



**MINISTRY OF HEALTH OF UKRAINE
NATIONAL UNIVERSITY OF PHARMACY
Faculty of Pharmaceutical Technologies and
Management
Department of Educational and Information
Technologies**

BIOPHYSICS, PHYSICAL METHODS OF ANALYSIS

(Course Name)

**WORK PROGRAM
of a course**

training for Master of Pharmacy
(Higher Educational Level Name)
field of knowledge 22 Public Health
(Code and Knowledge Field Name)
in specialty 226 Pharmacy, Industrial Pharmacy
(Code and Specialty Name)
of educational program Pharmacy
(Educational Program Name)
specialization _____
(Specialization Name)

2020
year of creation

Work program of a course **Biophysics, Physical Methods of Analysis**
in specialty **226 Pharmacy, Industrial Pharmacy** of educational program **Pharmacy**
specialization _____ for applicants for higher education **1st** year of study.

Educational course team:

Dr. Ihor Krasovskyi Candidate of Physical and Mathematical Sciences,
Assoc. Prof. of the Department of Educational and Information Technologies.
(indicate the authors' full names, their positions, scientific and academic degrees)

Work program of a course have been considered and approved at the Department of Educational and Information Technologies Meeting

Record from «1» September 2020 № 1

Head of the Department _____
(signature)

Prof. Lidiia KAIDALOVA
(name and surname)

Work program of a course have been approved at the meeting of the Methodical Profile Commission on Distance and Postgraduate Pharmaceutical Education

Record from «7» September 2020 № 1

Head of Specialized Committee _____
(signature)

Prof. Larisa GALIY
(name and surname)

1. The Description of the Course

The language of the study: English.

Course Status: Obligatory.

Entrance qualification for studying the course: mastering the professional competences that are formed during the study of the disciplines "Mathematics", "Physics", "Biology".

The object of study of the course "Biophysics, Physical Methods of Analysis" is the study of structure and functions of macromolecules, biological systems and biological processes using physics-based methods or based on physical principles. Many powerful tools for investigating biological systems as well as many computational techniques that are now widely used for modeling biomolecular systems have their origins in physics.

Information volume of academic course. To study the course is given **120 hours 4 ECTS credits.**

2. Objectives and tasks of the course

The objective of teaching the course "Biophysics, Physical Methods of Analysis" is to form the student's basic understanding of the physical processes occurring in biological environments; impact of external factors on living organisms; properties and the most general forms of matter motion; the most important physical laws underlying mechanical, thermal, electrical, magnetic, spectral, polarization and other physical methods of study of the drugs properties.

The **main tasks** of the course "Biophysics, Physical methods of analysis" is

- mastering of students of the basic principles and theoretical positions of biophysics;
- explaining of the relationship of physical and biological aspects of living systems;
- studying biological problems associated with physical and physicochemical mechanisms of interactions that underlie biological processes;
- investigation of transformation mechanisms of energy in biological systems, electronic-conformational interactions in biomacromolecules, regulation and self-organization of complex biological systems.

Achieving these goals will enable to students-pharmacists to master by physical, biophysical and mathematical knowledge and skills that necessary to prepare pharmacists as well as to explore other disciplines in higher medical and pharmaceutical educational establishments.

3. Competence and planned educational outcomes

The course "Biophysics, Physical methods of analysis" provides acquisition of competencies by applicants for higher education:

- *Integrated:*
 - the ability to solve typical and complex specialized tasks and practical problems in professional pharmaceutical activities using regulations, theories and methods of fundamental, chemical, technology, medical, pharmacological, social and economic sciences;

- integrate knowledge and handle complexity, formulate opinion with incomplete or limited information;
- clearly and unambiguously convey their conclusions and knowledge to professional and non professional audience, reasonably justify it.
- *General:*
 - the ability to apply knowledge in practical situations;
 - the ability to abstract thinking, analysis and synthesis;
 - the ability to learn and be trained in modern;
 - adaptability and actions in the new situation;
 - the ability to assess and provide the quality of performed work;
 - the ability to conduct research at an appropriate level.
- *Special (professional, substantive):*
 - ability to develop methods for quality control of medicinal products, pharmaceutical substances, medicinal plant materials and auxiliary substances using physical methods of control;
 - ability to identify drugs and its metabolites in biological fluids and tissues, to conduct research of the chemical composition of new pharmaceutical substances;
 - ability to ensure proper storage of medicines and medical devices in accordance with their physicochemical properties and rules of Good storage practices (GSP) in health facilities;
 - ability to ensure rational use of prescription and non-prescription medicines according to physicochemical and pharmacological characteristics.

