Medical and biological physics. Methodic recommendations for students

MODULE 1. Mathematic processing of medical and biological data

THEMATIC MODULE 1. The basics of mathematical analysis

TOPIC 1. **Basics of differential calculus**

IMPORTANCE OF THE THEME: Methods of differential and integral calculus are tools for statistical processing of medical and biological information.

Objective (general): to learn main notions of differential calculus and methods of functions differentiation.	
Specific objectives:	The result knowledge and skills level:
1. To interpret the notions of derivative of a composite function, partial derivative of function, partial and total functions differentiation, derivatives and differentials of higher order.	1. To know how to find a composite function derivative, differential of one variable function, total and partial differentials of two variable function, partial derivatives of two variables function.
2. To know when differentials are used in approximate calculations.	2. To know how to use differentials in approximate calculations.

Main theoretic issues on the topic:

1). Definition of a function derivative, its geometric and physical sense.

2). Derivative of main primitive functions.

3). Main rules of differentiation (rules of finding derivative of a sum, product and quotient of functions; the rule of taking the multiplier outside the character of the derivative

4). The rule of a composite function differentiation.

5). Derivatives of higher order.

6). Differential of one variable function.

7). The notion of partial derivatives of a two variable function.

8). The notion of partial differentials and total differential of a two variable function.

9). The use of differential in approximate calculations.

2. At the end of the lesson the result level of students' knowledge and skills on main notions and methods of differential calculus is defined in form of a written test.

MODULE 1.
CONTENTS MODULE 1.
TOPIC 2. Basics of integral calculus.

Specific objectives:	The result knowledge and skills level:
1. To understand the notion of integral calculus (definite, indefinite integral)	1. To now how to find simple indefinite integrals by typical methods of integration.
2. To learn the methods of integration (table, integrals, variables substitution, by parts)	2. To now how to solve examples of definite integrals.
3. To understand the place of integral calculus in the analysis of natural processes and phenomena.	

I. Plan of *verbal/oral inquiry* by/of main questions:

1) Interdependence between "integration" and "differentiation" operations; definition of primary function.

2) Definition of indefinite integral. Explanation of subintegral expression, subintegral function, integration variable.

3) Properties of indefinite integral. To be able to give examples of calculation of some simplest (table) integrals and of those reduced to table ones after some algebraic transformations.

4) The method of variable substitution (*substitution method).* Essence of the method, solutions of examples with variables substitution.

5) The essence of the method of integration by parts, cases of its use, important specific cases of integration by parts application and examples of solution of such integrals.

6) Definite integral (what is it). The Newton-Leibniz formula. Properties of the definite integral. To be able to give examples of solutions of some simplest definite integrals with application of Newton-Leibniz formula.

7) Features of definite integrals solution, emerging when variable substitution method and method of partial integration are applied, as distinct to application of these methods for indefinite integrals.

8) Geometric interpretation of definite integral;

9) Solution of examples of definite integral.

II There is result test control of how the topic was learnt at the end of the lesson. Examples of integration are given to students for solution.

The teacher makes a summary at the end of the lesson, announces marks and gives a task for the next lesson.

MODULE 1.

CONTENTS MODULE 1.

THEME 3. **«Differential equations».**

Objective (general): To apply methods of mathematical statistics for medical data processing.

Specific objectives:

1.To interpret the notion and methods of differential equations solution.

The result knowledge and skills level:

1. To interpret types of differential equations; order and solution of differential equations.

2. To know how to apply methods of differential equations solutions of the 1^{st} order: with variables divided; uniform as to y and x variables; linear differential equations.

3. To know how to apply methods of solutions for higher order differential equations

I. Determination of the initial level of students' knowledge on the theme of the lesson is conducted in accordance with the approved methods in form of written tests.

II. Main theoretic questions are looked at in form of oral inquiry under the following plan:

1. General notion of differential equations. Ordinary differential equations. Differential equations with partial derivatives.

2.Order of differential equation.

3.General notions of solution of a differential equation.

4.Solution of a differential equation: analytical, general, partial.

5.Types of first order differential equations:

а) differential equations with dividable variables;

б) differential equations uniform as to y and x variables

в) linear uniform differential equations;

г) linear non-uniform differential equations;

6.Differential equations of higher order:

а) uniform differential equations of higher order with constant coefficients;

б) non-uniform differential equations of higher order with constant coefficient.

MODULE 1

Contents module 2.

Theme 4. The elements of probability theory.

Part I.

