



MEDICAL UNIVERSITY – PLOVDIV

FACULTY OF PHARMACY

CURRICULUM IN PHYSICS AND BIOPHYSICS

FOR

PHARMACY

Adopted by the Department Council on №18/10.07.2026
Approved by the Faculty Council on №7/15.07.2026

ACADEMIC PLAN

Discipline	Exam Sem	In-Class Workload (Hours)			Non-auditorium Workload	Total Credits	Hours by Year & Sem	
		Total	Lectures	Practical			Year I, Sem I	Year I, Sem II
						Lectures/ Seminars	Lectures/ Seminars	
PHYSICS AND BIOPHYSICS	I	75	45	30	75	5.0	3 / 2	...

Course Title: Physics and Biophysics

Type of Discipline: Mandatory

Educational Level: Master's /M/

Forms of Training: Lectures, practical sessions, self-study

Year & Duration of Study: 1st Year (Winter Semester)

Workload: 75 hours (45 hours of lectures, 30 hours of practical sessions)

Teaching aids and interactive methods

- Multimedia presentations
- Laboratory educational experiments
- Solving test tasks and case studies
- Discussions and simulation scenarios

Methods for stimulating students' creative activity

In the process of work, students are given the opportunity to present their knowledge and their activity is stimulated through:

- developing projects and essays
- participating in discussions, presenting personal points of view
- creating presentations and student projects
- using multimedia, audio and video materials
- working with online platforms and simulation scenarios
- solving cases

FORMS OF ASSESSMENT

Current Assessment:

Current (sources for forming the current assessment) – demonstrated knowledge during exercises and/or written test; written colloquium – once per semester; written exam.

Grade Formation:

The formation of the semester grade (final grade) for the discipline includes the grades from the current control and the grade from the exam, according to an approved academic standard for the discipline.

Aspects when forming the grade:

The final grade is determined by the student's performance in the exercises/practicals during the semester (current assessment) and by the final exam (exam grade) at the end of the semester. The course ends with a positive exam.

Semester Exam:

The semester exam in the discipline is in-person and includes components described in the approved academic standard for the discipline. The final grade from the semester exam is formed according to the approved academic standard for the discipline.

State exam: No

Leading lecturer: habilitated lecturer from the Department of Medical Physics and Biophysics

Department: Medical Physics and Biophysics

ANNOTATION

Medical Physics and Biophysics are fundamental disciplines in pharmacy education, providing the basis for understanding the physicochemical processes in the body and the principles of modern pharmaceutical technologies.

Medical Physics introduces students to the physical nature of the phenomena underlying the development, analysis and qualification of drugs and medical devices. Theoretical and experimental methods (lasers, optical and electron microscopy, imaging diagnostics, etc.) are studied, as well as key sections of mechanics, optics and subatomic physics applicable to pharmaceutical practice.

The Biophysics section examines the functioning of living systems at the molecular, cellular and tissue levels, which is the basis for understanding the mechanism of action of drugs. The emphasis is placed on the structure of the cell membrane, the mechanisms of transmembrane transport (critical in the interaction of substances with cells), bioelectrogenesis, cell signaling and the effects of external factors (electromagnetic waves, mechanical waves and others) on biological objects.

Taken together, the two divisions in this new discipline will build in future pharmacists a comprehensive understanding of the physical laws governing living matter and its interaction with various biologically active substances.

MAIN TASKS OF THE CURRICULUM

The training in the disciplines aims to prepare future pharmacists through:

- Mastering the physical principles underlying laboratory activities, modern diagnostic and therapeutic equipment, as well as methods for protection from harmful factors.
- Studying the influence of external physical factors (light, ultrasound, ionizing radiation, UV and IR rays) on the living organism, which is of key importance for understanding the stability, storage and action of dosage forms.
- Elucidating fundamental processes in living tissue through an interdisciplinary approach. Students study the physical and physicochemical reactions at the molecular and cellular level, which serve as a scientific basis for explaining physiological processes and mechanisms of drug action.