As a result of studying the course, the applicant for higher education will be able to *know:*

- physical basis and biophysical mechanisms of the action of external factors on systems of the human body;
- theoretical foundations of physical methods of drugs research of, principles of structure and work of appropriate equipment;
- the possibility and scope learned methods;
- general physical and biophysical laws that underlie human life;

do:

- apply the physics methods in studies of biological objects;
- work with measuring equipment that is used in biology, medicine and pharmacy;
- apply mathematical methods in the analysis of research results;

have:

- physical methods of analysis and to know physical basis of the following methods: visible, ultraviolet and infrared spectroscopy; Raman spectroscopy; Mass spectroscopy; Spectroscopy of nuclear magnetic resonance; X-ray analysis; thermal analysis; chromatography; polarimetry; refractometry; microscopic analysis; colorimetry.

4. Structure of the course

Names of content modules and topics	The amount of hours											
	full time study						part time study					
	the whole amount	including					the whole amount	including				
		l	sem.	p.l.	lab.	self-study		l	sem.	p.l.	lab.	self-study
1	2	3	4	5	6	7	8	9	10	11	12	13
Content module 1. Fundamentals of General Biophysics												
Topic 1. Mechanical oscillations and waves. Biophysics of muscle contraction.	12	1		4		7						
Topic 2. Molecular Physics. Thermodynamics.	12	1		4		7						
Topic 3. Thermodynamics of biological processes. Molecular Biophysics.	12	1		4		7						
Topic 4. Biophysics of vision. Biophysics of hearing.	12	1		4		7						
Topic 5. Transport of substances through biological membranes. The content module 1 control.	12	1		4		7						
The whole amount of hours for the content module 1	60	5		20		35						
Content module 2. Fundamentals of Applied Biophysics												
Topic 6. Hydrostatics and hydrodynamics. Biophysics of the blood system.	12	1		4		7						
Topic 7. Electromagnetism	12	1		4		7						

Names of content modules and topics	The amount of hours											
	full time study						part time study					
	the whole amount	including					the whole amount	including				
		l	sem.	p.l.	lab.	self-study		l	sem.	p.l.	lab.	self-study
1	2	3	4	5	6	7	8	9	10	11	12	13
m Biophysics of nerve impulses.												
Topic 8. Nuclear physics. The action of physical factors on biological objects. Own physical fields of human.	12	1		4		7						
Topic 9. Mathematical Biophysics.	12	1		4		7						
Topic 10. Physical methods of analysis. The content module 2 control.	12	1		4		7						
The whole amount of hours for the content module 2	60	5		20		35						
The final test												
The whole amount of hours for the course	120	10		40		70						

5. Contents of the course

Content module 1. Fundamentals of General Biophysics

Topic 1. Mechanical oscillations and waves. Biophysics of muscle contraction.

Mechanical oscillation and waves. Oscillatory processes in living organisms. The muscle fibre structure. Muscle tension. The power and speed of muscle contraction.

Topic 2. Molecular Physics. Thermodynamics.

Principles of the molecular-kinetic theory of ideal gases. Basic concepts of thermodynamics. The first law of thermodynamics. The second law of thermodynamics. Thermodynamic potentials. Real gases. Phase transitions. Transport phenomena.

Topic 3. Thermodynamics of biological processes. Molecular Biophysics.

Features of biological objects as thermodynamic systems. The first law of thermodynamics in chemistry and biology. The second law of thermodynamics for opened systems. Change in standard free energy. Chemical and electrochemical potentials. The rate of increase of entropy and the dissipative function. Conjugated processes. Concepts of linear non-equilibrium

thermodynamics. Onsager's equation. Criteria for reaching and stability of stationary states. Types of interactions in macromolecules. The structure of water and hydrophobic interactions. The structure and properties of biopolymers. The structure of proteins. Transitions "spiral-ball". Enzyme catalysis. Biophysics of nucleic acids.

