Department of Physiology and Medical Biophysics
"Nicolae Testemitanu" State University of Medicine and Pharmacy
of the Republic of Moldova

BIOPHYSICS LABORATORY NOTEBOOK

Farmacy Faculty

Name Surname_____

Group No. F2509

Lecturer **Tonu Viorica**

Chisinau, 2026

REQUIREMENTS FOR SOLVING PRACTICAL WORKS AND SEMINARS

1. The notebook must be printed and bound according to the Euro standard (transparent front cover and opaque back cover).
2. The notebook must be completed in blue or violet pen, in the spaces reserved for calculations and content.
3. Drawings must be made in simple pencil or colored pencils/pens/markers, using a ruler, protractor, or compass, as appropriate. All elements must be described and completed according to the manual.
4. Formulas must be written with the specification of each physical quantity and its corresponding unit of measurement.
5. Tables must be completed with values, respecting the measurement units indicated in the header.
6. Calculations must include the units of measurement for all values of the physical quantities used.
7. Graphs must be drawn on graph paper, in pencil, with the necessary instruments, ensuring a clear, precise, and scientific appearance.
8. Each axis of the graph must be labeled with the name of the physical quantity and the corresponding unit of measurement.
9. Errors must be calculated in accordance with the formulas in the notebook (see below), respecting the measurement units.
10. Conclusions must reflect the practical observations of the experiment and, where appropriate, the interpretation of the result.

Concepts of Error Calculation
Mathematical Processing of Experimental Data

The recording of quantitative informational data regarding various quantities that characterize the studied phenomena in different fields, including medicine and biology, is carried out through certain practical procedures, called measurements.

The result of measuring a random quantity depends on several factors and may be affected by errors, which can have very different origins.

By measurement error we understand the difference between the exact (real) value of a quantity and the value obtained experimentally.

The main sources of errors can be:

- measuring instruments – instrumental errors;
- methods used – methodological errors;
- the influence of external factors – temperature, humidity, vibrations, electric and magnetic fields, etc.;
- the experimenter himself/herself – personal errors (depending on professional level, attention, visual acuity, etc.).

Due to the possible measurement errors mentioned above, when repeating an experiment several times, statistical fluctuations appear. Since the real value of the investigated quantity cannot be known, it becomes necessary to use mathematical calculation to indicate the interval within which the experimental values are distributed and the precision with which the measurements were performed.

We denote by **X** the real value of a quantity, by **x** the value measured with an instrument, and by **n** the number of measurements performed under the same conditions.

If the number of measurements is large, the value closest to the true one, with a certain degree of precision, is considered to be the **arithmetic mean**.

It is the sum of all determined values, divided by the number of determinations, and is calculated according to the relation:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + ... + x_n}{n} \qquad (1)$$

Or, in a general form:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (2)$$

To evaluate the degree of fluctuations mentioned above, the **individual deviation A**, also called the **apparent error**, is determined for each measurement:

$$A_1 = x_1 - \bar{x}\,;\; A_2 = x_2 - \bar{x}\,;\; \ldots\; A_n = x_n - \bar{x}$$

In general form, the individual deviation is given by the relation:

$$A_i = x_i - \bar{x} \qquad (i=1, 2, 3, ..., n) \qquad (3)$$

The **mean absolute error** $\overline{A}$ is obtained by summing all the absolute deviations from the arithmetic mean, divided by the number of determinations:

$$\overline{A} = \frac{|A_1| + |A_2| + |A_3| + ... + |A_n|}{n} \qquad (4)$$

Or, in general form:

$$\overline{A} = \frac{\sum_{i=1}^{n} |A_i|}{n} \qquad (5)$$

The **relative error** can be obtained, in the case of nnn measurements, by calculating the ratio between the mean absolute error and the mean value of the measured quantity:

$$\varepsilon = \frac{\bar{A}}{\bar{x}} \text{ sau } \varepsilon = \frac{\bar{A}}{\bar{x}} \cdot 100\% \qquad (6)$$

In measurement practice, the relative error functions as a unitless standard that normalizes the deviation to the scale of the measured quantity. Through this normalization, results become comparable across different experiments, instruments with distinct resolutions, or even diverse measurement units.

