National Technical University of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

Department biomedical engineering

Course work on the discipline

RADIATION SAFETY AND DOSIMETRY

Working program of the academic discipline (Syllabus)

Requisites for basic discipline	
Level of higher education	***First (bachelor'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*
Year of preparation, semester	*3rd course, autumn semester*
The scope of discipline	*5 ECTS/150 hours*
Semester control / Control measures	*Exam, Control Homework, Calculation and Graphic Work*
Lessons schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course leader / teachers	**Lecturer**: Orel Valerii Bingovich, MD orel.valeriy@gmail.com **Practical**: Orel Valerii Bingovich, MD orel.valeriy@gmail.com
Course placement	Course page on Moodle: https://do.ipo.kpi.ua/course/view.php?id=370

Curriculum of the discipline

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

The main aim of the discipline "Radiation Safety and Dosimetry" (hereinafter "Radiation Safety") is to form students' ability to solve fundamental and practical problems of medical, physical and physicochemical properties in relation to biology and medicine using basic theories, physical, physical - chemical and physical-mathematical methods and computer technology.

The subject of "Radiation Safety" covers the basics of radiation physics and radiobiology, dosimetric quantities and units of measurement to assess the risk of ionizing radiation during the organization of radiation safety in medical institutions, research institutions, enterprises and radioactive waste disposal sites.

The acquired practical skills and theoretical knowledge during the study of the discipline "Radiation Safety" can be used for the following disciplines:

- from the cycle of professional training (educational-professional program "Medical Engineering"): "Biomedical devices, apparatus and complexes";

- from elective disciplines (educational-professional program "Medical Engineering"): "Therapeutic medical equipment", "Development and operation of physiotherapeutic medical devices", "Therapeutic and diagnostic complexes based on biophotonic transducers".

Given that the discipline is mandatory, it is necessary to be proficient with:

- *skills: knowledge of the basics of physics, biophysics, circuitry, methods to statistically analyze the obtained results in dosimetry of ionizing and non-ionizing radiation;*
- *competences: to apply statistical methods to the analysis of relationship and dynamics of phenomena; collection, processing and analysis of the initial data required to calculate dosimetric indicators that characterize the health of the population and the activities of health care facilities; analyze and interpret statistical data of medical and biological processes and phenomena, identify trends in changes in ionizing and non-ionizing radiation; use databases of dosimetric characteristics of data; mathematical and software for data processing and computer modeling to prevent unregulated human exposure.*

-

General competencies *(OPP was put into effect by the Rector's Order NON/ 89/2021 of* ***19.04.2021):***

- ***GC 1 -*** *Ability to apply knowledge in practical situations.*
- ***GC 2 -*** *Knowledge and understanding of the subject area and understanding of professional activity.*
- ***GC 6 -*** *Ability to search, process and analyze information from various sources.*
- ***GC 7 -*** *Ability to generate new ideas (creativity).*
- ***GC 8 -*** *Ability to make well-grounded decisions.*

Special (professional) competencies (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):

- ***PC 1*** *- Ability to use engineering software packages for research, analysis, processing and presentation of results, as well as for automated design of medical devices and systems.*
- ***PC 2*** *- Ability to provide engineering expertise in the process of planning, development, evaluation and specification of medical equipment.*
- ***PC 3*** *- Ability to study and apply new methods and tools for analysis, modeling, design and optimization of medical devices and systems.*
- ***PC 5*** *- Ability to apply physical, chemical, biological and mathematical methods in the analysis, modeling of the functioning of living organisms and biotechnical systems.*
- ***PC 12*** *- Ability to develop, plan and apply mathematical methods to analyze and model the function of biological object, systems and processes in biology and medicine*
- ***PC 14*** *- Ability to perfect experiments according to specified technical and medical methods, perform computer processing, analysis and synthesis of the results.*

The program learning outcomes after studying the discipline "Radiation safety" are *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

- ***PLO 6*** *- Knowledge of object research methods, analysis and processing of experimental data.*
- ***PLO 13*** *- Use of methods and means of systematization and processing of experimental information.*
- ***PLO 22*** *- Use of methods of statistical processing, modeling and simulation of processes and systems of physical and biological nature in biomedical engineering.*
- ***PLO 28*** *- Use of databases, mathematical and software for data processing and computer modeling of biotechnical systems.*

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

The discipline "Radiation Safety" is an interdisciplinary study that is used to apply existing

scientific knowledge from other disciplines: physics, biophysics, higher mathematics, human anatomy and physiology, etc. Following the structural and logical scheme of the training program, the discipline "Radiation Safety" is closely related to other disciplines of general and professional training: "Biophysics", "Fundamentals of Clinical Engineering and Radiology". It is immediately preceded by the discipline "Fundamentals of Clinical Engineering and Radiology".

