Department of Physiology and Medical Biophysics
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BIOPHYSICS LABORATORY NOTEBOOK

Name Surname________________________

Group No. ____________

Lecturer ______________________

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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:

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

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

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

Or, in general form:

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

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**.**

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***	$\boldsymbol{U, V}$	$\boldsymbol{t, s}$	$\boldsymbol{d, m}$	$\boldsymbol{l, m}$	$\boldsymbol{M, \frac{m^2}{Vs}}$
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)?

6. SPECTRAL ANALYSIS

Purpose:

Study of the light dispersion, observation of the emission spectra of different sources, and study of the importance of spectral analysis in medical practice.

Theoretical Aspects:

1. Represent the diagram of the path of rays through the optical prism.

Experimental Procedure:

2. Fill in the table with data:

No	Color	Wavelength, λ, nm	Scale Reading, degree
Standart Hg			
1	Red	690	
2	Yellow	579	
3	Yellow	577	
4	Green	546	
5	Blue/Green	491	
6	Blue	436	
7	Violet	407	
	Sodium- studied substance		
	Yellow		

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

Assessment items:

1. How can spectral lines be visually identified and what information do the observed colors provide?
2. What is the relationship between the wavelength and frequency of the observed light radiation?
3. What medical or biological applications does spectral analysis have?

7. DETERMINATION OF WAVELENGTH AND ENERGY OF LASER RADIATION QUANTUM

Purpose:

Study of the construction and operating principle of the He-Ne laser, observation of the beam diffraction and determination of the wavelength, frequency and energy of the emitted quanta applied in medicine.

Theoretical Aspects:

1. Schematically represent the construction of the laser and the diffraction pattern of the laser beam.

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.	n	L, cm	S, cm	$\sin \alpha$	d, mm	λ, nm	ν, Hz	E, J
1	1							
2	2							
3	3							
Average								

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

Assessment items:

1. What conditions must be met to produce laser radiation and how is population inversion achieved?
2. How is the wavelength of laser radiation determined using a diffraction grating and what are the parameters measured in the experiment?
3. What is the mathematical relationship between wavelength, frequency and quantum energy, and what does each physical quantity represent?
4. What are the differences between spontaneous emission and stimulated emission in laser beam generation?
5. What medical and biological applications does laser radiation have?

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?

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:

1. Schematically represent the construction of the polarimeter.

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:

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?