EXPECTED RESULTS (COMPETENCIES)

After successful completion of the course, Pharmacy students must possess the following knowledge and practical skills:

- Fundamental physical laws: Knowledge of the basic physical quantities, units and mathematical/graphical expressions of physical laws and the application of the relevant laws.
- Wave processes: Understanding the principles of mechanical and electromagnetic waves.
- Radiation physics: Knowledge of the properties of ionizing radiation and methods of protection.
- Molecular and cellular biophysics: Understanding the structure of biomembranes, bioelectrogenesis (membrane and action potential), the mechanism of muscle contractions in different tissues.
- Transport processes: acquiring theoretical knowledge about passive and active transmembrane transport (key to pharmacokinetics), cell signaling, receptor function and intercellular communication.

- Physicochemical and toxicological processes: Knowledge of electrokinetic phenomena (surface charge, influence of pH and ionic strength on the electrophoresis of biomolecules) and mechanisms of oxidative stress (free radicals and toxicity).
- Impact of external factors: Understanding the physical and biological effects of the influence of electric current, light, UV, IR rays and ionizing radiation on living systems.
- Experimental work and biostatistics: Conducting physical measurements and subsequent processing of data using tabular, graphical and statistical methods.
- Applied medical and pharmaceutical research: Understanding the physical foundations of: hemodialysis (principles of filtration), ultrasound; measuring blood pressure.
- Radiopharmacy: Calculation of the basic parameters of radionuclides and obtaining calibration curves.

LECTURE COURSE SYLLABUS (THESES SUMMARY)

Lecture №	Lecture topic and content	Acad. hours
1	1. Physical characteristics of sound: pressure, intensity, frequency, wavelength, propagation speed, impedance, spectrum. 2. Psychophysical characteristics of sound: relative level of intensity and loudness; pitch, timbre. Hearing range. 3. Sound methods for diagnosis and therapy: audiometry, auscultation; hearing aids, noise protection devices.	3
2	4. Physical properties of ultrasound (US). Generators. The use of US in drug technology – fountain and cavitation. Extraction of biologically active substances, dissolution, dispersion, sterilization. 5. Physical principles of ultrasound imaging. Pharmaceutical forms used in ultrasound imaging: contact gels and contrast agents. Infrasound, properties. 6. Molecular structure of liquids. Surface tension of liquids, surface tension coefficient, molecular pressure. Hydrophilic and hydrophobic surfaces, meniscus, capillary phenomena, Laplace pressure. Gas embolism.	3
3	7. Law of flow continuity and Bernoulli's law. Laminar and turbulent motion, Reynolds number. Blood pressure measurement. Poiseuille's law, viscometry. Non-Newtonian behavior and microrheological processes in fluids.	3

	8. Transport processes in pharmaceutical practice: diffusion, Newton's law of internal friction, thermal conductivity. Dialyzers and percolators, heat treatment, cooling and sterilization products. 9. Physical principles of hemodialysis. Hemodialyzer.	
4	10. Phase separation in liquid heterogeneous systems. Heterogeneous system. Sedimentation and centrifugation. Sedimentation rate, centrifugal force, types of centrifuges. Methods of preparative centrifugation. Filtration. 11. Electric current - definition, properties and quantities. Electrical conductivity of solids. Energy levels and zones in conductors, semiconductors and insulators. Mixed conductivity of semiconductors: n-type and p-type semiconductors. Electron-hole transition in semiconductors 12. Direct, pulsating and alternating current. Ohm's law. Types of resistance: R, X_L, X_C. Impedance.	3
5	13. Electrical conductivity of electrolytes. Faraday's laws. Drug electrophoresis. Requirements for pharmaceutical forms for electrophoresis and sonophoresis. Electrical conductivity of gases. Types of aeroions. Biological action of aeroions and requirements for aerosol pharmaceutical forms. 14. Magnetic properties of substances. Origin. Application of electron paramagnetic resonance (EPR) and nuclear magnetic resonance (NMR) for the analysis of pharmaceutical forms. Imaging diagnostics with NMR (MRI) and pharmaceutical forms used as contrast agents. 15. Electromagnetic radiation – spectrum, parameters. Interaction of light with matter – reflection, refraction, total internal reflection of light, absorption, scattering and polarization. Laws.	3
6	16. Optical microscope. Optical scheme. Images. Resolution and magnification. Methods of observation with microscopes in pharmaceutical practice. 17. Optical system of the eye: focusing elements, optical defects and corrections. Perceptive system of the eye - spectral sensitivity. 18. Ultraviolet (UV) and infrared rays (IR) in pharmacy. Parameters, zones, properties, sources. Characteristics of pharmaceutical forms used for protection from UVA and UVB radiation.	3
7	19. Examination of pharmaceutical forms with a refractometer, photocolormeter, spectrophotometer, polarimeter, nephelometer. 20. Optical atomic spectra. Energy states of the atom, Pauli principle, optical transitions between energy levels. Atomic spectral analysis - emission and absorption analysis. 21. Luminescence. Characteristics and laws. Requirements for pharmaceutical forms for luminescent analysis.	3