Objective (general): To master main notions of the probability theory, practical use of main theses and elementary operations of probability theory.	
Specific objectives:	The result knowledge and skills level:
1. To understand the notion of probability of an event. 2. To consider main theses and elementary operations of probability theory.	1. To be able to interpret the notion of probability of an event. 2. To learn the theorem of addition and multiplication of probabilities. 3. To know how to apply theorems in practice.

Importance of the issue: The probability theory is applied in biology and medicine for evaluation of probability of event in cases of epidemics, in elaboration of mathematical methods of medical diagnostics.

Theoretic questions for initial test control and inquiry of students

I. The teacher conducts initial test control of students' knowledge on the topic according to the known methods.

II. After the initial test control is carried out, such basic notions of probability theory are considered:

—event;

—experiment;

— relative frequency of events;

— statistical calculation of probability of an event; problems for solution offered;

— equally possible, incompatible events;

— possibility of an occasional event for classic model, problems for solution offered.

III. Then the students should formulate and write down on the board:

— the theorem of possibilities adding for incompatible events;

explain:

— which events are collectively exhaustive events;

— which events are called opposite;

— which events are called dependent and independent;

— formulate the theorem of possibilities multiplication in cases of both dependant and independent events.

IV. At the end of the lesson the teacher makes a summary, puts marks with tests results and answers taken into account in the register and in the record card, gives tasks for homework.

MODULE 1.

CONTENTS MODULE 2.

THEME 4.**Elements of the probability theory (Part 2).**

IMPORTANCE OF THE THEME: the probability theory is the methodic basis for statistical processing of experiments.

Objective (general): <u>To know how to create complex accidental occurrences and learn the methods of probability theory for calculation of events probability.</u>	
Specific objectives:	The result knowledge and skills level:
To know how to formulate and apply methods of problems solving in the following cases: 1. Repeated independent tests; 2. Complex dependent occurrence with application of full probability formula and Bayes' formula	1. To know how to apply and calculate probability of events with help of Bernoulli formula; 2. To know how to apply and calculate probability of complex dependent events with help of total probability formula and Bayes' formula.

1. Introduction
2. Solving problems on the theme:
   2.1. Bernulli formula for repeated independent test and problems solving.
   2.2. Total probability formula and Bayes' formula, solving and interpreting problems with application of them.
3. Estimation of the result knowledge and skills level, result test control.
4. General remarks and conclusions on the lesson.

MODULE 1.

CONTENTS MODULE 2.

THEME 5. **Random variables.**

PART I.

IMPORTANCE OF THE THEME: Random variables are applied to characterize phenomena of probable nature, as well as to describe human vital activity.

Objective (general): To know how to apply the laws of random variables distribution. Numeric characteristics of discrete random quantities.

Specific objectives:	The result knowledge and skills level:
To learn the notions:	To know how to:
1. random variables (RV), their types;	1.formulate and determine types of RV;
2. the law of discrete RV distribution;	2. write down and explain the law of discrete RV distribution and their normalizing conditions;
3. numerical features of a discrete RV;	3. know and calculate numerical features of discrete RV;
4. probability density of a continuous RV, distribution function, the probability a continuous RV getting into the given interval, normalizing condition;	4. formulate the notion of probability density of a continuous RV, distribution function, the probability a continuous RV getting into the given interval, normalizing condition;
5. Numerical features of a continuous RV.	5. calculate continuous RV.

There is a test for determination of students' initial knowledge level at the beginning of the lesson.

After the test results are announced, training problems are solved according to the plan:

1) random variable, their types;

2) the law of discrete random variable distribution, normalizing condition of a discrete variable;

3) probability density of a continuous RV, distribution function, the probability a continuous RV getting into the given interval, normalizing condition;

4) numerical features of a discrete random variable.

It is recommended to start theoretic review with definition of random variable, division of random variables to discrete and continuous. The students have to give definitions and examples.

Then the students have to introduce the notion of the law of discrete random variable distribution, write down the normalizing condition. When looking at normalizing condition, the teacher points out that events, when any of possible values of a random variable results from the test, are incompatible and make collectively exhausted events.

Further, issues of continuous random variable are considered:

- probability density of a continuous random variable;
- function of continuous random variable distribution ,
- the probability a continuous RV getting into the interval from a to c;
- normalizing condition.

Some numerical characteristics of discrete random variables are looked at then. The students have to explain the meaning and write down formulae of mathematic expectation, dispersion, average second order deviation.

MODULE 1.
CONTENTS MODULE 2.
THEME 5. **Random variables.**
PART II. **Continuous random variables.**
IMPORTANCE OF THE THEME: Random variables are applied to characterize phenomena of probable nature, as well as to describe human vital activity.

