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 FUNDAMENTAL MEDICINE

APPROVED НТС ИФИБ

Protocol No. 3.1

dated 30.08.2024

ACADEMIC COURSE OUTLINE

МЕДИЦИНСКАЯ И БИОЛОГИЧЕСКАЯ ФИЗИКА / 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 course is designed to provide students with a fundamental understanding of the physical laws, processes, and phenomena that underlie the functioning of living systems and modern medical technologies. Students will study the physical properties of biological objects, the specific features of biophysical processes occurring in the human body, as well as the mechanisms by which various physical factors affect the organism. The course also covers the principles of operation of medical equipment, physicochemical research methods, and contemporary diagnostic and therapeutic technologies.

Particular attention is paid to the application of mathematical and statistical methods for data analysis in medical practice, as well as to the development of practical skills in working with diagnostic devices and biophysical instruments. The course fosters an interdisciplinary approach to solving professional tasks involving physical methods in medicine and prepares students to apply this knowledge in scientific research and practical work.

1. ACADEMIC COURSE GOALS AND OBJECTIVES

The goal of studying the discipline is for students to acquire comprehensive knowledge of the physical characteristics of biological systems; to understand the physical processes occurring in the human body; to study the mechanisms by which physical factors affect the organism; and to prepare for the use of fundamental physical, biophysical, physicochemical, mathematical, and other natural-science concepts and methods in professional practice.

Objectives:

• To ensure the formation of comprehensive theoretical, scientific, and applied knowledge about the physical properties and biophysical processes occurring in the human body under normal and pathological conditions, as well as an understanding of the principles of operation of medical equipment.

• To develop skills in working with physical instruments for the effective application of biophysical methods in research and diagnostics, and to ensure knowledge of safety rules when working with medical devices.

• To teach the application of mathematical and statistical methods for solving intellectual tasks and using them in medical practice.

• To promote the development of professionally significant personal qualities necessary for mastering the competencies of the chosen field.

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

The implementation of the discipline begins at the start of training and continues for two semesters. The knowledge, skills, and competencies acquired in the course are essential for the successful study of such disciplines as normal physiology, life safety, radiobiology, radiological diagnostics, radiology and radiotherapy, academic practice, research work, and others.

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	Section One	1-8	8/8/8	T-8 (25)	25	T-8	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	Section Two	9-16	8/8/8	T-15 (25)	25	T-15	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	Section One	1-8	8/8/8	T-8 (25)	25	T-8	З-ОПК-5, У-ОПК-5, В-ОПК-5
2	Section Two	9-15	7/7/7	T-14 (25)	25	T-14	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
T	Testing
PFE	Pass/fail examination
Ex	Exam

SYLLABUS

Weeks	Topics / Content	Lect., hrs.	Pr./sem., hrs.	Lab., hrs.
	1 Semester	16	16	16
1-8	**Section One**	8	8	8
1 - 4	**Biophysical Foundations and Physicochemical Properties of**	All		