Topic 4. Biophysics of vision. Biophysics of hearing.

Optics. Thermal radiation. The optical system of the human eye. The molecular mechanism of vision. Sound waves. Intensity of sounds. Intensity level. Doppler Effect. Biophysical function of the ear.

Topic 5. Transport of substances through biological membranes.

The structure of biological membranes. Phase transitions in membranes. Passive transport of neutral particles. Passive transport of ions. The Nernst equation. The Donnan equilibrium. Ion transport through channels. Passive transport of substances with carriers. Induced ion transport. Active transport. The secondary active transport.

Content module 2. Fundamentals of Applied Biophysics

Topic 6. Hydrostatics and hydrodynamics. Biophysics of the blood system.

Hydrostatics and hydrodynamics. Surface phenomena. Rheological and hemodynamic characteristics of blood. The erythrocyte sedimentation rate. The Frank's model. The pulse wave. Mass transfer in the capillary network.

Topic 7. Electromagnetism. Biophysics of nerve impulses.

Electrostatics. Conductors in an electric field. Energy of the electric field. Dielectrics in the electric field. Direct electric current. Magnetostatics. Magnetic properties of bodies. Electromagnetic induction. Alternating current. Electromagnetic oscillations. Maxwell's equations. Electromagnetic waves. The resting membrane potential. The action potential. Electric stimulation of membranes. Excitation propagation along a nerve fibre. The rate of the nerve impulse propagation.

Topic 8. Nuclear physics. The action of physical factors on biological objects. Own physical fields of human.

The Bohr's theory of the atomic structure. Nuclear reactions. Radioactivity. The Planck's formula. Photo effect. Corpuscular properties of light. Wave properties of particles. The Heisenberg uncertainty principle. The wave function. The Schrödinger's equation. Quantum numbers. The Pauli Exclusion Principle. X-rays. Interaction of the ionizing radiation with matter. The effect of the electric current on living organisms. The mechanism of the biological action of electromagnetic waves of the radio-frequency range. Electronic transitions in atoms and molecules. The effect of the optical range on biological objects. The effect of the ultraviolet radiation on biological molecules. The target theory. The optical radiation in medicine. Doses of the ionizing radiation. The effect of the ionizing radiation on a living organism. Quantitative evaluation of radio damage. Modification of radiobiological effects. Electric and magnetic fields of human. Physical principles of electrocardiography. Thermal radiation. Bioluminescence.

Topic 9. Mathematical Biophysics.

Features of modelling of pharmacokinetic processes. The one-compartment pharmacokinetic model. The subcompartment pharmacokinetic model. The model of continuous introduction of a medicine.

Topic 10. Physical methods of analysis.

Spectral analysis. Visible spectroscopy. Ultraviolet spectroscopy. Infrared spectroscopy. Raman Spectroscopy. Spectroscopy of nuclear magnetic resonance. Mass spectroscopy. X-ray. Microscopic analysis. Polarimetry. Thermal analysis. Refractometry. Chromatography. Computational methods.

The final test

6. Names of lectures

№	Name of topic	The amount of hours	
		full time study	part time study
1	Mechanical oscillations and waves. Biophysics of muscle contraction.	1	
2	Molecular Physics. Thermodynamics.	1	
3	Thermodynamics of biological processes. Molecular Biophysics.	1	
4	Biophysics of vision. Biophysics of hearing.	1	
5	Transport of substances through biological membranes.	1	
6	Hydrostatics and hydrodynamics. Biophysics of the blood system.	1	
7	Electromagnetism Biophysics of nerve impulses.	1	
8	Nuclear physics. The action of physical factors on biological objects. Own physical fields of human.	1	
9	Mathematical Biophysics.	1	
10	Physical methods of analysis. The final test.	1	
The whole amount of hours		10	

7. Topics of seminars

Seminars workshop is not provided by the working curriculum.