8	22. Lasers. Spontaneous transition, stimulated emission. Normal and inverse population of energy levels. Main parts of the laser, principle of operation. Types of lasers. Properties of laser radiation. Application of the laser in pharmacy. 23. Radioactivity, radionuclides. Alpha and beta nuclear transformations, energy spectra. Gamma radiation, spectra. Metastable state, isomeric transition. 24. Activity of a radioactive source. Law of radioactive transformation, half-life of a radionuclide. Biological half-life. Radiopharmaceuticals, method of preparation, application. Neutron activation analysis.	3
9	25. X-rays. Basic structure of an X-ray tube. Bremsstrahlung and characteristic X-ray radiation. Properties of X-rays. X-ray structural and fluorescence analysis. Conventional radiography and radioscopy, angiography. Computed tomography. Pharmaceutical forms used in X-ray imaging. 26. Interaction of ionizing radiation with matter. Photoelectric absorption, Compton scattering, electron-positron pair formation. Law of intensity reduction. Total linear attenuation coefficient. Bremsstrahlung, linear ionization, mean linear range. 27. Effect of ionizing radiation on the human body. Dosimetric quantities. External and internal irradiation. Dose, dose rate, exposure, equivalent dose, radiation weighting factor, effective dose.	3
10	28. Subject, basic concepts and sections of thermodynamics. Thermodynamic systems and quantities. First principle of thermodynamics and its application in biological systems. 29. Second principle of thermodynamics. Entropy. Free energy. Thermodynamics of open systems. Prigogine's equation. 30. Subject and importance of biological membranology, types of membranes. Functions and basic chemical composition of biomembranes. Membrane phospholipids, glycolipids and cholesterol.	3
11	31. Mobility of membrane components – lateral and transverse diffusion. Liquid crystalline state of the lipid bilayer. Molecular mechanism of phase transitions. Types of lipid liquid crystalline phases and their applications as drug carriers. 32. Passage of substances through the cell membrane. Essence and importance of membrane transport. Types of transport. Passive transport. 33. Energy prerequisites for passive membrane transport. Concentration and electrical gradient.	3
12	34. Free diffusion of uncharged particles and ions. Fick's first and second law, Stokes-Einstein equation. through a membrane. Nernst-Planck equation. Non-free diffusion through a porous membrane.	3

	35. Facilitated and exchange diffusion. Ionophores - mobile carriers (valinomycin) and channel formers (gramicidin A). Ion channels - types, mechanisms of activation/inactivation. 36. Active membrane transport. Types. Sodium-potassium pump and calcium pump - importance, role of ATP, molecular structure and model of action. Drugs affecting active transport.	
13	37. Diffusion and equilibrium potential - conditions and mechanisms of occurrence, dependence on concentrations and time. Resting potential. Equilibrium potential. 38. Electric membrane potential. Prerequisites for its existence. Nernst-Bernstein and Goldman equations. 39. Action potential in a neuron. Essence, occurrence and propagation of the action potential. Fixed voltage method. Membrane currents during excitation. Refractory period. Trace potentials. Accommodation. Propagation of the action potential. Electrotonic potential. Conduction mechanism. Propagation speed.	3
14	40. Intercellular communication. Chemical type of intercellular information system. Perception of intercellular chemical signals. Receptors - information inputs of cells. Main functions of receptors. Regulatory mechanisms 41. Structure and mechanical properties of striated muscles. Types of contractions. Contractile mechanisms in striated muscles. Electro-mechanical connection. 42. Contractile activity of smooth muscles. Types of contractions. Contractile mechanisms in smooth muscles. Electro and pharmacomechanical connection. Bioelectrical activity of smooth muscles.	3
15	43. Surface electric charge of cells and molecules. Electric double layer. Electrokinetic potential. Dependence of electrokinetic potential on pH and ionic strength of the medium. Electrokinetic phenomena – electrophoresis, electroosmosis and current potential. 44. Electrical conductivity of tissues for direct and alternating current. Polarization. Types. Dispersion of dielectric permittivity. Effect of electric current on biological objects. 45. Oxidative stress and antioxidant protection. Consequences of oxidation of membrane components. Molecular mechanisms of oxidative stress induced by various physicochemical factors. Antioxidant defense systems of organisms. Oxidation of pharmaceutical preparations.	3

