Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Institution of Higher Education
“National Research Nuclear University “MEPhI”

INSTITUTE OF ENGINEERING PHYSICS FOR BIOMEDICINE

DEPARTMENT OF MEDICAL PHYSICS

APPROVED НТС ИФИБ

Protocol No. 3.1

dated 30.08.2024

ACADEMIC COURSE OUTLINE

MEDICAL AND BIOLOGICAL PHYSICS

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**
1	2	72	16	16	16		24	0	PFE
2	5	180	15	15	15		81	0	Ex
Total	7	252	31	31	31	0	105	0	

ABSTRACT

The main subject of the discipline is the physical and physico-chemical processes occurring in organisms at the molecular level, which allows us to consider the mechanisms of physiological processes and explain the causes of observed biological phenomena. The study of the physico-chemical foundations of physiological processes that occur in the body under special, peculiar conditions that are absent anywhere in inanimate nature is carried out taking into account the exceptional specificity, heterogeneity and dynamism for integral biological systems without decomposing them into separate components, if possible.

Knowledge of the physical laws of functioning of living systems allows not only to understand their work, but also to identify the physical and physico-chemical parameters used for objective diagnosis of the functional state of the body, and to conduct research on the basics and mechanisms of pathological processes. Much attention is paid to the methods and principles of operation of modern medical equipment, which is used for clinical laboratory diagnostics of biomaterial (fluids, tissues, cells) of the human body to identify or confirm the presence of pathology, and functional diagnostics for an objective assessment, detection of abnormalities and to establish the degree of malfunction of various organs and physiological systems of the body.

The discipline also examines complex highly informative methods introduced into research practice, such as electron paramagnetic resonance, nuclear magnetic resonance, the method of detecting ultra-weak luminescence of biological objects, spectrophotometric methods, fluorescent methods, and a number of others.

1. ACADEMIC COURSE GOALS AND OBJECTIVES

Training of highly qualified specialists in the field of medical and biological physics, ensuring the competitiveness and demand of university graduates in the domestic and foreign labor market, for practical and research work in practical healthcare institutions, for research activities aimed at developing and introducing into medical practice the achievements of biomedical sciences, as well as for teaching activities in medical universities.

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

The study of the biophysics course is based on the full range of natural science knowledge acquired by the student in secondary school, as well as in the first years of higher education in the study of physics, chemistry, mathematics, biology, biochemistry, pharmacology. At the same time, the knowledge, skills and abilities acquired in the study of biophysics are used by students in mastering the above-mentioned academic disciplines. This discipline is a precursor to the following disciplines: clinical laboratory diagnostics, radiation diagnostics and therapy, instrumental diagnostic methods, medical electronics, functional methods of studying body systems.

3. DEVELOPED COMPETENCIES AND INTENDED LEARNING OUTCOMES

Universal and/or general professional competencies:

Competency code and title	Code and title of competency-based rubrics
ОПК-5 [1] – Capable of assessing morphofunctional and physiological states, as well as pathological processes in the human body to solve professional tasks.	З-ОПК-5 [1] – Know: - basic medical, pharmaceutical, and morphofunctional terminology, including Latin terms; - structure and functions of the human body, age-related, gender-specific, and individual characteristics of the structure and development of a healthy organism; - physical and chemical nature of processes occurring in a living organism; - patterns of vital activity of the organism, mechanisms of self-regulation and regulation; - features of regulation of the functioning of human body systems in pathological conditions; - patterns of occurrence, development, and outcome of typical pathological processes, the concept of sanogenesis; - etiology and pathogenesis of the most common diseases; - the concept of nosology, principles of disease classification; - principles of microorganism classification, their morphology, physiology, and impact on human health; - structure and functions of the human immune system. У-ОПК-5 [1] – Be able to: - analyze mechanisms of disease development and manifestation; - recognize morphological and functional changes in cells, tissues, organs, and systems of the human body; - use basic physical-chemical and other natural science concepts and methods in solving professional tasks; - determine the cause of death and formulate a pathological diagnosis. В-ОПК-5 [1] – Possess skills in: - conducting microscopy and analyzing microscopic specimens; - correlating morphological and clinical manifestations of diseases; - assessing morphofunctional, physiological states, and pathological processes in humans; - clinical-anatomical analysis of autopsy results.