The acquired practical skills and theoretical knowledge during the study of the discipline "Radiation Safety" can be used to study the following disciplines:

- from the cycle of professional training (educational-professional program "Medical Engineering"): "Biomedical devices, apparatus and complexes";
- from elective disciplines (educational-professional program "Medical Engineering"): "Therapeutic medical equipment", "Development and operation of physiotherapeutic medical devices", "Therapeutic and diagnostic complexes based on biophotonic transducers".

3. The content of the discipline

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

Subject 1. Types of ionizing radiation.

Subject 2. Interaction of ionizing radiation with matter.

Subject 3. Doses and units of ionizing radiation.

Subject 4. Methods and devices in dosimetry of ionizing radiation.

Subject 5. Ionizing radiation effects on cells and organs.

Subject 6. Dose loads and maximum permissible radiation exposures.

Subject 7. Regulatory documents in the field of radiation safety.

Subject 8. Physical and technical principles of equipment and radiation safety for radiation diagnostics and therapy.

Subject 9. Modular control work

Subject 10. Control Homework

4. Training materials and resources

Basic literature:

1. Иванов В. И. Курс дозиметрии : учебник для физич. и физ.-технич. спец. вузов / В.И. Иванов / 4 изд., перераб. и доп. - Москва: Энергоатомиздат, 1988. - 399 с. http://www.studmed.ru/ivanov-vi-kurs-dozimetrii_4a201af6617.html

2.Гродзинський Д. М. Радіобіологія - К. : Либідь, 2001- 448 с. // http://www.twirpx.com/file/839255/

3. Алексеев А. А. и др. ; под ред. А. В. Носовского. Вопросы дозиметрии и радиационная безопасность на атомных электрических станциях. - Славутич : Укратомиздат, 1998. - 405 с. // http://www.twirpx.com/file/1413399/

3.Костылев В.А., Наркевич Б.Я. Медицинская физика. М.: Медицина, 2008. - 464с. // http://www.twirpx.com/file/546057/

4. Тарутин И.Г. Радиационная защита при медицинском облучении. - Мн.: Выщ.шк, 2005. – 335 с.

5. Норми радіаційної безпеки України (НРБУ-97): Державні гігієнічні нормативи. ДГН 6.6.1.-6.5.001-98.- Київ, 1998. – 135 с.

6.Гудков І.М. Радіобіологія. К.2016. НУБіП України, 2016. – 485 с.// http://nubip.edu.ua/sites/default/files/u172/%_2016.pdf/

Additional literature:

1. Radiation Protection and Safety of Radiation Sources : International Basic Safety Standards // IAEA Safety Standards Series No. GSR. Part 3. – Vienna : IAEA, 2011. – 303 p.

2.Электромагнитное поле радиоволн в онкологии / В.Э. Орел, И.И. Смоланка, С.И. Коровин, А.Ю. Паливец, М.И. Данко, Н.Н. Дзятковская. – К.: Книга плюс, 2005. – 152 с.
3. Яремко З.М. Безпека життєдіяльності. Навчальний посібник / Яремко З.М. – Львів : Видав. центр ЛНУ ім. Івана Франка, 2005. – 300 с.
4. Мурашко В. О., Мечев Д. С., Бардов В. Г., Омельчук С. Т., Рущак Л. В., Ластков Д. О. Радіаційна гігієна: підручник для лікарів-інтернів та лікарів- слухачів. Вінниця .Нова книга. 2013. – 376 с.5.
5.Радіаційна безпека населення // Словник – довідник з екології : навч.-метод. посіб. / уклад. О. Г. Лановенко, О. О. Остапішина. — Херсон : ПП Вишемирський В.С., 2013. — С. 150.
6. Кутлахмедов Ю.О., Войціцький В.М., Хижняк С.В. Радіобіологія. Підручник. – К.: ВПЦ «Київський університет, 2011. – 543 с.

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	*Types of ionizing radiation.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 1*	*Week 3*
2.	*Interaction of ionizing radiation with matter.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 2*	*Week 4*
3.	*Doses and units of ionizing radiation.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 3*	*Week 5*
4.	*Methods and devices of ionizing radiation dosimetry.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 4*	*Week 6*
5.	*Ionizing radiation effects on cells and organs.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 5*	*Week 7*
6.	*Dose loads and maximum permissible exposure levels.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 6*	*Week 8*
7.	*Regulatory and legal documents in the field of radiation safety.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 7*	*Week 9*
8.	*Physical and technical principles of equipment and radiation safety for radiation diagnostics and therapy.*	PLO 6 PLO 13 PLO 22 PLO 28	*Practical work 8*	*Week 10*
9.	*Modular control work*	PLO 7 PLO 28	*Taking the modular control work*	*Week 11*
10.	*Control homework*	PLO18	*Preparation and handling in the work*	*Week 12-13*

6. Independent student work

One of the main types of semester control during the mastering of the discipline "Radiation Safety" is the performance of control homework. Control homework is performed according to the requirements, within the period specified by the teacher.