PRACTICAL LESSONS SYLLABUS (THESES SUMMARY)

№	Topic of the practical lesson and content	Acad. hours
1	Determining errors in experimental studies. Interpolation. <u>Seminar part:</u> Reminding students of basic physical quantities and their units of measurement; converting multiple units of measurement. <u>Tasks:</u> ✓ working with tabular data in the Excel program; ✓ calculating the arithmetic mean; ✓ calculating the arithmetic mean error of the average result; ✓ determining a confidence interval for different confidence probabilities;	2
2	Audiometry – a method for diagnosing hearing aids. <u>Seminar part:</u> Subject and tasks of audiometry. Psychophysical quantities related to acoustics – intensity level and loudness. Psychophysical law of Weber-Fechner. <u>Experimental part:</u> ✓ Familiarization with the device and principle of operation of an audiometer; ✓ measurement of intensities for certain frequencies without noise and with the presence of white noise produced by an audiometer; ✓ reading the intensity values; ✓ construction of a graph for the hearing threshold on a logarithmic scale.	2
3	Physical principles of Doppler ultrasound. Working with a Doppler ultrasound machine. Measuring linear blood velocity. <u>Seminar part:</u> Acoustic spectrum. Acoustic impedance. Physical principle of ultrasound. Doppler effect. <u>Experimental part:</u> ✓ placing gel on the examined area and choosing an angle for directing the transducer; ✓ determining the direction of measurement for the venous portion and arterial portion. ✓ qualitatively determining the dependence of the resolution on the frequency of the ultrasound wave.	2
4	Blood pressure measurement, measured by sphygmometric method (Korotkoff method) <u>Seminar part:</u> Physical foundations of blood pressure determination. Laminar and turbulent blood flow. Pulse wave. Changes in blood pressure over time.	2

	<u>Experimental part:</u> ✓ measuring the heart rate by palpation; ✓ determining the area for measuring blood pressure; ✓ placing the rubber cuff, increasing the pressure in it with the pump. Perception of the noise effects of blood movement; ✓ determining systolic and diastolic pressure by changing the intensity of Korotkoff sounds;	
5	Converters of non-electrical quantities. Calibration of semiconductor thermometer and photocell. ✓ working with different types of thermometers (alcohol, semiconductor and thermocouple); ✓ measuring with an electronic ohmmeter; ✓ measuring with a voltmeter; ✓ working with metric scales and conversions: from centimeters to meters; from millivolts to volts; from kilohms to ohms; ✓ drawing graphical relationships and finding the most appropriate scale.	2
6	Observations of microobjects with an optical microscope. Calculation of the magnification and resolution of an optical microscope and selection of observation technique. <u>Seminar part:</u> Geometric optics – basic elements, laws and rules. Optical images – formation, features. Introduction to the device of an optical microscope. <u>Experimental part:</u> ✓ working with a microscope; ✓ selecting an appropriate combination of objective and eyepiece in view of the nature and size of the observed object; ✓ ensuring the necessary intensity of illumination, focusing, orientation of the ocular scale and grid; ✓ determining linear dimensions and areas of unknown microobjects and their morphological elements. ✓ choosing an observation method;	2
7	Determination of dispersion and power of a He-Ne laser. <u>Seminar part:</u> Atomic transitions – light absorption, spontaneous emission and stimulated emission. General device of a laser. <u>Experimental part:</u> ✓ work with a laboratory He-Ne laser; ✓ determination of the stereometric divergence angle; ✓ measurement of power; ✓ study of the polarization of laser radiation.	2