4. PEDAGOGIC POTENTIAL OF THE COURSE

Pedagogic tracks/objectives	Pedagogic goals (code)
Intellectual education	Establishing conditions for: formation of culture of intellectual work (В11)
Vocational and labor education	Establishing conditions for: formation of a deep understanding of the profession's social role, a positive and active commitment to the values of the chosen specialty, and a responsible attitude towards professional activity and work (В14)
Vocational and labor education	Establishing conditions for: formation of a culture of research and engineering (В16)

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
	1 Semester						
1	The first section	1-8	8/8/0		20	SA-8	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	The second section	9-16	8/8/0		20	SA-16	З-ОПК-5, У-ОПК-5, В-ОПК-5
3	The third section	1-16	0/0/16		10	Lab-16	З-ОПК-5, У-ОПК-5, В-ОПК-5
	Totals for 1 Semester		16/16/16		50		
	Assessment events for 1 Semester				50	PFE	З-ОПК-5, У-ОПК-5, В-ОПК-5
	2 Semester						
1	The first section	1-8	8/8/0		20	SA-8	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	The second section	9-15	7/7/0		20	SA-15	З-ОПК-5, У-ОПК-5, В-ОПК-5
3	The third section	1-15	0/0/15		10	SA-15	З-ОПК-5, У-ОПК-5, В-ОПК-5
	Totals for 2 Semester		15/15/15		50		
	Assessment events for 2 Semester				50	Ex	З-ОПК-5, У-ОПК-5, В-ОПК-5

* – 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
Lab	Laboratory-based work
SA	Summative assessment
PFE	Pass/fail examination
Ex	Exam

SYLLABUS

Weeks	Topics / Content	Lect.,	Pr./sem.,	Lab.,

		hrs.	hrs.	hrs.
	1 Semester	16	16	16
1-8	**The first section**	8	8	0
1 - 2	**Topic 1** Introduction. Biophysics as a science. Methodology of biophysics.	All		
		2	2	0
		Online		
		0	0	0
3 - 4	**Topic 2** Theoretical biophysics: kinetics and thermodynamics of biological processes.	All		
		2	2	0
		Online		
		0	0	0
5 - 6	**Topic 3** Molecular Biophysics	All		
		2	2	0
		Online		
		0	0	0
7 - 8	**Topic 4** Biophysics of membrane processes. Intermediate control.	All		
		2	2	0
		Online		
		0	0	0
9-16	**The second section**	8	8	0
9 - 10	**Topic 5** Biophysics of cellular processes.	All		
		2	2	0
		Online		
		0	0	0
11 - 12	**Topic 6** Biophysics of photobiological processes.	All		
		2	2	0
		Online		
		0	0	0
13 - 15	**Topic 7** Radiation biophysics.	All		
		3	3	0
		Online		
		0	0	0
16	**Topic 8** Analysis of questions and elaboration of tasks assigned to homework	All		
		1	1	0
		Online		
		0	0	0
1-16	**The third section**	0	0	16
1 - 16	**Laboratory work** Laboratory work No. 1 and No. 2	All		
		0	0	16
		Online		
		0	0	0
	2 Semester	15	15	15
1-8	**The first section**	8	8	0
1 - 2	**Topic 1** Medical electronics. Physical and biophysical foundations of rheography.	All		
		2	8	0
		Online		
		0	0	0
3 - 4	**Topic 2** The concept of electrography of organs and tissues.	All		
		2	0	0
		Online		

		0	0	0
5 - 6	**Topic 3** Optical refractometry .Elements of geometric optics.	All		
		2	0	0
		Online		
		0	0	0
7 - 8	**Topic4** Wave optics. Optical microscopy. The interaction of light with matter. Intermediate control.	All		
		2	0	0
		Online		
		0	0	0
9-15	**The second section**	7	7	0
9 - 10	**Topic 5** Basic concepts and laws of quantum physics. Spectroscopy. Thermal radiation of bodies, its characteristics.	All		
		2	7	0
		Online		
		0	0	0
11 - 12	**Topic 6** Induced radiation. Resonance methods of quantum mechanics.	All		
		2	0	0
		Online		
		0	0	0
13 - 15	**Topic 7** Photometry. X-ray radiation. Radioactivity. Ionizing radiation and its dosimetry. Elements of radiobiology.	All		
		3	0	0
		Online		
		0	0	0
1-15	**The third section**	0	0	15
1 - 15	**Laboratory work** Laboratory work No. 3 and No. 4	All		
		0	0	15
		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