8. Topics of practical lessons

№	Name of topic	The amount of hours	
		full time study	full time study
1	Mechanical oscillations and waves.	2	
2	Biophysics of muscle contraction.	2	
3	Molecular Physics. Thermodynamics.	2	
4		2	
5	Thermodynamics of biological processes. Molecular Biophysics.	2	
6		2	
7	Biophysics of vision. Biophysics of hearing.	2	
8		2	
9	Transport of substances through biological membranes. The content module 1 control.	2	
10		2	
11	Hydrostatics and hydrodynamics. Biophysics of the blood system.	2	
12		2	
13	Electromagnetism Biophysics of nerve impulses.	2	
14		2	
15	Nuclear physics. The action of physical factors on biological objects. Own physical fields of human.	2	
16		2	
17	Mathematical Biophysics. The content module 2 control.	2	
18		2	

19	Physical methods of analysis.	2	
20		2	
The whole amount of hours		40	

9. Topics of laboratorial lessons

Laboratory workshop is not provided by the working curriculum.

10. Self-study work

№	Name of topic	The amount of hours	
		full time study	full time study
1	Mechanical oscillations and waves. Biophysics of muscle contraction.	7	
2	Molecular Physics. Thermodynamics.	7	
3	Thermodynamics of biological processes. Molecular Biophysics.	7	
4	Biophysics of vision. Biophysics of hearing.	7	
5	Transport of substances through biological membranes.	7	
6	Hydrostatics and hydrodynamics. Biophysics of the blood system.	7	
7	Electromagnetism Biophysics of nerve impulses.	7	
8	Nuclear physics. The action of physical factors on biological objects. Own physical fields of human.	7	
9	Mathematical Biophysics.	7	
10	Physical methods of analysis.	7	
The whole amount of hours		70	

Tasks for self-study work

1. Tasks for determining of the maximum speed of muscle contraction, the work that carried by muscle, muscle heat, general muscle power.
2. Tasks for finding of internal energy, enthalpy, Gibbs potential, Helmholtz potential, entropy.
3. Tasks for calculation of osmotic electric work, changes of electrochemical potentials in the transport of ions through the cell membrane, the efficiency of coupling processes, changes of thermodynamic potential in the cell.
4. Tasks for calculation of the optical power of glasses and other optical devices, intensity levels of sounds.
5. Tasks for finding of radioactive decay constant, mass defect and binding energy, the limits of the Balmer's series of the hydrogen atom, the absorption coefficient of X-ray ionization, de Broglie wavelength.
6. Tasks for the calculation of the work of sodium-potassium pump, distribution coefficients of substance, diffusion coefficient, Gibbs free energy, the potential difference on the membrane, ion concentration inside and outside the cell.
7. Tasks for the calculation of speed of blood flow in different parts of the circulatory system, hydraulic resistance of peripheral part of the circulatory system, erythrocyte sedimentation rate, pulse wave propagation velocity .
8. Tasks for the determining the resting potential, action potential, temperature, constant length of cell nerve fibers, the speed of nerve impulses.

9. Tasks for calculating of the characteristics that associated with the absorption of X-ray by different tissues of the human body, the depth of penetration of electromagnetic radiation in tissues, energy of quantum radiation in different ranges of electromagnetic waves.
10. Tasks for calculating of elimination constants, half-time period of drug, initial concentration, maximum concentration of drug in the body.
11. Tasks for building a block and diagram of the device used in physical methods of analysis.

11. Individual tasks

Individual tasks are not provided by the working curriculum.

12. Criteria and evaluation order of educational outcomes

Evaluation order of educational outcomes of the course "Biophysics, physical methods of analysis" is graded on a 100-point scale, which is translated to the national grading scale ("excellent", "good", "satisfactory", "unsatisfactory") and the grading scale of the European Credit Transfer System (ECTS - A, B, C, D, E, FX, F), respectively. The final rating in the discipline is summed from rating of ongoing control and the final testing one.

The **ongoing control** is carried out at each practical lesson and it shows the result of work on individual assignments. It provides the evaluation of the theoretical knowledge and practical skills in the specified topics of higher education applicants (including self-studied material) on practical lessons. In addition, the ongoing control involves score of two content modules tests. For both content modules "Fundamentals of General Biophysics" and "Fundamentals of Applied Biophysics", the maximum and minimum total scores per content module are 18 and 30 points, respectively.