1. VISCOSITY MEASUREMENT OF BIOLOGICAL LIQUIDS

Purpose:

Determination of the viscosity coefficient by the relative method (using the Ostwald viscometer) and the application of viscometry in medical practice.

Theoretical Aspects:

1. Draw the diagram of the device used in the experiment.

2. Identify the working formula for the relative method:

3. Explain each parameter in the working formula and indicate the units of measurement in SI:

Experimental Procedure:

4. Fill in the table with data:

No. of experiment	$\eta_{0,} cP$	$\rho_0, g/cm^3$	$\rho, g/cm^3$	$t_{0,} s$	t, s	η, cP	$\eta, Pa \cdot s$
1							
2							
3							
4							
5							

5. Determine by calculations the viscosity coefficient for alcohol and insert the values in the table of measurements.

6. Calculate the absolute and relative error.

7. Write conclusions based on your own observations during the experiment and regarding the achieved results.

Assessment items:

1. What is the difference between the direct method and the relative method of determining the viscosity coefficient?
2. What type of flow (laminar or turbulent) is observed in the experiment and how does this influence the viscosity measurement?
3. How do the density and flow time of the liquid influence the value of the viscosity coefficient?
4. In what medical or biological contexts is the measurement of the viscosity of blood and other biological fluids important?
5. How might the viscosity of a liquid vary with temperature and why is this important in medicine?

2. ULTRASOUND EFFECTS. TECHNIQUES AND METHODS USED IN MEDICINE

Purpose:
Study of ultrasound emission and reception methods and their applications in medical practice.

Theoretical Aspects:

1. Draw the diagrams of ultrasound production and reception.

2. Write conclusions based on your own observations during the experiment.

Assessment items:

1. Explain the method used to observe the transformation of mechanical (sound) oscillations into electromagnetic oscillations.
2. Describe the differences between the transducer used for ultrasound reception and the one used for ultrasound emission.
3. Explain the method by which ultrasonic oscillations are transmitted to a medical solution.
4. Discuss the effects of transmitting ultrasound to a medical solution.
5. Explain the working principle of a piezoelectric transducer and its role in ultrasound generation**.**

Biophysics laboratory notebook (Farmacy), 2026

3. DETERMINATION OF THE SURFACE TENSION OF THE BIOLOGICAL LIQUIDS

Purpose:

Study of the surface tension phenomenon using the direct method and its importance in medical practice.

Theoretical Aspects:

1. Draw the diagram of the device used in the experiment.

2. Identify the working formulas:

3. Explain each parameter in the working formula and indicate the SI units of measurement:

Experimental Procedure:

4. Fill in the table with data:

Nr. exp.	$\overline{d}$, cm	F, dyn			$\overline{F}$, dyn	$\overline{\sigma}$, dyn/cm	$\overline{\sigma}$, N/m
0%							
25%							
50%							
100%							
X%							

5. Determine by calculations the surface tension coefficient and insert the values in the table of measurements.

6. Plot the graph of the dependence of the surface tension coefficient on the concentration of the solution, $\sigma = f(C)$. From the graph, determine the concentration of the unknown solution.

   Use a millimeter paper!! Attach the graph sheet here.

7. Write conclusions based on your own observations during the experiment and regarding the achieved results.

Assessment items:

1. What factors influence the value of the surface tension coefficient?
2. How is the ring method applied to determine the surface tension force?
3. What is the meaning of the graph $\sigma = f(C)$ and how is the unknown concentration interpreted?
4. How do you convert units from dyn/cm to N/m and why is this conversion important?
5. What medical implications does surface tension have in processes such as gas embolism?

4. CELL OSMOTIC PHENOMENA

Purpose:

Study of the phenomenon of turgor and plasmolysis with the evaluation of cell size using a microscope and familiarizing with the biological and medical aspects of osmotic pressure.