LABORATORY (LAB) SESSIONS TOPICS

Weeks	**Topics / Content**
	1 Semester
1 - 2	Introductory lesson
3 - 5	Reaction time
6 - 8	Electromyography 1
9 - 16	Protection of laboratory work
	2 Semester
1 - 2	Introductory lesson

3 - 5	ECG and pulse
6 - 8	Респираторный цикл
9 - 15	Protection of laboratory work

6. EDUCATIONAL TECHNOLOGIES

In the course of mastering the discipline, the following educational technologies are used in classroom teaching: lectures, laboratory work, seminars using active and interactive forms of teaching. The following educational technologies are used to organize independent work of classes: reports with computer presentations, testing, and control papers.

Teaching in the discipline is also possible in a mixed form, both traditionally in the classroom and using distance learning technologies. The educational process, designed and organized in this form, combines the best features of both approaches and, in many ways, is devoid of their disadvantages.

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)**	**Assessment activity (Syl 2)**
ОПК-5	З-ОПК-5	PFE, SA-8, Lab-16, SA-16	Ex, SA-8, SA-15
	У-ОПК-5	PFE, SA-8, Lab-16, SA-16	Ex, SA-8, SA-15
	В-ОПК-5	PFE, SA-8, Lab-16, SA-16	Ex, SA-8, SA-15

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 – *«excellent»*	*«pass»*	A
85-89	4 – «*good*»		B

75-84			C
70-74			D
65-69	3 – «*satisfactory*»		
60-64			E
below 60	2 – «*fail*»	*«fail»*	F

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. 57 Р38 Медицинская и биологическая физика : учебник, Ремизов А.Н., Москва: ГЭОТАР Медиа, 2023

2. 57 Р38 Медицинская и биологическая физика : учебник, Ремизов А.Н., Москва: ГЭОТАР Медиа, 2018

3. ЭИ Р 38 Медицинская и биологическая физика. Сборник задач : , Ремизов А.Н., Максина А.Г., Moscow: ГЭОТАР-Медиа, 2014

FURTHER READING:

SOFTWARE:

No special softwares is required

LMS AND ONLINE RESOURCES

https://online.mephi.ru/

http://library.mephi.ru/

9. LOGISTICAL SUPPORT

Any special logistical support is not required

10. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS

Due to the introduction of the Federal State Educational Standard into the educational process, the task of organizing students' independent work is becoming more urgent. Independent work is defined as an individual or collective educational activity carried out without the direct guidance of a teacher, but according to his assignments and under his supervision. Students' independent work is one of the main forms of extracurricular work in the implementation of curricula and programs.

Independent work is a cognitive learning activity when the sequence of a student's thinking, mental and practical operations and actions depends on and is determined by the student himself.

In the learning process, the student must not only master the curriculum, but also acquire the skills of independent work. Students are given the opportunity to work more independently during their studies than students in secondary school. The student should be able to plan and do their job.

The purpose of students' independent work is to master fundamental knowledge, professional skills and professional skills in the field, experience in creative and research activities. Students' independent work contributes to the development of independence, responsibility and organization, as well as a creative approach to solving problems at an academic and professional level.

Stages of independent work:

- awareness of the learning task that is being solved with the help of this independent work;
- familiarization with the instructions on its implementation;
- implementation of the work execution process;
- introspection, self-control;
- checking the student's work, highlighting and analyzing typical advantages and errors.

Students' independent work is a mandatory component of the educational process for each student and is determined by the curriculum. When determining the content of students' independent work, their level of independence and the requirements for the level of independence of graduates should be taken into account in order to achieve the desired level during the study period. Thus, the proportion of independent work in the full-time department is up to 50% of the number of classroom hours allocated to study the discipline, while in the correspondence department the number of hours allocated to master the discipline increases to 90%.

The forms of independent work of students are determined by the content of the academic discipline when developing work programs and educational methodological complexes of disciplines.