The forms of the ongoing control are:

1. Oral survey (frontal, individual, combined).
2. Verification of existing professional skills.
3. Test control (open and closed tests).

Practical lessons evaluation criteria (for 2-hours lesson):

2.5 points – the student gives correct, clear, logical and full answer all standardized questions of current topic, including theoretical and self-study questions. The student can link theory and practice closely, solves the problems with professional content of high difficulty level properly.

2.0 points – the student properly and essentially answers the standardized theoretical and self-study questions of current topics, uses the theoretical knowledge correctly in solution of practical problems. The student is able to solve the problems with professional content of low and medium difficulty level.

1.5 point – the student can answer the standardized questions of current topic incompletely and only with help of additional questions, is unable to build a clear and logical answer. The student makes mistakes in answers and demonstration of practical skills, is able to solve only the easiest problems.

1.0 points – the student knows the educational material of the current topic partially, cannot build a logical answer or answer the additional questions. The student makes mistakes in answers and demonstration of practical skills.

0 points – the student does not know the educational material of the current topic, cannot build a logical answer or answer the additional questions, does not understand the content of the educational material. The student makes serious and significant mistakes in answers and demonstration of practical skills.

The maximum number of points that can get a student for ongoing academic activity to take the admission to pass the final module control is 60 points.

The minimum number of points that student must collect for ongoing academic activity to take the admission to pass the final module control is 36 points.

The final testing evaluation criteria

The final testing is carried out to determine the state of success of applicants for higher education after the period of theoretical training. The final testing of students' knowledge has a form of classroom written test. Each ticket contains 9 test questions of a theoretical part and 1 test question of a practical part. Each correct answer is rated at 4 points.

The final testing is rated at maximum 40 points for a successful theoretical training and for mastering practical skills, and is considered as passed if the student is scored at least 24 points.

Total score accumulated applicant for higher education for all ongoing types of academic work on practical (seminar) classes and the final testing, indicates his degree of mastery of the discipline curriculum at a particular stage of its learning. During the semester, students can gain from 0 to 100 points, that are translated into national grading scale and ECTS grading scale, respectively. The score corresponds to a level of mastering the discipline:

The final rating	The scale of ECTS	The national scale	Definition
90-100	A	5 (excellent)	The student is completely and thoroughly mastered all the topics of the curriculum and is able to express the content of all topics of discipline freely; completely understands its importance for his professional training; is fulfilled all tasks of each topic and final testing as a whole. He took part in contests and conferences.
82-89	B	4 (very good)	The student has learned certain work program issues incompletely. He is able to present the content of the general topics of the discipline curriculum, has completed the task of each topic and final testing as a whole.
74-81	C	4 (good)	The student has learned certain work program topics incompletely. He is unable to present the content of the certain topics of the discipline curriculum He did not complete the specific objectives of each topic and final testing as a whole.
64-73	D	3 (satisfactory)	The student is mastered only the specific topics of the curriculum He does not know how to express the content of the basic topics of the discipline. The specific tasks on each topic in final testing are not done.
60-63	E	3 (sufficient)	The student has learned only a few questions curriculum. Cannot express the content of the main part of discipline curriculum questions. Has completed only the few tasks each topic and final testing as a whole.
35-59	FX	2 (fail)	The student is not mastered the curriculum, cannot express the content of most of the major issues of discipline, does not fulfilled the most of each topic and the final testing as a whole.
1-34	F	2 (fail)	The student is not mastered the curriculum, cannot present the content of every topic of discipline, does not pass the final testing.

13. Forms of progress and final tests of academic achievements

Current control based on control of theoretical knowledge and skills.

Forms of current control:

- Oral examination (frontal, individual, combined);
- Practical test of existing professional skills;
- Test control (open and closed tests).

Independent student work is evaluated at seminars and is part of the final grade of the student.
After studying the discipline, students get the grade.

14. Teaching course materials

1. Work program of the course.
2. Textbook.
3. Workbook.
4. Set of multimedia presentations of lectures.
5. Supporting set of lectures.
6. Guideline for educators.
7. Guideline for self-study work.
8. Preparation guideline for practical lessons.
9. Final testing preparation guideline.
10. Test and control tasks for practical classes.
11. Questions and tasks for the final control.