Theoretical Aspects:

1. Represent the diagram of the cell structure in different environments.

Work progress:

2. Insert the photographic images obtained after placing the plant sample in hypertonic and hypotonic solution.

3. Determine by the experiment the dimensions of the cells and introduce the results in the Table.

No.of experiment	Hypotonic		Hypertonic	
	Trans-versal	Longi-tudinal	Trans-versal	Longi-tudinal
1				
2				
3				
4				
5				
Average				

4. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results.

Assessment items:

1. How is the behavior of cells in hypotonic and hypertonic environments differentiated?
2. What formulas are used to calculate osmotic pressure and how are they applied in practice?
3. What role does the semipermeable membrane play in the osmosis process?
4. How are changes in cell size interpreted depending on hypotonic and hypertonic environments?
5. What clinical applications does the phenomenon of plasmolysis and turgor have?

5. DETERMINATION OF THE ION MOBILITY BY THE ELECTROPHORESIS METHOD

Purpose:

Study of the phenomenon of electrophoresis using the porous medium method with determination of the mobility of $Cu2^{+}$ and $Fe3^{+}$ ions.

Theoretical Aspects:

1. Represent the diagram of the electrophoretic chamber.

2. Identify the working formulas:

3. Explain each parameter in the working formula and indicate the SI units of measurement:

Experimental Procedure:

4. Fill in the table with data:

Nr of Experiment	***Ions***	U, V	t, s	d, m	l, m	$M, \frac{m^2}{Vs}$
1	Cu^{2+}					
	Fe^{3+}					
2	Cu^{2+}					
	Fe^{3+}					
3	Cu^{2+}					
	Fe^{3+}					

5. Determine by calculations the ionic mobility of copper and iron ions separately and write the results in the table.

6. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What is the influence of migration time on ion mobility?
2. How is ion mobility calculated and what units are used in SI?
3. What forces act on ions in an electric field and how are they balanced?
4. What differences occur between the mobility of Cu^{2+} and Fe^{3+} ions and how can they be explained?
5. What applications does electrophoresis have in laboratory medicine (e.g. blood serum analysis)?

Biophysics laboratory notebook (Farmacy), 2026

6. DETERMINATION OF DENSITY OF SOLID OBJECTS USING THE PYCNOMETER

Purpose:

Study of the theoretical notions of densitometry, familiarization with the types and components of balances and scales, and determination of the density of liquids and solid objects.

Theoretical aspects:

1. Represent the diagram of the pycnometer.

1. Identify the working formulas:

2. Explain each parameter in the working formula and indicate the SI units of measurement:

Experimental Procedure:

3. Fill in the tables with data:

No.	m, g	m_1, g	m_0, g	ρ, g/cm^3
1				
2				
3				
Average				

No.	m_2, g	m_3, g	m_0, g	ρ, g/cm^3
1				
2				
3				
Average				

4. Determine by calculations the density of the unknown solution and density of the solid object and write the results in the table.

5. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What factors influence the density of a liquid or a solid, and why is temperature control necessary in pycnometric determinations?
2. How is the pycnometric method applied to determine the density of a liquid, and what is the role of each weighing performed?
3. What is the meaning of the quantities m_0, m_1 and m_2 in the density calculation formula, and what does the mass of the displaced water represent?
4. Why is it important to repeat measurements and calculate the mean value when determining density using the pycnometric method?
5. What is the medical importance of determining the density of biological fluids (urine, blood, plasma), and what clinical information can be inferred from deviations from normal values?

7. AIR HUMIDITY. METHODS OF DETERMINATION OF THE RELATIVE AND ABSOLUTE HUMIDITY

Purpose:

The aim of this work is to study the theoretical notions of humidity, understand the principles of construction of devices used for determining relative and absolute humidity, determine air humidity using a psychrometer and a hygrometer, and highlight the importance of air humidity in medical and pharmaceutical practice.

Theoretical aspects:

6. Represent the diagram of the psychrometer.

Experimental Procedure:

7. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What is meant by absolute humidity and relative humidity of air? What are their units of measurement?
2. How does the relative humidity of air depend on temperature and the saturated vapor pressure?
3. What is the operating principle of a hygrometer, and which type of humidity can it determine?
4. What does the psychrometric method of determining air humidity consist of? What is the role of the dry-bulb and wet-bulb thermometers?
5. What is the importance of controlling air humidity in medical and pharmaceutical practice?