According to the Regulations on the organization of independent work of students based on a competence-based approach to the implementation of professional educational programs, the types of tasks for independent work are:

- to acquire knowledge: reading a text (textbook, primary source, additional literature), drawing up a text outline, graphically depicting the structure of the text, taking notes on the text, extracts from the text, working with dictionaries and reference books, familiarization with regulatory documents, educational and research work, the use of audio and video recordings, computer equipment and the Internet, etc.

- to consolidate and systematize knowledge: work with lecture notes, text processing, repeated work on educational material (textbooks, primary sources, additional literature, audio and video recordings, drawing up a plan, compiling tables for systematizing educational material, answering control questions, filling out a workbook, analytical text processing (annotation, review, referencing, summary analysis, etc.), completion of classroom practical work and preparation of reports on them, preparation of multimedia messages/reports for presentation at a seminar (conferencto consolidate and systematize knowledge: work with lecture notes, text processing, repeated work on educational material (textbooks, primary sources, additional literature, audio and video recordings, drawing up a plan, compiling tables for systematizing educational material, answering control questions, filling out a workbook, analytical text processing (annotation, review, referencing, summary analysis, etc.), completion of classroom practical work and preparation of reports on them, preparation of multimedia messages etc.

Independent work can be carried out individually or in groups of students, depending on the purpose, scope, specific topic of independent work, the level of complexity, and the level of students' skills.

Monitoring of the results of students' independent work can be carried out within the time allotted for compulsory academic classes in the discipline and extracurricular independent work of students in the discipline, can take place in written, oral or mixed form.

When studying the discipline, the following types and forms of independent work of students are practiced:

- performing laboratory and practical work;
- preparation of reports;
- preparation of reports and information messages on specific topics;
- preparation and writing of research papers;
- completion of practical work;
- creation of presentation material;
- preparation for an oral interview, for a discussion;
- preparation for testing;
- preparation for writing, control work, testing, control point;
- preparation for the colloquium;
- formation and execution of a creative task;
- writing term papers, etc.

Independent work is carried out in the form of preparatory exercises for learning new things, exercises when learning new material, exercises in the process of consolidation and repetition, exercises of verification and control work, as well as for self-control.

The following conditions are necessary for the organization of independent work:

- students' willingness to work independently;
- availability and accessibility of the necessary educational, methodological and reference material;
- consulting assistance.

Independent work can take place in a lecture room, laboratory, vivarium, computer room, library, or at home. Independent work trains the will, promotes efficiency, attention, discipline, etc.

11. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR TEACHERS

The lecture as a form of classroom work is designed to convey to students the knowledge of the theoretical material of the discipline. Lectures provide, first of all, the formation of the "know" component of competencies. The lecture materials are the basic basis for preparing students for seminars, practical classes, colloquium and independent work assignments, as well as for ongoing academic performance monitoring and interim assessment in the discipline. It is recommended to take notes on the educational material during the lectures.

At the beginning of each lecture session, time is allocated to repeat the main points of the previous lecture and answer questions that arose as a result of independent study of the lecture material. At the end of each lecture, additional time is also allocated to answer questions that students may have while listening to the lecture. This lecture management strategy allows you to eliminate gaps in understanding that arise at different stages of perception of the lecture material. For a deeper understanding of the theory, at the end of each lecture, students are offered links to literature or electronic resources that provide a more detailed description of the problems under consideration.

Practical exercises are aimed at developing skills in solving practical problems, applying the acquired theoretical knowledge, as well as independent work skills under the guidance of a teacher. They form, first of all, the components of "be able" and "own" competencies and are focused on solving typical (basic) tasks containing typical mechanisms, procedures for applying the studied methods, techniques, approaches, algorithms, models, etc.

The criteria for evaluating the student's work results in a practical lesson are:

– the student's ability to use the acquired theoretical knowledge when doing homework;

– formation of skills and abilities;

– design of the material in accordance with the requirements;

– the student's level of mastering the educational material.

Requirements for the level of mastering the course content.

Current monitoring of learning outcomes is usually carried out in the course of practical exercises and can be carried out both in the form of a personal survey and in the form of testing students.

The study of the academic discipline ends with an exam.

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