The main purpose of control homework is to solve a practical problem using the material gained in lectures and independent work, skills acquired during practical work. The student can write homework only on the subject agreed with the teacher.

Approximate subject of control homework:

№1 Physical and technical principles of thermoluminescent dosimetry.
№2 Individual dosimetry in medical institutions.
№3 Methods of micro- and nanodosimetry.
№4 Methods of measuring radioactive aerosols and gases.
№5 Design of clinical dosimeters.
№6 Design of individual dosimeters.
№7 Calibration and calibration of dosimeters.

The title page of the control 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, name of academic discipline; theme of control homework ; surname and name of the student, course, number of the academic group, year.

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

The total content of control homework, depending on the chosen topic can vary from 15 to 25 pages of the main text (in consultation with the teacher). The content of control homework is determined by the student's ability to briefly and at the same time comprehensively explain and analyze the program code in the Code Composer Studio environment.

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 number of the source in the list of references given at the end of the creative 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 15 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.

Control homework is evaluated by the following criteria: logic of the plan; completeness and depth of topic disclosure; reliability of the received data; reflection of practical materials and results of calculations; correctness of formulation of conclusions of the received results and conclusions; design; substantiation of the student's own opinion on this issue in the form of a conclusion.

The deadline for submission of control homework for verification: week 12-13 of study.

Control 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

Attendance at lectures is optional. Attending practical classes is desirable, as they are used to write express tests / tests, as well as to defend practical work.

The grading system is focused on obtaining points for student activity, as well as performing tasks that are able to develop practical skills and abilities.

Control measures missed

Missed control measures (defense of practical work) must be practiced in the next classes, provided that the task is scheduled for the current lesson, or in consultations.

Omissions of writing a module exam and express test are not fulfilled.

Control homework, 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 encouragement points

Encouragement points		*Penalty points **	
Criterion	*Weight points*	*Criterion*	*Weight points*
Improving practical work	*1 point (for each practical work)*	*Untimely implementation and test of practical work*	*From -0.5 points to -5 points (depending on the delivery date)*
Passing distance courses on topics that are agreed with teachers	*5 points*	*Untimely handling in and test of control homework*	*From -2 points to -20 points (depending on the construction period)*
Registration of scientific work for participation in the competition of student scientific works	*10 points*		
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 "Radiation safety" 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 «Sikorsky».

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

Performance of practical works, and also performance of control homework, is 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 the discipline in 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. Monitor and evaluate the system of evaluation of learning outcomes (Rating System of Evaluation)

Evaluation system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Express control works / test tasks	21	1,5	14	21
2.	Assessment of practical works	21	3	7	21
3.	Modular control work (MCW)	8	8	1	8
4.	Control homework (CHW)	10	10	1	10
5.	Exam	40	40	1	40
				Total	100

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

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
Deadline of calendar controls		week 7	week 13
Conditions for	Current rating	≥ 12 points	≥ 24 points

obtaining a positive result from the calendar control	*Practical work*	*PW № 1-4*	+	+
		PW № 5-8	-	+
	Express control works / test tasks	*At least 4 of any lectures*	+	-
		At least 10 of any lectures	-	+
	Modular control work	*Assessed MCW*	-	+
	Control homework	*Assessed CHW*	-	-

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

Semester certification of students

Mandatory condition for admission to the test		*Criterion*
1	*Current rating*	*RD ≥ 30*
2	*Obtaining a positive assessment for the control homework*	*More than 6 points*
3	*All practical works are tested*	*More than 0 points*
4	*Writing at least 6 express tests / tests*	*More than 6 points*

The results are announced to each student separately in the presence or remotely (by e-mail). Also recorded in the system "Electronic Campus".

Optional conditions for admission to closure:

1. *Activity during 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 a university scale:

Total rating points	*Grades according to the university scale*
100-95	*Excellent*
94-85	*Very good*
84-75	*Good*
74-65	*Satisfactory*
64-60	*Passed*
Below 60	*Unsatisfactory*
Violation of passing requirements	*Not passed*

The exam is conducted orally.

