

INSTITUTE OF ENGINEERING PHYSICS FOR BIOMEDICINE

APPROVED ИТС ИФИБ

Protocol No. 3.1

dated 30.08.2024

ACADEMIC COURSE OUTLINE

РАДИОФАРМАЦЕВТИЧЕСКИЕ ПРЕПАРАТЫ / RADIOPHARMACEUTICALS

Educational program track (speciality) [1] 31.05.01 General Medicine

Semester	Labour input, credits	Total course academic, hours	Lectures, hrs.	Practical sessions, hrs.	Laboratory sessions, hrs.	In the form of practical studies, hrs.	Independent studies, hrs.	Independent studies monitoring, hrs.	Course progress, Exam/Pass-fail exam/Term
6	4	144	16	44	0		30	0	Ex
Total	4	144	16	44	0	0	30	0	

ABSTRACT

This program will provide a comprehensive understanding of the use of radiopharmaceuticals (RP), introduce students to the basic historical facts, physical, radiological, and chemical principles of creating and using radiopharmaceuticals (RP), the basic principles of safety control during the manufacturing and use of radiopharmaceuticals, the principles of imaging with radionuclides and the use of radionuclides for therapeutic purposes, and ensure safety control during the manufacturing and use of RP.

1. ACADEMIC COURSE GOALS AND OBJECTIVES

Goal: To develop a comprehensive understanding of the use of radiopharmaceuticals and radiobiological effect modifiers in clinical practice.

Objectives to be addressed during the course:

- To educate students on the basic historical facts, physical, radiological, and chemical principles of the manufacturing and use of radiopharmaceuticals (RP),
- To educate students on the basic principles of safety control during the creation and use of RPP,
- To educate students on the principles of image visualization using radionuclides and the use of radionuclides for therapeutic purposes.
- To provide knowledge in the use of radiopharmaceuticals for radiodiagnostics and radiotherapy.

2. PLACE OF THE ACADEMIC COURSE IN THE MAIN HIGHER EDUCATION CURRICULUM

This course is mastered in parallel with other disciplines such as Radiology and Pharmacology. The knowledge and skills acquired in this course are necessary for successful mastery of the specialized disciplines of Radiology and Radiotherapy, Oncology, diagnostic practical training, and other clinical disciplines.

3. DEVELOPED COMPETENCIES AND INTENDED LEARNING OUTCOMES

Universal and/or general professional competencies:

Competency code and title	Code and title of competency-based rubrics
OPIK-7 [1] – Capable of prescribing treatment and monitoring its effectiveness and safety.	3-OPIK-7 [1] – Know: - pharmacological groups of medicinal drugs and their intended purposes; - mechanisms of action of pharmacological and non-pharmacological treatments, indications and contraindications for their use, side effects, and complications caused by their application; - methods for monitoring the effectiveness and safety of various treatment approaches. Y-OPIK-7 [1] – Be able to: - make rational choices for pharmacological and non-pharmacological treatments based on clinical guidelines and in accordance with medical care standards; - develop a treatment plan for a disease or condition

	<p>considering the diagnosis, age, disease course characteristics, and comorbidities, based on clinical guidelines and medical care standards; - prescribe medications, medical devices, and therapeutic nutrition considering the diagnosis, age, disease course characteristics, and comorbidities, based on clinical guidelines and medical care standards; - justify prescribed pharmacological and non-pharmacological treatments; - evaluate the effectiveness and safety of medications, medical devices, therapeutic nutrition, and other treatment methods.</p> <p>B-ОПК-7 [1] – Possess skills in: - administering medications through various routes of administration; - developing treatment plans for diseases or conditions considering diagnosis, age, disease course characteristics, and comorbidities; - assessing the effectiveness and safety of prescribed treatments.</p>
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4. PEDAGOGIC POTENTIAL OF THE COURSE

Pedagogic tracks/objectives	Pedagogic goals (code)
Professional education	Establishing conditions for: formation of responsibility for professional choice, professional development and professional decisions (B18)
Professional education	Establishing conditions for: formation of motivation to improve the quality of medical care to the population and the desire to follow the rules and norms of interaction between the doctor, colleagues and the patient, contributing to the creation of the most favorable environment for the patient's recovery (B34)

5. ACADEMIC COURSE STRUCTURE AND CONTENT

Academic course sections, their scope, terms of study and assessment:

No.	Academic course section name	Weeks	Lectures/ Practical (seminars)/ Laboratory sessions, hrs.	Compulsory current assessment (form *, week)	Maximum grade per section**	Section assessment (form *, week)	Competency-based rubrics
	<i>6 Semester</i>						
1	The First Section	1-5	6/14/0	RTD-5 (15)	15	RTD-5	3-ОПК-7, У-ОПК-7, В-ОПК-7
2	The Second Section	6-9	4/12/0	RTD-9 (15)	15	RTD-9	3-ОПК-7, У-ОПК-7, В-ОПК-7
3	The Third Section	10-	6/18/0	RTD-15	20	RTD-15	3-ОПК-7,

		15		(20)			У-ОПК-7, В-ОПК-7
	<i>Totals for 6 Semester</i>		16/44/0		50		
	Assessment events for 6 Semester				50	Ex	3-ОПК-7, У-ОПК-7, В-ОПК-7

* – abbreviated name of assessment

** – 100 maximum points per semester including a pass/fail exam and (or) an exam

Abbreviated current assessment forms and section assessment

Abbreviation	Full name
RTD	Round table discussion
Ex	Exam

SYLLABUS

Weeks	Topics / Content	Lect., hrs.	Pr./sem., hrs.	Lab., hrs.
	<i>6 Semester</i>	16	44	0
1-5	The First Section	6	14	0
1	Radiopharmaceuticals and Nuclear Medicine: Basic Concepts Radiopharmaceuticals and Nuclear Medicine: Basic Concepts and Terminology. Radiopharmacology. Radiopharmaceuticals. Radioactivity. Radioisotopes.	All 2	2	0
		Online		
		0	0	0
2	Fundamentals of the Development and Use of Radiopharmaceuticals 1 The Law of Radioactive Decay. Types of Radiation	All 2	3	0
		Online		
		0	0	0
3	Fundamentals of the Development and Use of Radiopharmaceuticals 2 Fundamentals of the Manufacturing and Use of Radiopharmaceuticals. Types of Radiation. Definition of α -, β -, and γ -Radiation	All 0	3	0
		Online		
		0	0	0
4	Pharmacokinetics of radioactive drugs. Half-life and elimination half-life. Units of radioactivity	All 2	3	0
		Online		
		0	0	0
5	Round table: Fundamental Laws Used in the Development of Radiopharmaceuticals Round table: Fundamental Laws Used in the Development of Radiopharmaceuticals Final Test, Group Presentations, Discussion	All 0	3	0
		Online		
		0	0	0
6-9	The Second Section	4	12	0
6	Production of radiopharmaceuticals. Production of radionuclides for nuclear medicine. Use of nuclear reactions with charged particles to produce radionuclides. Use of accelerators to produce radionuclides used in nuclear medicine. Use of nuclear reactions with	All 2	3	0
		Online		
		0	0	0

	neutrons to produce radionuclides for nuclear medicine. Production of radionuclides using nuclear reactors. Radionuclide generators. Generator types and their design. Radionuclide generators used in nuclear medicine. Primary targets, nuclear reactions, and radionuclide extraction methods. Radionuclides for used in nuclear medicine. Primary targets, nuclear reactions, and radionuclide extraction methods. Radionuclide product characteristics: radionuclide purity, radiochemical purity, and specific activity.			
7	Radiopharmaceutical Production Labeled Compounds. The Concept of a Labeled Substance. Nomenclature of Labeled Organic Compounds. Specifics of Compound Production. Handling Radionuclides. Methods for Producing Labeled Compounds: Chemical Synthesis, Biosynthesis, and Isotope Exchange. Nuclear-Chemical and Physicochemical Methods for Producing Labeled Compounds	All		
		0	3	0
		Online		
		0	0	0
8	Methods of analysis and quality control of radiopharmaceuticals. Requirements for labeled substances and radiopharmaceuticals. Chemical, radionuclide, and radiochemical purity. Radiation stability of labeled compounds and radiopharmaceuticals. Storage conditions for labeled compounds and radiopharmaceuticals.	All		
		2	3	0
		Online		
		0	0	0
9	Roundtable: Production and Control of Radiopharmaceuticals Final testing, group presentations, discussion	All		
		0	3	0
		Online		
		0	0	0
10-15	The Third Section	6	18	0
10	General issues in radiopharmaceutical diagnostics. General issues in radiopharmaceutical diagnostics. The concept of a radiopharmaceutical and types of diagnostics. Physical principles and technical support for radionuclide diagnostics. Radiopharmaceuticals used for diagnostics.	All		
		2	3	0
		Online		
		0	0	0
11	Radionuclide diagnostics of organs and systems Radionuclide diagnostics of cardiac diseases. Radionuclide diagnostics in angiology. Radionuclide diagnostics of diseases of the lungs, gastrointestinal tract, hepatosplenic system, urinary system, endocrine system, skeletal system, nervous system, and lymphatic system.	All		
		0	3	0
		Online		
		0	0	0
12	General issues of radiopharmaceutical therapy. Physical principles and technical support for radiopharmaceutical therapy. Radiosensitivity of normal and tumor tissues. Concepts of radiosensitivity and radiation damage of normal and tumor tissues. Dose-response relationship. Classification of normal cells, tissues, organs, and systems by radiosensitivity. Factors influencing tumor radiosensitivity. Factors reducing the degree of radiation damage to healthy tissues. Factors enhancing radiation damage to tumors.	All		
		2	3	0
		Online		
		0	0	0
13	Radiopharmaceutical therapy of organs and systems. Radiopharmaceutical therapy of organs and systems.	All		
		0	3	0