Objective (general): To know how to apply the laws of random variables distribution.	
Specific objectives:	The result knowledge and skills level:
1. To learn the function of distributions and characteristics of continuous random variables.	To know how to: 1. Find distribution function with given function of probability density.
2. To learn the normal law of distribution.	2. To know how to calculate mathematic expectation, dispersion and average quadratic deviation of continuous random variables. 3. To know how to use Gaussian distribution.

There is a test for determination of students' initial knowledge level at the beginning of the lesson.
After the test results are announced, training problems are solved according to the plan:
1. distribution function;
2. numeric characteristics of continuous random variable;
3. Gaussian distribution.

When the question of "The function of distribution of continuous random variables" is considered, it is necessary to understand connection between the function of distribution of a continuous random variable and density of probability of such variable.

When the question "Numeric characteristics of continuous random variable" is considered, formulae for calculation of mathematic expectation, dispersion and average quadratic deviation should be known and explained, and then the problems of the following types should be solved:

- to find out density of probability, if the distribution function is given;
- to find out distribution function, if the density of probability function is given.

The next question for consideration is "Gaussian distribution". The following plan is recommended:
- probability density of a continuous random variable with normal distribution;
- graph of density of probability of a normally distributed random variable X function f(x);
- influence of numeric values of distribution parameters a and σ on the Gauss curve form;
- the function of distribution of a normally distributed random variable; Laplace function;
- probability of a normally distributed random variable getting into the given interval.

The marks are announced and home task is given at the end of the lesson.

MODULE 1. Mathematic processing of medical and biological information

THEMATIC MODULE 2. The basics of probability theory and mathematical statistics

THEME 6. **Elements of mathematical statistics. Correlation dependence between random variables**

PART 1. Elements of mathematical statistics.

IMPORTANCE OF THE THEME: Methods of mathematical statistics are widely used in analysis and processing of medical and biological information

Objective (general): To master methods of mathematical statistics for processing medical information	
Specific objectives:	The result knowledge and skills level:
1. Learning key notions of mathematical statistics.	1. To know how to interpret the notions of universal and selective sets, bar chart, statistical characteristics of a set.
2. Development of doing the simplest statistical processing of experimental data skills.	2. To be able to give point selective estimate of stat statistical characteristics of a set (mathematic expectation, dispersion, average quadratic deviation).
	3. To be able to give interval elective estimate of mathematic expectation of a set.

1. Initial level of students' knowledge on main notions and methods of mathematical statistics is tested in written form.

2. Thematic problems are proposed for solution after the test. Consideration of main theoretic questions in form of oral inquiry is held according to the following plan:

1) To define main notions of mathematical statistics and give examples:
- set (universal and selective),
- elements of a set,
- set volume.

2) What for and how is a bar chart built?

3) What are statistical characteristics of a set?

4) What is the difference between true and estimate value of a statistical characteristic?

5) What are the methods of estimating statistical characteristics?

6) What does point selective estimate of statistical characteristic mean?

Give examples of formulae for calculation of point selective estimates of mathematic expectation, dispersion, average quadratic deviation, for calculation of mean error.

7) What does interval (reliable) estimate of statistical characteristic by sampling mean? What is a reliable interval? What is reliable probability and significance level?

8) What methods are used for calculation of a reliable interval for expectation of as random variable? What does application of this or that method depend on? How should a random variable be distributed in universal set so that these methods can be used?

9) To write down and explain formula for calculation of borders of a reliable interval if the value of random variable dispersion is known.

10)To write down and explain the formula for calculation of borders of a reliable interval if the value of dispersion is not known.

11)How should probability of difference of simple averages of two selective sets be estimated? What is a null hypothesis? Formula for calculation of T value.

12)To write down the simplified formula for calculation of T (in case when volumes of samples are big and approximately equal).

3. At the end of the lesson the work is summarized, marks are announced (based on the results of written test and oral inquiry) and task for the next time is given.

laws of lighting

MODULE 1.

THEMATIC MODULE 2.

THEME 6. **Elements of mathematical statistics. Correlation dependence between random variables.**

IMPORTANCE OF THE THEME: The method of correlation and regression analyses is widely used in statistical processing of medical and biological information.

Objective (general): To master methods of mathematical statistics for processing medical information	
Specific objectives:	The result knowledge and skills level:
1. To interpret the notion of functional and correlation dependences.	1. To know main notions of correlation and regression analysis: regression function; regression line; regression coefficients; correlation field; selective correlation coefficient.
2. To analyze connection between characteristics of biological objects with the help of correlation coefficient.	2. To understand the meaning of the least squares method.