9. Additional information on the discipline (educational component)

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

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

Work program of the discipline (syllabus):

Compiled by *Assistant of Biomedical Engineering Deaprtment, MD Valerii Bingovich Orel*

Approved by *the Department of Biomedical Engineering (protocol № ___ to _____)*

Approved by *the Methodical Commission of the Faculty of Biomedical Engineering (protocol № __ to _____)*

Appendix 1 to the syllabus of the discipline «Radiation safety»

The list of questions for preparation for modular control work as well as for preparation for exam

1. The main properties of ionizing radiation, dose and unit of measurement.
2. What is the difference between the excitation effect and ionization?
3. Provide the percentage distribution of human radiation doses.
4. Define corpuscular and electromagnetic radiation.
5. Analyze the difference between Compton and photoelectric effects.
6. Define the effect of annihilation.
7. Analyze the types of ionizing radiation.
8. Justify the effects of the interaction of ionizing radiation with matter.
9. Analyze the features of the interaction of neutron radiation with matter.
10. Formulate the principles of dosimeters for registration of ionizing radiation.
11. Natural sources of electromagnetic fields and ionizing radiation.
12. Artificial sources of electromagnetic fields and ionizing radiation.
13. Parameters of ionizing radiation.
14. What is braking radiation X-rays. Basic properties.
15. Formation and interaction of alpha particles with matter.
16. Formation and interaction of beta particles with matter.
17. Formation and interaction of gamma radiation with matter.
18. Describe and characterize sources of radiation by ionizing radiation.
19. Write the criteria for absorbed doses and their values: low, high and medium.
20. Definitions and units of measurement of the equivalent dose of ionizing radiation.
21. Analyze the sequence of processes that lead to radiation damage.
22. Explain the dependence of life expectancy on the value of the absorbed dose.
23. Analyze the effect of radiation on water.
24. Analyze the effect of radiation on nucleic acids.
25. Analyze the effect of radiation on proteins.
26. Analyze the effect of radiation on lipids.
27. To determine the relative biological efficiency of radiation.
28. Analyze the principles of biological action of ionizing radiation.
29. Explain the probable nature of radiobiological effects.
30. What is the radioprotective effect and the mechanism of its action?
31. Explain the primary and secondary processes in the formation of radiation damage to cells and organisms.
32. Determine the relative biological efficiency of irradiation.
33. Analyze the principle of target theory.
34. What is the rule (law) Bergonie and Tribondeau?
35. Define the law of radiobiology H.R. Withers 4R.
36. Biological dosimetry.
37. Provide the principles of treatment for radiation damage.
38. What is the difference between stochastic effects of radiation from deterministic?
39. To determine the lethal dose of 50/30.
40. Name the principles of treatment for radiation damage.
41. What causes different sensitivity to radiation of different organs of the body?
42. Give the physical and technical principles of X-ray diagnostic systems.
43. What are the quality criteria for X-ray aperture?
44. The principle of registration of X-ray images.
45. Analyze the quality of medical X-ray images.
46. Formulate the concept of digital imaging.

47. The principle of operation of the system "screen-film".
48. Provide the physical and technical principles of imaging in X-ray computed tomography.
49. Analyze the requirements for radiation safety in X-ray diagnostics.
50. Provide the physical basis of nuclear magnetic resonance (MRI).
51. Safety in MRI diagnostics.
52. Analyze methods for obtaining radionuclides.
53. Describe the physical and technical principles of gamma cameras.
54. Radiation safety in nuclear medicine.
55. Physical and technical principles of radiation therapy.
56. Radiation safety in radiation therapy.
57. Describe the content of "Radiation Safety Standards of Ukraine" (NRBU-97).
58. Provide the main regulated values of NRBU-97.
59. Provide the values and units used in accordance with NRBU-97.
60. Provide a list of IAEA core standards on radiation safety.
61. Provide the normative levels of the maximum dose load of radiation.
62. Provide the bases of radiation protection of patients in X-ray diagnostics.
63. Provide the basics of radiation protection of patients in nuclear medicine.
64. Provide the basics of radiation protection of patients in radiation therapy.
65. What are the lessons learned from previous accidents during medical exposure?
66. Analyze the requirements for radiation monitoring in departments for radiation diagnostics and therapy.
67. Analyze the requirements for radiation protection of personnel.
68. Describe and provide a scheme of the device for blocking and signaling of premises where ionizing radiation is used.
69. Describe methods for determining radiation exposure to patients.
70. Definition and units of collective dose of ionizing radiation.
71. Analyze ways to reduce the doses received by patients.
72. Provide requirements for ionizing radiation protection of patients.
73. What is the value of the minimum registered dose of ionizing radiation and what method of dosimetry is used for this purpose.
74. The main tasks of the State Inspectorate for Nuclear Regulation of Ukraine.
75. Give examples of the elimination of accidents during medical exposure.
76. Analyze the requirements for changing rooms. Analyze the requirements for radiation diagnostic and treatment rooms.
77. How does non-ionizing radiation affect the human body?
78. What is the safe dose limit for non-ionizing radiation in mobile phones?