	Treatment of thyroid diseases, palliative care for skeletal diseases, liver cancer, neuroendocrine tumors, and non-Hodgkin's lymphomas.	Online	0	0	0
14	General and specific issues of radiation safety Adverse effects of ionizing radiation on the health status of individuals and the general population. Radiation safety criteria for external and internal irradiation. The concepts of equivalent, effective, and effective equivalent doses. Calculation methods. Determining internal radiation doses and the concept of radiotoxicity. The "benefit-harm" concept in radiation safety. Methods for reducing individual and collective doses of external and internal irradiation. Radiation monitoring. General provisions and principles of radiation safety.	All	2	3	0
		Online	0	0	0
15	Roundtable: Use of Radiopharmaceuticals in Diagnostics and Therapy Final testing, group presentations, discussion	All	0	3	0
		Online	0	0	0

Abbreviated names of online options:

Abbreviation	Full name
EC	E-course
FtM	Full-text material
FtL	Full-text lectures
VM	Video materials
AM	Audio materials
Prs	Presentations
T	Tests
ERM	E-reference materials
IS	Interactive site

PRACTICAL SESSIONS TOPICS

Weeks	Topics / Content
	<i>6 Semester</i>
1	Radiopharmaceuticals and Nuclear Medicine: Basic Concepts Radiopharmaceuticals. Radioactivity. Radioisotopes. Definition of Radionuclides, Isotopes, and Radiopharmaceuticals
2	Fundamentals of the creation and use of radiopharmaceuticals. The law of radioactive decay. Types of radiation.
3	Fundamentals of the Development and Use of Radiopharmaceuticals Fundamentals of the Development and Use of Radiopharmaceuticals. Types of Radiation. Definition of α -, β -, and γ -Radiation
4	Pharmacokinetics of radioactive drugs. Half-life and elimination half-life. Units of radioactivity
6	Production of radiopharmaceuticals. Production of radionuclides for nuclear medicine. Use of nuclear reactions with charged particles to produce radionuclides. Use of accelerators to produce radionuclides used in nuclear medicine. Use of nuclear reactions with neutrons to produce radionuclides used in nuclear medicine. Production of radionuclides using nuclear reactors. Radionuclide generators. Generator types and their design. Radionuclide generators used in nuclear