8. DETECTION OF NUCLEAR RADIATION

Purpose:

Detection of nuclear radiation using the B-4 radiometer and its use in medicine.

Theoretical aspects:

1. Represent the diagrams of nuclear radiation detectors.

Experimental Procedure:

2. Fill in the tables with data:

A. Determination of the activity of a radioactive substance.

No.	**Time** t, min	**Number of pulses** N	$n = \frac{N}{t}$
1	0.5		
2	0.5		
3	0.5		
4	0.5		
5	0.5		
Average			

B. Determination of the activity of the radioactive substance and the absorption of radiation by the air layer, depending on the thickness of the layer:

No.	**Distance** d, cm	**Number of pulses** N	**Activity** $n = \frac{N}{t}$
0			
1	5		
2	10		
3	15		
4	20		
5	25		

C. Determination of the activity of the radioactive substance and research of the absorbing properties of different materials:

No.		**Time** t, min	**Number of pulses** N	**Activity** $n = \frac{N}{t}$
1	Aluminum	0.5		
2	Iron	0.5		
3	Copper	0.5		
4	Lead	0.5		
5	Lead rubber	0.5		

3.Draw the graph of the function $n = f(d)$. ***Use a millimeter paper.***

5.Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results

Assessment items:

1. What are the types of nuclear radiation and what different properties do they have (penetration, ionization)?
2. What information can be obtained from the shape of the radioactive background graph and how are its variations interpreted?
3. How is the activity of a radioactive preparation determined and what is the unit of measurement used, in SI and extra SI?
4. What role does the thickness of the air layer or other materials play in the absorption of radiation and how is this effect reflected in experimental graphs?
5. What are the practical and medical applications of nuclear radiation detection?

Biophysics laboratory notebook (Farmacy), 2026

9. DETERMINATION OF CONCENTRATION OF OPTICALLY ACTIVE SUBSTANCES BY POLARIMETRICMETHOD

Purpose:

Study of the phenomenon of light polarization and its use in the construction and operation of the polarimeter for determining the concentration of solutions, with practical applications in medicine.

Theoretical Aspects:

8. Schematically represent the construction of the polarimeter.

9. Identify the working formulas:

10. Explain each parameter in the working formula and indicate the SI units of measurement:

Experimental Procedure:

11.Fill in the table with data:

The researched solution	Experiment No.	φ_0, degree	φ', degree	$\varphi = \varphi' - \varphi_0$	C, %
1 (water)	1				
	2				
	3				
2 (glucose)	1				
	2				
	3				

5.Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What is polarized light and how is it obtained experimentally?
2. How is the angle of rotation of the plane of polarization determined and what role does it play in calculating the concentration of solutions?
3. What is the mathematical relationship between the specific angle of rotation, the length of the layer, concentration and total rotation?
4. What are the roles of the length of the polarimetric tube and the concentration of the solution when determining optical activity?
5. What applications does polarimetry have in the analysis of optically active solutions?

10. STUDY OF COLORED SOLUTIONS BY FOTOCOLORIMETRY METHOD

Purpose:

Study of light absorption in colored solutions and the use of the photocolorimetric method to determine concentration, with applications in medicine.

Theoretical aspects:

1. Represent the diagram of the fotocolorimeter.

Experimental Procedure:

2. Fill in the table with data:

The number of the solution.	C,%			τ,%	*D*
1.					
2.					
3.					
4.					
5.					
$X_{1.}$					
$X_{2.}$					

3. Draw the graph of the function $\tau = f(C)$ and a graph of the function $D = f(C)$. ***Use a millimeter paper.***

4.The X_1 and X_2 concentrations for unknown solutions are determined from the two graphic dependences using the indications from teacher.

5.Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations and graph.

Assessment items:

1. How is the photocolorimeter prepared and used in the work to determine the concentration of solutions?
2. How is the transmittance and optical density of a solution determined and what is the physical significance of these quantities?
3. How is the Beer–Lambert law applied in the laboratory experiment and what mathematical relationship does it express?
4. What information can be extracted from the shape of the graph $\tau = f(C)$ and how are unknown concentrations determined?
5. What are the applications of photocolorimetric methods in medical practice and biological research?