	Biological Systems This section covers the basic physicochemical properties of cells and biological tissues, including the characteristics and structure of biological membranes. It examines the principles of osmotic phenomena, the distribution of substances across semipermeable membranes, and chemical equilibrium in cells. The laws of thermodynamics, heat exchange and its role in metabolism are studied, as well as the fundamental concepts of viscosity and density of biological fluids, which are important for understanding the functioning of the circulatory system and other physiological processes. The section also includes the study of the operation of hematological and biochemical analyzers.	4 Online 0	4 0	4 0
5 - 8	**Optics and Photophysics of Biological Processes** This section is dedicated to studying the interaction of light with biological tissues. It examines the laws of light absorption by matter, including the Bouguer–Lambert–Beer laws, and concentration colorimetry. The principles of light scattering and research methods such as colorimetry, turbidimetry, and nephelometry—used to study microstructures in tissues—are discussed. The structure of the eye as an optical system is studied, including its light-conducting apparatus and the features of light perception, accommodation, visual defects, and their correction. The section also covers the use of lasers in medicine, the principles of their operation, and the properties of laser radiation, including its applications in diagnostics and therapy.	All 4 Online 0	 4 0	 4 0
9-16	**Section Two**	8	8	8
9 - 11	**Mathematical and Statistical Modeling in Biophysics** This section introduces students to the fundamentals of mathematical and statistical modeling of biophysical processes. It covers methods for constructing mathematical models of physiological processes, the basics of statistical analysis of medical data, and their interpretation.	All 4 Online 0	 4 0	 4 0
12 - 16	**Mechanics and Biomechanics of the Body. Photodynamic Therapy and Fluorescence Diagnostics** This section examines the biomechanical aspects and mechanical properties of biological tissues. It covers the characteristics of muscle force, tissue elasticity and resistance, the principles of the musculoskeletal system, the movement of fluids in the body, and the main mechanical processes associated with the functioning of the cardiovascular and respiratory systems. Students acquire skills in analyzing biomechanical processes and learn to apply them in diagnosing musculoskeletal pathologies. The concept of fluorescence is introduced. Methods of photodynamic therapy, fluorescence diagnostics, as well as light and fluorescence microscopy, spectroscopy, and imaging are also studied.	All 4 Online 0	 4 0	 4 0
	2 Semester	15	15	15
1-8	**Section One**	8	8	8
1 - 4	**Electrical and Electromagnetic Processes in the Body** This section covers processes related to electrical and magnetic	All 4	 4	 4

	fields in the body. It includes the study of biopotentials such as ECG (electrocardiography), EEG (electroencephalography), and EMG (electromyography), as well as the principles of their generation and propagation. Students learn the laws governing the interaction of electrical and magnetic fields with biological structures, the characteristics of biopotential generation in cardiac, muscle, and nervous tissues, and acquire skills in recording and interpreting these signals, which is an important component in diagnosing various diseases.	Online		
		0	0	0
5 - 8	**Ultrasound Diagnostics and Its Applications** This section covers the physical foundations of ultrasound and its use in diagnostics. It includes the principles of sound wave propagation, the interaction of ultrasound with biological tissues, and the basics of echolocation. Students study the parameters of ultrasound signals, the features of forming and interpreting ultrasound images, and the possibilities of using ultrasound in diagnosing diseases of internal organs. The structure and operation of an ultrasound device, as well as the safety of ultrasound diagnostics, are also examined.	All		
		4	4	4
		Online		
		0	0	0
9-15	**Section Two**	7	7	7
9 - 11	**Nuclear Magnetic Resonance (MRI) and Radiological Methods, and Methods of Radiation Physics and Protection of the Body** This section covers the principles of nuclear magnetic resonance and its use in medical diagnostics. Students become familiar with the fundamental principles of MRI: the magnetic field, proton precession, spin, and resonance. The acquisition, interpretation, and analysis of tomographic images are studied, as well as the role of MRI in detecting pathologies of tissues and organs. Particular attention is given to safety principles and the prevention of possible side effects of MRI diagnostics. This section also covers the basics of the interaction of ionizing radiation with biological tissues, as well as methods of radiation protection. Students study the types of radiation, their properties, the concept of radiation dose, and methods of its measurement, including dosimetry and various types of radiation protection. Radiological safety in the context of medical diagnostics and therapy is examined, along with methods and means of protecting personnel and patients from ionizing radiation.	All		
		4	4	4
		Online		
		0	0	0
12 - 15	**Physical Principles of Nanotechnology in Biomedicine** Introduction to Nanomedicine. Methods of nanoparticle production and conditions of their use. Personalized medicine. Nano–bio interactions. Nanoparticles in biomedicine: types, properties, and characteristics. Biocompatibility and toxicity of nanoparticles. Examples of nanoparticle applications in biomedicine. Nanoplasmonics. The use of nanophotosensitizers for diagnosing pathological conditions in oncological and inflammatory diseases.	All		
		3	3	3
		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 - 4	**Study of the Physicochemical Properties of Biological Fluids** Determination of viscosity, density, and other physical parameters of biological fluids. Examination of their changes under normal and pathological conditions.
5 - 8	**Analysis of Thermodynamic Processes in Biological Systems** Study of heat transfer and heat distribution processes in biological tissues. Determination of temperature gradients and their influence on physiological processes.
9 - 11	**Optical Microscopy: Study of Biological Tissues** Use of an optical microscope to examine the microstructure of tissues. Study of methods for preparing microscopic specimens and analyzing cellular structures.
12 - 16	**Application of Photodynamic Methods in Medicine** Study of the principles of photodynamic therapy and diagnostics. Investigation of the effects of light energy on biological tissues, determination of light exposure parameters and their outcomes.
	2 Semester
1 - 4	**Study of Electrophysiological Processes Using BioPAC** Examination of the electrical activity of muscles (EMG), the heart (ECG), and the brain (EEG). Determination of the main parameters of biopotentials, their recording and analysis.
5 - 8	**Study of Ultrasound Diagnostic Methods Using an Ultrasound Device** Study of the principles of ultrasound diagnostics, recording of echograms, and analysis of the features of ultrasound imaging of various organs and tissues.
9 - 11	**Fundamentals of Nuclear Magnetic Resonance: Working with an MRI Simulator** Study of the principles of magnetic resonance imaging, acquisition of tomographic images, analysis of MRI data, and their use in diagnosing various diseases.
12 - 15	**Determination of Blood Flow Parameters Using BioPAC and Doppler Technologies** Study of blood circulation in vessels, measurement of blood flow velocity, and analysis of physiological parameters related to the cardiovascular system.