	medicine. Primary targets, nuclear reactions, and methods of radionuclide extraction. Radionuclides for therapeutic use in nuclear medicine. Primary targets, nuclear reactions, and methods of radionuclide extraction. Characteristics of radionuclide products: radionuclide purity, radiochemical purity, and specific activity
7	Radiopharmaceutical Production Labeled Compounds. The concept of a labeled substance. Nomenclature of labeled organic compounds. Specifics of compound production. Features of working with substances containing radionuclides. Methods for producing labeled compounds: chemical synthesis, biosynthesis, isotope exchange. Nuclear-chemical and physicochemical methods for producing labeled compounds.
8	Methods of analysis and quality control of radiopharmaceuticals. Requirements for labeled substances and radiopharmaceuticals. Chemical, radionuclide, and radiochemical purity. Radiation stability of labeled compounds and radiopharmaceuticals. Storage conditions for labeled compounds and radiopharmaceuticals.
10	General issues in radiopharmaceutical diagnostics. The concept of a radiopharmaceutical and types of diagnostics. Physical principles and technical support for radionuclide diagnostics. Radiopharmaceuticals used for diagnostics
11	Radionuclide diagnostics of organs and systems Radionuclide diagnostics of heart diseases. Radionuclide diagnostics in angiology. Radionuclide diagnostics of diseases of the lungs, gastrointestinal tract, hepatosplenic system, urinary system, endocrine system, skeletal system, nervous system, and lymphatic system
12	General issues of radiopharmaceutical therapy. Physical principles and technical support for radiopharmaceutical therapy. Radiosensitivity of normal and tumor tissues. Concepts of radiosensitivity and radiation damage of normal and tumor tissues. Dose-response relationship. Classification of normal cells, tissues, organs, and systems by radiosensitivity. Factors influencing tumor radiosensitivity. Factors reducing the degree of radiation damage to healthy tissues. Factors enhancing radiation damage to tumors.
13	Radiopharmaceutical therapy of organs and systems. Treatment of thyroid diseases, palliative care for skeletal diseases, liver cancer, neuroendocrine tumors, and non-Hodgkin's lymphomas.
14	General and specific issues of radiation safety. Adverse effects of ionizing radiation on the health of individuals and the general population. Radiation safety criteria for external and internal irradiation. The concepts of equivalent, effective, and effective equivalent doses. Calculation methods. Determining internal radiation doses and the concept of radiotoxicity. The "benefit-harm" concept in radiation safety. Methods for reducing individual and collective doses of external and internal irradiation. Radiation monitoring. General provisions and principles of radiation safety.

6. EDUCATIONAL TECHNOLOGIES

Educational methods include the use of multimedia, interactive approaches, and laboratory equipment to acquire theoretical knowledge and practical skills.

For self education for practical classes and exams, students are provided access to full-text textbooks and articles from electronic databases: materials located on the educational platform online.mephi.ru

7. ASSESSMENT TOOLKIT

The assessment toolkit ensures verification of the intended learning outcomes achievement (competency-based rubrics) using current, midterm and interim assessment of the course.

The link between developed competencies and their assessment is presented in the following table:

Competency	Achievement rubrics	Assessment activity (Syl 1)
ОПК-7	3-ОПК-7	Ex, RTD-5, RTD-9, RTD-15, KCT-5, KCT-9, KCT-15
	Y-ОПК-7	Ex, RTD-5, RTD-9, RTD-15, KCT-5, KCT-9, KCT-15
	B-ОПК-7	Ex, RTD-5, RTD-9, RTD-15, KCT-9

Educational achievement rubrics scales

The scale of each assessment activity varies from 0 to the maximum established point, inclusive. The final assessment of the course is performed on a 100-point scale and represents the sum of the points earned by the student in the section assessments, framework of current and interim assessment.

Sections and interim assessments are considered passed when the student achieves a minimum score equal to 60% of the maximum. The final grade is assigned only upon passing all sections and the interim assessment.

The final grade is assigned in accordance with the following scale:

Total score	Rating on a 4-point scale	Pass/fail examination	ECTS assessment
90-100	5 – « <i>excellent</i> »	« <i>pass</i> »	A
85-89	4 – « <i>good</i> »		B
75-84			C
70-74			D
65-69	3 – « <i>satisfactory</i> »		E
60-64		F	
below 60	2 – « <i>fail</i> »	« <i>fail</i> »	

An “excellent” grade indicates a deep and solid mastery of the program material by a student who presents their answers consistently, clearly, and logically, is able to closely link theory with practice, and uses materials from monographic literature in their answers.

A “good” grade corresponds to a student’s solid knowledge of the material, who presents their answers competently and to the point, without any significant inaccuracies.

A “satisfactory” grade corresponds to the basic level of mastery of the material by the student, in which the main material has been mastered, but its details have not been assimilated, the answers contain inaccuracies, insufficiently correct wording and logical inconsistencies.

A grade “pass” corresponds to at least a basic level of mastery of the program material, in which the student possesses the necessary knowledge, skills, and abilities, and is able to apply theoretical principles to solve typical practical problems.

A grade “fail” is given to a student who lacks a significant understanding of the curriculum material, makes significant errors in their answers, or fails all required assignments. These students are generally unable to continue their studies without additional classes.