15. Reading suggestions

The main reading suggestions

1. Vladimir Timanyuk, Elena Zhivotova, Igor Storozhenko. Biophysics: Textbook for students of higher schools / Kh.: NUPh, Golden Pages, 2011.- 576p.
2. Vladimir Timaniuk, Marina Kaydash, Ella Romodanova. Physical methods of analysis / Manual for students of higher schools/– Kharkiv: NUPh: Golden Pages, 2012. – 192 p.
3. Philip Nelson. Biological Physics. – W. H. Freeman, 1st Edition, 2007. – 600 p.

Supplementary reading suggestions

1. Eduard Lychkovsky. Physical methods of analysis and metrology: tutorial / Eduard Lychkovsky, Zoryana Fedorovych. – Lviv, 2012. – 107 p.
2. Daniel Goldfarb. Biophysics DeMYSTiFied. – McGraw-Hill Professional, 1st Edition, 2010. – 400 p.
3. Irving P. Herman: Biological and medical physics, biomedical engineering: Physics of the Human Body (Springer, Berlin Heidelberg New York 2007). – 858 p.
4. J.R. Cameron, J.G Skofronick, R. Grant: Physics of the Body, 2nd edn (Medical Physics, Madison, WI 1999). – 736 p.
5. H. Ab'e, K. Hayashi, M. Sato (eds.): Data Book on Mechanical Properties of Living Cells, Tissues, and Organs (Springer, Berlin Heidelberg New York 1996). – 1022 p.
6. Posudin Yuriy. Physics with Fundamentals of Biophysics. Підручник для студентів вищих навчальних закладів України на англійській мові) / Київ, 2016. – 212 p.
7. Laboratory practicum with discipline "Physics with fundamental of biophysics" for the students, who attend the English-speaking lectures: практикум / Y. I. Posudin ; National University of Life and Environmental Sciences of Ukraine. – К. : НУБіП України, 2014. – 105 p.

8. Chalyi A.V. Medical and biological physics: textbook for the students of higher medical institutions of the IV accreditation level / A.V. Chalyi, Ya.V. Tsekhmister, B.T. Agapov [et al.]. – 2nd ed. – Vinnytsia, Nova Knyha, 2013. – 480 p.

16. Electronic resources

1. Center for distance learning technologies of NUPh. Access mode:
<http://pharmel.kharkiv.edu/moodle/login/index.php> (date of the application: 28.08.2019).
2. Introduction to the Physics of Hearing [Electronic resource]. – Access mode:
<https://opentextbc.ca/physicstestbook2/chapter/introduction-to-the-physics-of-hearing/>
(date of the application: 28.08.2019). – Screen name.
3. Laws of Thermodynamics as Related to Biology [Electronic resource]. – Access mode:
<https://www.thoughtco.com/laws-of-thermodynamics-373307> (date of the application: 28.08.2019). – Screen name.
4. Wikipedia. Biophysics [Electronic resource]. – Access mode:
<https://en.wikipedia.org/wiki/Biophysics> (date of the application: 28.08.2019). – Screen name.
5. Oscillations and Waves. Richard Fitzpatrick. Professor of Physics. [Electronic resource]. – Access mode:
<http://farside.ph.utexas.edu/teaching/315/Waves/Waveshtml.html> (date of the application: 28.08.2019). – Screen name.
6. BRITANNICA KIDS. Students. Biophysics. [Electronic resource]. – Access mode:
<https://kids.britannica.com/students/article/biophysics/273222/197539-toc> (date of the application: 28.08.2019). – Screen name.
7. Max Planck Institute for Medical Research. Introduction to Muscle Contraction. [Electronic resource]. – Access mode:
https://www.mpimf-heidelberg.mpg.de/emertus_groups/biophysics/muscle_contraction/part_one (date of the application: 28.08.2019). – Screen name.
8. Physics 561: Radiation Biophysics. Department of Biological, Chemical, and Physical Sciences. Illinois Institute of Technology. [Electronic resource]. – Access mode:
<http://csrri.iit.edu/~howard/radbio/> (date of the application: 28.08.2019). – Screen name.