PRACTICAL SESSIONS TOPICS

Weeks	Topics / Content
	1 Semester
1 - 4	**Biophysical Foundations and Physicochemical Properties of Biological Systems** Osmotic phenomena, distribution of substances across semipermeable membranes, and chemical equilibrium in cells. Laws of thermodynamics, heat exchange and its role in metabolism. Basic concepts of viscosity and density of biological fluids. Hematological and biochemical analyzers.

5 - 8	**Optics and Photophysics of Biological Processes** Interaction of light with biological tissues. Law of light absorption by matter, Bouguer–Lambert–Beer law, concentration colorimetry. Use of lasers in medicine, principles of their operation and properties of laser radiation, applications in diagnostics and therapy.
9 - 11	**Mathematical and Statistical Modeling in Biophysics** Fundamentals of mathematical statistics in biophysics. Methods for constructing mathematical models of physiological processes. Statistical analysis of medical data and its interpretation.
12 - 16	**Mechanics and Biomechanics of the Body. Photodynamic Therapy and Fluorescence Diagnostics** Biomechanical aspects and mechanical properties of biological tissues. Characteristics of muscle force, tissue elasticity and resistance, principles of the musculoskeletal system, fluid movement in the body, and the main mechanical processes associated with cardiovascular and respiratory function. Diagnosis of musculoskeletal pathologies.
	2 Semester
1 - 4	**Electrical and Electromagnetic Processes in the Body** Laws of interaction between electrical and magnetic fields and biological structures; characteristics of biopotential generation in cardiac, muscle, and nervous tissues.
5 - 8	**Ultrasound Diagnostics and Its Applications** Principles of sound wave propagation, interaction of ultrasound with biological tissues, and basics of echolocation. Parameters of ultrasound signals, features of forming and interpreting ultrasound images.
9 - 11	**Nuclear Magnetic Resonance (MRI) and Radiological Methods, and Methods of Radiation Physics and Protection of the Body** Principles of nuclear magnetic resonance and its use in medical diagnostics. Principles of MRI: magnetic field, proton precession, spin, and resonance. Safety principles and prevention of possible side effects of MRI diagnostics. Interaction of ionizing radiation with biological tissues. Types of radiation, their properties, the concept of radiation dose and its measurement methods, including dosimetry and types of radiation protection. Radiological safety in medical diagnostics and therapy
12 - 15	**Physical Principles of Nanotechnology in Biomedicine** Nanomedicine. Methods of nanoparticle production and conditions for their use. Personalized medicine. Nano–bio interactions. Nanoparticles in biomedicine: types, properties, and characteristics. Biocompatibility and toxicity of nanoparticles. Nanoplasmonics.