1. Initial level of students' knowledge on main notions of correlation and regression analysis is tested in written form

2. Thematic problems are proposed for solutions after the test. Consideration of main theoretic questions in form of an oral inquiry according to the following plan:

1. What is the difference between functional and correlation dependencies?
2. What is a Y regression function at X, regression line, regression coefficient?
3. What is correlation field?
4. What is linear regression?
5. What is R selective correlation coefficient?
6. What are the borders in which R selective correlation coefficient values vary? What does R module proximity to one mean? To zero?
7. What does the method of the least squares imply?
8. How are linear regression coefficients calculated?
9. What specific tasks are to be carried out in laboratory work?

3. Then the students proceed to practical part of the laboratory work: calculation of necessary parameters; building correlation field and putting regression lines on the charts; conclusions as to character of connection between random variables X and У. The teacher marks completion of laboratory works in notebooks.

4. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

MODULE 1

THEMATIC MODULE 2

THEME № 7: **Methods of processing measurements results**

IMPORTANCE OF THE THEME: A correctly measured value is the guarantee of precise information about the object under consideration, and there is a notion of measurement error in mathematics, depending on many factors. The task of the seminar is to learn how to calculate measurement errors and take them into account in different types of examinations.

Objective of the lesson: to define types of measurements and measurement errors. To know how to calculate the measurement results obtained.

Specific objectives:	The result knowledge and skills level:
1. To interpret types of errors	1. To know components of measurement error.
2. To learn how to make calculation in different kinds of measurements	2. To know how to process results of direct and indirect measurements

I. Students' knowledge on the topic is controlled at the beginning of the lesson in form of written tests.

II. After the test main theoretic questions are considered in form of an oral inquiry according to the following plan:

1. Definition of a measurement. How are measurements divided?
2. What is measurement error? Which errors are called absolute and relative ones? How can absolute and relative measurement errors be calculated?
3. What components should a measurement error have?
4. What causes appearance of systematic and random errors? What are the methods for their elimination?
5. How does the method of direct results processing depend on random and instrumental errors?
6. What is the method of processing indirect measurements results?

III. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

MODULE 2.
THEMATIC MODULE 3.
THEME 8. **Basics of mechanics and biomechanics.**

IMPORTANCE OF THE THEME: Main notions and laws of biomechanics enable us to examine principle mechanical properties of biological tissues, thanks to which various mechanic phenomena take place, such as: the functioning of the musculoskeletal system, processes of deformation of tissues and cells, contraction and relaxation of muscles etc.

Objective (general): To master basic notions and laws of mechanics, biomechanics and material science.

Specific objectives:	The result knowledge and skills level:
1.To understand the notions and laws of mechanics of rotary motion.	1.To know how to explain the notions and laws of mechanics of rotary motion.
2. To master basics of material science.	2. To know basics of material science.
3. To consider mechanical properties- of biological tissues.	3. To understand dependence of mechanical properties of biological tissues from mechanical and biological factors.
4. To learn the peculiarities of work of biomechanical systems.	4. To know the biomechanics of human musculoskeletal system.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of written test.
2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:
   - notions of perfectly rigid body;
   - characteristics of uniform motion in circle: angular velocity; angular acceleration;
   - moment of force, equilibrium condition of a body in circular motion;
   - moment of inertia of a material particle;
   - moment of body impulse, the law of conservation of impulse moment;
   - types of deformation: resilient, inelastic, highly elastic;
   - mechanical tension, allowable mechanical pressure, extension strain;
   - Hooke's law;
   - brittle and plastic materials, Poisson's ratio;
   - shear deformation;
   - linear and volume coefficients of thermal expansion;
   - mechanical properties of biological tissues, Hill equation.
3. At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 2.

THEMATIC MODULE 3.

THEME 9. **Mechanics of liquids and some issues of hemodynamics**

IMPORTANCE OF THE THEME: The circulatory system is exceptionally important in the functioning of a human body, and blood's running through veins is a complicated process from biophysics point of view .

Objective (general): to master basic notions, understand main laws of real liquids when flowing.	
Specific objectives:	The result knowledge and skills level:
1. To interpret mechanical models of viscose and elastic features of biological tissues.	1. To master main laws of real liquids when flowing.
	2. To understand what are viscose and elastic features connected with.
2. To explain physical basics of measurement methods of blood viscosity and methods of measuring blood pressure and velocity of blood circulation.	3.To clearly understand how human circulatory system works from hemodynamics point of view.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.

