on a new page.
The total amount of homework depending on the chosen topic can vary from 20 to 40 pages of the main text. The scope of homework is determined by the student's ability to briefly and comprehensively disclose the topic: the relevance of the topic under consideration, current trends and problems, analyze the best foreign and Ukrainian technologies, draw conclusions and justify their own suggestions and recommendations.
An annotation is provided for homework in two languages - Ukrainian and English, indicating keywords.
Mandatory requirement: clear reference to sources of information. All figures, facts, opinions of scientists, quotations, formulas should have a reference in the form [2, p.54] (the first digit means the source number in the list of references at the end of the work, and the second digit - the page number in this source). It is desirable to use tables, diagrams, graphs, charts, etc. The list of used sources (not less than 10 sources) is made out according to operating rules. If the information is taken from the Internet, you need, as for ordinary literature, specify the author, the title of the article, and then provide the address of the site on the Internet.
Home control work is evaluated by the following criteria: logic of the plan; completeness and depth of disclosure of the topic; reliability of the received data; reflection of practical materials and results of calculations; availability of illustrations (tables, figures, diagrams, screenshots of web pages, etc.); the number of sources used and the clarity of references to them; design; substantiation of the student's own opinion on this issue in the form of a conclusion.
Deadline for submission of homework for examination: 17th week of study.
Homework is not tested for plagiarism, but must meet the requirements of academic integrity. In case of academic dishonesty, the work is canceled and not checked.

Policy and control

7. Policy of academic discipline (educational component)

Attending classes

The missed lecture can be completed during the week by writing a synopsis on the relevant topic and showing the teacher the mastery of the material. Otherwise the penalty point "-1" is applied.
Missed practical training can be performed and defended during the week without penalty points. Otherwise the penalty point "-1" is applied.

Control measures missed

Missed control measures (defense of practical work) must be practiced in subsequent classes, provided that the task is scheduled for the current lesson, or in consultations.
Omissions to write a modular test are not fulfilled.
Home control work, which is submitted for inspection in violation of the deadline is evaluated with a decrease in the number of weight points.

Violation of deadlines and incentive points

Encouragement points		*Penalty points**	
Criterion	*Weight points*	*Criterion*	*Weight points*
Improving practical work	*+ 1 point (for each practical work)*	*Violation of deadlines for practical work (for each such work)*	*-1 point*
Passing distance courses on topics that are agreed with the teacher	*+ 5 points*	*Untimely execution and delivery of HCW*	*From -2 points to -10 points (depending on the delivery date)*
Registration of scientific work for participation in the competition of student scientific works	*+ 10 points*	*Missed and not completed during the week lecture*	*-1 point for each lesson*
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	*+ 5 points*		

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not accrued.*

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". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive education

The discipline "Medical Physics" can be taught to most students with special educational needs, except for students with severe visual impairments who do not allow to perform tasks using personal computers, laptops and / or other technical means.

Distance Learning

Distance learning takes place through the Sikorsky Distance Learning Platform.

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

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the distance course (in case of a full course) or provides completed practical tasks from the distance course and provided an interview with the teacher on the topics can receive grades for tests that are provided for the studied topics.

Performance of practical works, and also performance of modular control work can be carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Learning a foreign language

Teaching in English is carried out only for foreign students.

At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.

8. Types of control and rating system for assessing learning outcomes (Rating System of Evaluation)

Evaluation system (current control):

№ s / n	Control measure	%	Weight points	Number	Total
1.	Practical work	42	2	21	42
2.	Modular control work	12	12	1	12
3.	Home control work	6	6	1	6
4 .	Exam	40	40	1	40
	Total				100

Calendar control *(CC) - is carried out twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.*

The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.

Criterion			The first CC	The second CC
Term of calendar controls			8th week	14th week
Conditions for obtaining a positive result from the calendar control	Current rating		≥ 10 points	≥ 19 point s
	Performing practical work	PW№№ 1-11	+	+
		PW №№ 12-21	-	+
	Modular control work	Estimated MCW	-	-
	Home control work	Estimated HCW	-	-

In case of academic dishonesty during training - the control measure is not credited.

Semester certification of students

Mandatory condition for admission to the exam		Criterion
1	Current rating	RD ≥ 30
2	All practical works are protected	More than 20 points
3	Execution of modular control work	More than 10 points
4	Execution and protection of home control work	More than 6 points

The results are announced to each student separately in the presence of a control event or in a remote form (by e-mail , in the system "Sikorsky"). Also recorded in the "Electronic Campus" system.