	✓ demonstrations of wave-particle phenomena.	
8	Practical tasks related to the type and quantity of radiopharmaceuticals used in nuclear medicine. <u>Seminar part:</u> Radioactivity – definition, basic law. Types of radioactive transformations. Radiopharmaceutical – definition. <u>Tasks:</u> ✓ solving nuclear equations; ✓ principle of obtaining ^{99m}Tc - eluate from a radionuclide generator; ✓ working with a certificate of a radionuclide source for medical purposes; ✓ calculating radioactivity from given data; ✓ calculating the amount of radiopharmaceutical required for application for a specific diagnostic study; ✓ calculating the mass of the radiopharmaceutical introduced into the patient during the study.	2
9	Colloquium	2
10	Model for studying lipid aggregates in aqueous media. <u>Seminar part:</u> Composition of biomembranes – lipids, proteins and cholesterol. Mobility of lipids and proteins in membranes. Phase states. Phase transition. <u>Experimental part:</u> ✓ working with automatic pipettes; ✓ experimental determination of the thickness of a lipid monolayer; ✓ computational tasks for determining the thickness of a monolayer.	2
11	Passive and active membrane transport. Influence of bioactive molecules on transport. <u>Seminar part:</u> Passive transport – definition, laws, types. Ion channels – types and mechanism of action. Active transport – primary and secondary active transport. Ion pumps – Na^+/K^+ pump, Ca^{2+} pump. <u>Tasks:</u> ✓ illustrating the mechanism of action of membrane-potential dependent ion channels and receptor-gated channels; ✓ illustrating the mechanism of action of membrane-potential dependent ion channels and receptor-gated channels; ✓ Computational tasks for determining the amount of blockers for the respective type of transport based on practically obtained data. ✓ Construction and analysis of graphical dependencies.	2

12	Receptors – cellular information inputs. Smooth muscle effects of activation and blockade of muscarinic cholinergic receptors <u>Seminar part:</u> Intercellular communication - types. Cellular mechanisms of transmission of intercellular communication. Types of receptors. Secondary mediators. <u>Taks:</u> ✓ illustrating the mechanism of action of different types of receptors; ✓ computational tasks for determining the amount of blockers for the respective type of receptor. ✓ using experimental records to determine the effect of bioactive substances on gastric smooth muscle. ✓ constructing and analyzing graphical dependencies.	2
13	Study of changes in the membrane potential of a squid axon upon stimulation with pulsed electric current of varying density, direction, and duration. <u>Seminar part:</u> Membrane potential – definition, hypotheses. Action potential – definition, occurrence and propagation. Ionic currents. Fixed voltage method. <u>Tasks:</u> ✓ illustrating the mechanism of action potential; ✓ using simulation to track changes in the membrane potential of an axon when stimulated with a pulsed electric current of different density, direction and duration; ✓ analyzing the resulting relationships.	2
14	Contractile apparatus and mechanism of striated muscle. Electrical conductivity of striated muscle for direct current. Myoneural synapse. Electromuscular stimulation. <u>Seminar part:</u> Contractile apparatus of striated muscle (SRM). Role of Ca^{2+} in SRM contraction. Electromechanical coupling – myoneural synapse. Polarization of biological tissue under direct current. Electromuscular stimulation (EMS). <u>Tasks:</u> ✓ illustration of the mechanism of reduction of the SRM; ✓ demonstration of the EMC;	2
15	Contractile and bioelectrical activity of smooth muscle tissue. Role of Ca^{2+}. <u>Seminar part:</u> Contractile apparatus of smooth muscle (SM). Role of Ca^{2+} in SM contraction. Electromechanical and pharmacomechanical coupling. Cellular mechanisms. <u>Tasks:</u>	2

	✓ illustrating the cellular mechanisms of SM contraction; ✓ using experimental recordings to determine the main characteristics of SM contraction; ✓ using experimental recordings to determine the main characteristics of SM bioelectric activity;	
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LITERATURE

1. Emilia Milieva, Franco Milano, Iordan Kostourkov, Martianna Yaneva, Lubka Mihova “Physics and Biophysics of Clinical Radiation Therapy” — 2017
2. Kwan Hoong Ng, Jeannie Hsiu Ding Wong, Geoffrey D. Clarke, Problems and Solutions in Medical Physics – 2018
3. Tom A. Waigh – “Applied Biophysics”, John Wiley and Sons, Ltd, Manchester, UK – <https://epdf.pub/biophysics.html>
4. Rodney M. J. Cotterill, “Biophysics”- An introduction, John Wiley and Sons, Ltd – 2002 – <https://epdf.pub>
5. Patrick F. Dillon, Biophysics – A Physiological Approach, Published by Cambridge University Press, 2012

CONSPECTUS

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