6. EDUCATIONAL TECHNOLOGIES

During the study of the discipline, the following educational technologies are used in classroom sessions: lectures, laboratory work, and seminars employing active and interactive teaching methods. In organizing students' independent work, the following educational technologies are used: presentations with computer-based slides, testing, and written assignments.

Instruction in the discipline can also be delivered in a blended format—both traditionally in the classroom and with the use of distance learning technologies. The educational process designed and implemented in this form combines the best features of both approaches and is largely free of their shortcomings.

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, T-8, T-15, T-8, T-15	Ex, T-8, T-14, T-8, T-14
	У-ОПК-5	PFE, T-8, T-15, T-8, T-15	Ex, T-8, T-14, T-8, T-14
	В-ОПК-5	PFE, T-8, T-15, T-8, T-15	Ex, T-8, T-14, T-8, T-14

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. ЭИ R42 Medical and biological physics : , Remizov A.N., Москва: ГЭОТАР-Медиа, 2022

2. ЭИ R38 Medical and biological physics : учебник, Remizov A.N., Москва: ГЭОТАР-Медиа, 2021

FURTHER READING:

1. ЭИ В 19 Медицинская и биологическая физика. Лабораторный практикум : учебное пособие для вузов, Васильев А. А., Москва: Юрайт, 2024

2. ЭИ В 19 Медицинская и биологическая физика. Тестовые задания : учебное пособие для вузов, Васильев А. А., Москва: Юрайт, 2024

SOFTWARE:

No special softwares is required

LMS AND ONLINE RESOURCES

https://online.mephi.ru/

http://library.mephi.ru/

9. LOGISTICAL SUPPORT

1. Лаборатория функциональной диагностики (64-306)

2. Персональный компьютер: Процессор CPU Intel Core i7-8700 (3.2GHz/12MB/6 cores) Материнская плата Gig (64-306)

3. Мышь, клавиатура (64-306)

4. Аппарат для электрофизиологических исследований MP35 (Biopac Student Lab, полная комплектация для PC (64-306)

5. Интерактивная доска SMART SBM 685 (64-306)

6. Монитор Dell P2720D (64-306)

7. Видеокамера Microsoft LifeCam Cinema HD (64-306)

8. Персональный компьютер: Моноблок Lenovo V540-24IWL All-In-One 23,8" i3-8145U 8Gb 256GB_SSD_M.2 Intel (64-306)

9. 3D принтер Anycubic Kobra 2Neo (64-306)

10. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS

With the introduction of the Federal State Educational Standard into the educational process, the task of organizing students' independent work has become increasingly important. Independent work is defined as individual or group academic activity carried out without the direct supervision of an instructor, but according to their assignments and under their control. Independent work is one of the main forms of extracurricular activity in the implementation of curricula and educational programs.

Independent work is a cognitive learning activity in which the sequence of the student's thought processes, mental operations, and practical actions is determined by the student.

During the learning process, the student must not only master the academic program but also acquire skills for independent work. A student is given the opportunity to work more independently than pupils in secondary school. A student must be able to plan and complete their work.

The goal of students' independent work is to master fundamental knowledge, professional skills, and competencies relevant to their field, as well as to gain experience in creative and research activities. Independent work contributes to the development of independence, responsibility, organization, and a creative approach to solving academic and professional tasks.

Stages of independent work:

- understanding the academic task to be solved through the given independent work;
- familiarization with the instructions for completing it;
- carrying out the work process;
- self-analysis and self-monitoring;
- review of the student's work, identification and discussion of typical strengths and errors.

Independent work is a mandatory component of the educational process for every student and is determined by the curriculum. When defining the content of students' independent work, one should consider their level of independence and the required level of independence for graduates, so that over the course of study the necessary level is achieved. Thus, the proportion of independent work in full-time programs reaches up to 50% of the classroom hours allocated for the discipline; in part-time programs, the number of hours allocated for mastering the discipline increases to 90%.