8. ACADEMIC COURSE EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT

CORE READING:

1. ЭИ Т 80 Лучевая диагностика : учебник, , Москва: ГЭОТАР-Медиа, 2018
2. ЭИ Т 35 Основы лучевой диагностики и терапии : практическое руководство, , Москва: ГЭОТАР-Медиа, 2012

FURTHER READING:

1. ЭИ К59 Radiopharmaceuticals for Therapy : , Dash, Ashutosh. , Knapp, F. F. (Russ). , New Delhi: Springer India, 2016

SOFTWARE:

No special softwares is required

LMS AND ONLINE RESOURCES

1. Radiopharmaceutical drugs (<https://online.mephi.ru/course/view.php?id=1164>)
2. BASIC PHYSICS OF NUCLEAR MEDICINE.
(https://en.wikibooks.org/wiki/Basic_Physics_of_Nuclear_Medicine)
3. Nuclear Medicine Physics A Handbook for Teachers and Students (<https://www-pub.iaea.org/mtcd/publications/pdf/pub1617web-1294055.pdf>)

<https://online.mephi.ru/>

<http://library.mephi.ru/>

9. LOGISTICAL SUPPORT

1. Интерактивная доска SMART SBM 685 (64-405)
2. Мышь, клавиатура (64-405)
3. Персональный компьютер: Моноблок Lenovo V540-24IWL All-In-One 23,8" i3-8145U 8Gb 256GB_SSD_M.2 Intel (64-405)

10. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS

Recommendations for preparing for seminars.

The plan for practical classes, their topics, recommended readings, and the purpose and objectives of the course are communicated by the instructor during introductory classes or in the curriculum for the given course. Practical classes help students gain a deeper understanding of the course material and acquire skills in creative work with scientific literature.

Before you begin studying the topic, you need to familiarize yourself with the main questions of the practical lesson plan and the list of recommended literature.

When preparing for a practical lesson, you should first review lecture notes, textbook sections, and teaching aids to gain a general understanding of the topic's place and significance in the course being studied. Then, consult additional literature and take notes on the recommended sources.

In the process of studying the recommended material, it is necessary to understand the structure of the topic being studied, identify the main points, follow their logic and thereby delve into the essence of the problem being studied.

It is necessary to keep records of the material being studied in the form of notes, which, along with visual memory, also includes motor memory and allows for the accumulation of an individual fund of auxiliary materials for the rapid repetition of what has been read, for the mobilization of accumulated knowledge.

Basic note-taking forms: outline (simple and detailed), excerpts, and abstracts. During preparation, it is important to compare sources, consider the material being studied, develop an action plan, and carefully consider your oral presentation.

11. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR TEACHERS

Grading and criteria for tests, extended quizzes, homework, and the final test:

1 - Tests are graded according to the following formula: 1 point for every 1 correct answer. A student who has not started the test will receive a (-1) point.

2 - Extended quizzes are graded according to the following formula: complete answer – 2 points, incomplete answer – 1 point, no answer – 0 points, student who has not started the test – (-2) points.

3 - Homework must be completed by all students to be eligible for the final assessment. Late submissions will result in a deduction of -1 point from the final grade.

4 - Roundtables - Students must develop and present a group presentation on a specific topic, answer questions from the instructor and other students, and pose several questions to the audience on the topic.

The maximum grade for Roundtables 1 and 2 is 15 points, and for Roundtable 3 - 20 points.

Credit/Exam Assessment Criteria

1. Submit all homework assignments and participate in or complete all seminars for the course.

2. Successfully complete tests and pass checkpoints for each section of the semester. Obtain at least 8 points for checkpoints 1 and 2, and at least 12 points for checkpoint 3 (round tables) in accordance with the course curriculum.

3. Score at least 15 points out of 25 on the final test (to qualify for the oral exam).

To pass the exam, a student must:

1. Obtain admission to the exam (see above)
2. Attend the exam according to the schedule
3. Bring only a pen and paper! Cell phones, computers, notebooks, and textbooks are prohibited!

4. A minimum of 30 points out of a possible 50 must be scored on the exam.

5. The RPF exam ticket contains three questions on the following topics:

1. Introduction to Radiopharmacology - 15 points

2. Production of Radiopharmaceuticals - 15 points

3. Application of RPF in Medicine for Diagnostics and Treatment - 20 points

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