Optional conditions for admission to the exam:

1. *Activity in practical classes.*
2. *Positive result of the first attestation and the second attestation.*
3. *Attending lectures.*

Table of translation of rating points to grades on the university scale:

Number points	*Assessment on the university scale*
100-95	*Perfectly / Відмінно*
94-85	*Very good / Дуже добре*
84-75	*Good / Добре*
74-65	*Satisfactorily / Задовільно*
64-60	*Enough / Достатньо*
Less 60	*Unsatisfactorily / Незадовільно*
Admission conditions are not met	*Not allowed / Не допущено*

The exam is performed in writing.

9. Additional information on the discipline (educational component)

The list of questions for preparation for modular control work, and also for preparation for exam is given in appendix 1.

Ability to enroll in certificates of distance learning

1. Online courses in the Moodle system

Distance learning through online courses in the Moodle system on certain topics is allowed subject to agreement with students. If a small number of students willing to go online course on a specific subject, study material through such courses is allowed but students have to complete all the tasks provided in the discipline (practical work, modular control work, TP).

2. Taking online courses on the Coursera platform

Students are offered courses on the Coursera platform, which give them the opportunity to obtain credits as blended or additional training, as well as to receive additional points in the discipline.

Courses from the Coursera for Campus catalog or online courses selected by students from the wider Coursera catalog complement the curriculum of the discipline. The list of distance courses is given on the website of the Department of Biomedical Engineering: http://bmi.fbmi.kpi.ua/non-formal-education

Work program of the discipline (syllabus) :

Compiled by: associate professor, PhD, Solomin Andriy Vyacheslavovich

Approved by the Department of Biomedical Engineering (protocol № 13 to 25.06. 2021);

Approved by the Methodical Commission of the Faculty of Biomedical Engineering (protocol № 11 to 25.06.2021)

Appendix 1 to the syllabus of the discipline "Medical Physics"

The list of questions for preparation for modular control work, as well as to prepare for the exam

Question I

1. *Explain the features of the application of the principles of deontology for medical physicists.*
2. *Analyze the rights and responsibilities of a medical physicist.*
3. *Reveal modern ideas about the composition and structure of the atomic nucleus.*
4. *Explain the essence of the concept of "ionizing radiation" and describe its types.*
5. *Reveal the law of radioactive decay and its application.*
6. *Analyze the means of generating ionizing radiation.*
7. *Explain the physical meaning of dosimetric quantities.*
8. *Compare the concepts of exposure, absorbed, equivalent and effective equivalent radiation doses.*
9. *Analyze the methods of dosimetry.*
10. *Explain the current radiation safety standards in Ukraine.*
11. *Explain the types and mechanisms of radioactive decay.*
12. *Describe the schemes of radioactive decay.*
13. *Reveal the physical characteristics of radionuclides.*

Question II

14. *Explain the physical principles of X-ray generation.*
15. *Reveal the physical essence of characteristic radiation and Mosley's law.*
16. *Explain the structure and characteristics of the X-ray tube.*
17. *Explain the structure of a linear accelerator, the principle of operation, types, characteristics.*
18. *Analyze the interaction of electrons with matter.*
19. *Analyze the interaction of photon radiation with matter.*
20. *Analyze the interaction of neutrons and heavy charged particles with matter.*
21. *Reveal the content of modern ideas about the state, paradoxes and prospects of quantum mechanics.*
22. *Explain the nature of the discreteness of the energy states of quantum systems and its use in modern applications of medical physics. Give examples.*
23. *Analyze the features of quantum mechanical interpretation of the measurement of physical quantities, the concept of the operator of a physical quantity, the confusion of the states of quantum systems and the prospects for the use of these features.*
24. *Analyze the processes of interaction of ionizing radiation with biological tissues.*
25. *Describe radiation and chemical damage to DNA, repair of DNA and other molecules in the cell, oxygen effect.*
26. *Explain the nature of exponential dose dependences of cell survival under the action of ionizing radiation.*
27. *Describe the principles of target theory in radiobiology and their practical significance.*
28. *Compare the unique and mass structures of cells in terms of their survival criteria.*
29. *Explain the physical essence of the concept of multi-impact targets in radiobiology and the meaning of its consideration in practice.*

Question III

30. *Reveal the basic principles (ideas) of computer tomography.*
31. *Reveal the methods of radiation therapy.*
32. *Describe the principles of planning radiation therapy procedures.*
33. *Reveal the methods of radiosurgery.*
34. *Explain the principle of operation and design of ionization radiation detectors.*
35. *Explain the principle of operation and design of semiconductor radiation detectors.*

36. *Explain the principle of operation and design of scintillation radiation detectors.*
37. *Explain the physical and technical foundations and radiotherapy capabilities of the gamma knife.*
38. *Explain the physical and technical foundations and radiotherapy capabilities of a linear accelerator.*
39. *Explain the physical rubber base and radiotherapy capabilities of CyberKnife.*

Question IV. Task.