The forms of students' independent work are determined during the development of course syllabi and teaching-methodological packages based on the content of the discipline.

According to the Regulation on the Organization of Students' Independent Work based on the competence-based approach to the implementation of professional educational programs, the types of assignments for independent work include:

- For acquiring knowledge: reading texts (textbooks, primary sources, supplementary literature), making a text outline, graphical representation of text structure, summarizing, making

excerpts, using dictionaries and reference materials, reviewing normative documents, academic research work, using audio/video materials, computer technologies and the Internet, etc.

• For reinforcement and systematization of knowledge: working with lecture notes, processing text, repeated work with study materials (textbooks, primary sources, supplementary literature, audio/video materials), making outlines and tables to systematize material, answering review questions, completing workbook tasks, analytical text processing (annotating, reviewing, abstracting, analytical summaries, etc.), completing practical classroom work and preparing written reports, preparing multimedia presentations and conference reports, creating bibliographies, thematic crosswords, testing, etc.

• For skill development: solving sample problems and exercises, solving variable problems, drawing diagrams and schemes, performing calculations, solving situational (professional) tasks, preparing for business games, designing and modeling components of professional activity, experimental work, reflective analysis of professional skills with audio/video tools, etc.

Independent work may be completed individually or in groups depending on the purpose, scope, specific topic, level of complexity, and students' skill level.

The assessment of students' independent work may be conducted during the time allocated for mandatory classroom sessions or during extracurricular independent work. It may take written, oral, or mixed forms.

During the study of the discipline, the following types and forms of independent work are practiced:

• performing laboratory and practical work;
• preparing written reports;
• preparing presentations and informational messages on assigned topics;
• preparing and writing essays;
• completing practical assignments;
• creating presentation materials;
• preparing for oral questioning and discussions;
• preparing for testing;
• preparing for written and control assignments;
• preparing for colloquia;
• completing creative assignments;
• writing course papers, etc.

Independent work includes preparatory exercises for learning new material, exercises during the study of new topics, reinforcement and review exercises, as well as tasks for monitoring and self-assessment.

The following conditions are necessary for organizing independent work:

• students' readiness for independent work;
• availability and accessibility of required educational, methodological, and reference materials;
• advisory support.

Independent work may take place in a lecture hall, laboratory, vivarium, computer room, library, or at home. Independent work develops willpower, fosters work capacity, attention, discipline, and other essential qualities.

11. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR TEACHERS

A lecture, as a form of classroom work, is intended to convey theoretical knowledge of the discipline to students. Lectures ensure, first and foremost, the formation of the “to know” component of competencies. Lecture materials serve as a foundational basis for students’ preparation for seminars, practical classes, colloquia, independent work assignments, and for activities related to ongoing academic performance assessment and interim attestation in the discipline. During lectures, students are encouraged to take notes.

At the beginning of each lecture, time is allocated for reviewing key points from the previous lecture and addressing questions that arose during students’ independent study of the lecture material. At the end of each lecture, additional time is provided for answering questions that arise while listening to the lecture. This lecture strategy allows for the elimination of gaps in understanding that may occur at different stages of perceiving the material. For deeper comprehension of the theory, students are given references to literature or electronic resources that provide more detailed explanations of the issues discussed.

Practical classes are aimed at developing skills for solving practical problems using the acquired theoretical knowledge, as well as skills for independent work under the instructor’s supervision. They primarily form the “to be able” and “to possess” components of competencies and focus on solving standard (basic) tasks that involve typical mechanisms, procedures, and applications of the studied methods, techniques, approaches, algorithms, models, etc.

• The criteria for evaluating a student's performance in practical classes include:

the student’s ability to apply acquired theoretical knowledge when completing homework assignments;

• the formation of skills and practical abilities;

• the correct formatting of material in accordance with requirements;

• the student’s level of mastery of the academic material.

Requirements for the level of mastery of the course content.

Ongoing assessment of learning outcomes is usually carried out during practical classes and may be conducted in the form of individual questioning or student testing.

The study of the discipline concludes with an examination.

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