11. DETERMINATION OF THE CONCENTRATION OF A SOLUTION BY THE REFRACTIVE METHOD

Purpose:

The aim of this work is to study the phenomenon of refraction, determine the refractive index of solutions with different concentrations, explore the principle of construction of a laboratory refractometer, and emphasize the importance of refractometry in medical practice.

Theoretical aspects:

1. Represent the diagram of the refraction of light in Abbe refractometer.

2. Fill in the table with data:

No.	C, %	n
1		
2		
3		
4		
5		
6	X1	
7	X2	

3. Draw the graph of the function $n = f(C)$ (refractive index in function of concentration) and determine the unknown solution concentrations. ***Use a millimeter paper.***

4. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from graph.

Assessment items:

1. What is the refractive index, and on what does its value depend for a liquid solution?
2. What is the principle of the refractometric method, and how is the dependence of the refractive index on the solution concentration used?
3. What is the role of refractometer calibration, and why is distilled water usually used as a reference substance?
4. How is the graph $n=f(C)$ interpreted, and how is the concentration of an unknown solution determined based on it?
5. What is the importance of the refractometric method in medical practice, especially for the analysis of biological fluids (serum, plasma, urine)?

Biophysics laboratory notebook (Farmacy), 2026

12. DETERMINATION OF FOCAL LENGTH OF CONVERGING AND DIVERGING LENS

Purpose:

The aim of this work is to study the types of lenses and their characteristics, determine the focal length of a thin lens, explore the differences between convex and concave lenses and determine their focal lengths, and highlight the importance of lenses in medical practice.

Theoretical aspects:

1. Represent the diagram of the image formation by a converging lens.

2. Represent the diagram of the image formation by a diverging lens.

3. Fill in the tables with data:

No.	d, cm	f, cm	F_1, cm	β
1				
2				
3				
Average				

No.	d, cm	f, cm	F_2, cm	β
1				
2				
3				
Average				

4. Determine by calculations focal length for the converging lens F_1 and focal length for the lenses system F_2 and write the results in the tables above.

5. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What is the focal length of a lens, and on what does its value depend for converging and diverging lenses?
2. What is the principle of image formation by thin lenses, and what is the role of the principal rays in determining the image position?
3. How is the focal length of a converging lens experimentally determined using the thin lens equation and measurements of the object–lens and image–lens distances?
4. By which method can the focal length of a diverging lens be determined, and why is the use of an auxiliary converging lens necessary?
5. What is the importance of determining the focal length of lenses in medical optics, and in which clinical applications is knowledge of this quantity essential?

Biophysics laboratory notebook (Farmacy), 2026

13. OPTICAL MICROSCOPY

Purpose:

The aim of this work is to study the components of a microscope, examine the characteristics of the magnifying glass, explore the method of image formation in the microscope, determine the linear magnification of the microscope, and emphasize the importance of optical microscopy in medical practice.

Theoretical aspects:

1. Represent the diagram of the magnifying glass image formation.

2. Represent the diagram of the image formation in the microscope.

3. Fill in the table with data:

Objective	Nr.	*n*	*m*	G_{ob}	G
10x	**1**				
	2				
	3				
40x	**1**				
	2				
	3				
90x	**1**				
	2				
	3				

4. Determine by calculations the objective magnification G_{ob} of the lens, microscope magnification G and write the results in the table.

5. Formulate the necessary conclusions based on your own observations during the experiment and regarding the achieved results from calculations.

Assessment items:

1. What is optical microscopy, and what physical principles underlie the formation of a microscopic image?
2. What are the main methods of optical microscopy, and how do they differ in terms of image formation?
3. What roles do the objective and the eyepiece play in an optical microscope, and how do they influence image resolution and magnification?
4. What is the resolving power of a microscope, and why does it represent a fundamental limitation of optical microscopy?
5. What are the applications of optical microscopy in medical practice, and what types of biological structures can be analyzed using these methods?

Biophysics laboratory notebook (Farmacy), 2026