2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

I. Perfect liquid and real liquid:

- *Bernoulli equation;*
- *Condition of flow's continuity.*
- *Notion of liquid's ductility, Newton formula*
- *Newton formula, notion of liquid's dynamic viscosity, viscosimetry.*

II Flow of viscous liquid in tubes:

- *Newton and non-Newton liquids*
- *Laminar and turbulent flows*
- *Reynolds number*.
- *Poiseuille formula;*
- *Hydraulic resistance of the system;*

IV. The subject of rheology; biorheology.

V. Real liquid flow as displacement deformation:

- *main rheological characteristics and correlation between them (displacement velocity, displacement tension).*
- *flow curves for Newtonian and non-Newtonian fluids*

VI. Properties of blood as a viscous and elastic liquid:

- *Role of red corpuscles, hematocrit;*
- *Shvedov-Bingham equation;*
- *Kesson equation;*

VII. Physical basics of hemodynamics:

- *velocity of blood flow and average blood pressure in the circulatory systemy,*
- *physical basics of clinical methods of blood pressure measurement (by Korotkov);*
- *mechanical work and power of the heart.*
- *pulse wave.*

3. At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 2.

THEMATIC MODULE 3.

THEME 9. **Basics of hydrodynamics, biorheology and hemodynamics.**

PART 2. **Measureing liquid's viscosity by Ostwald and Hess.**

IMPORTANCE OF THE THEME: The measuring of blood viscosity is a well-known diagnostic method, therefore acquiring the skills of working with viscosimeters is a current need.

Objective (general): To acquire the skills of measuring liquids viscosity with Ostwald and Hess viscosimeter.

Specific objectives:	The result knowledge and skills level:
1. To demonstrate skills of measuring liquids viscosity.	1. To know how to measure liquids viscosity with Ostwald and Hess viscosimeter.
2. To explain physical basics of methods for measuring blood viscosity.	2. To be able to explain the physical basics of methods for measuring blood viscosity.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.
2. After the test problems on the topic are solved. Main theoretic questions are considered in form of n oral inquiry according to the following plan:

1. The notion of perfect liquid. Real liquid.
2. Newton formula for inner friction force, viscosity coefficient, its physical sense, measurement unit. 3. Newton and non-Newton liquids.
4. Poiseuille formula, its analysis..
5. Organization of Ostwald viscosimeter and determination of liquid's viscosity coefficient with the its help.
6. Organization of Hess viscosimeter and determination of liquid's viscosity coefficient with the help thereof.

3. Then the students proceed to practical part of the laboratory work.. The teacher marks completion of the practical part in students' notebooks.
4. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

MODULE 2.

THEMATIC MODULE 3.

THEME 10. **Mechanical oscillations and waves.**

IMPORTANCE OF THE THEME: Knowing main notions of the theory of mechanical oscillations and waves will let medical students better know physical basics of examining hearing, as well as sound and ultrasound methods applied in diagnostics.

Objective (general): To learn main notions of mechanical oscillations and waves theory.	
Specific objectives:	The result knowledge and skills level:
1. To explain main notions of mechanical oscillations and waves theory.	1. To know how to explain main notions of mechanical oscillations and waves theory.
2. To classify mechanical oscillations and waves.	2. To be able to classify mechanical oscillations and waves.
3. To understand differential equations describing mechanical oscillations and waves.	3. To learn differential equations.

1. Initial level of students' knowledge on main notions of correlation and regression analysis is tested in written form.

2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

1. Continuous, damping and driven oscillations.
2. Differential equations of continuous, damping and driven oscillations and their solution.
3. Resonance and resonance frequency.
4. Vibrations.
5. Self-exciting oscillations.
6. Wave processes and characteristics.
7. Wave equation.
8. Differential wave equation.
9. The flow of energy flow, intensiveness, Umov vector.

3. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

MODULE 2.
THEMATIC MODULE 3.
THEME 10. **Bioacoustics**

IMPORTANCE OF THE THEME: main physical notions and laws of bioacoustics allow us to explain the physical basics of methods of sound research in medicine, mechanisms of ultrasound and infrasound influence on human body, as well as understand the biophysical sense of perception of sounds by a human being

Objective (general): To explain main notions and laws of bioacoustics.

Specific objectives:	**The result knowledge and skills level:**
1.To know physical nature of the sound, its main characteristics (objective and subjective). 2. To study how sound and ultrasound are used in medicine. 3. To understand how sound is perceived by a human being from biophysics point of view.	1. To know the link between physiological and physical characteristics of sound. 2. To know how to explain the psychophysical Weber-Fechner law. 3. To know how to determine loudness of the sound knowing the level of sound intensity and its frequency (by curves of equal loudness). 4. To interpret physical basics of sound examination methods in medicine, 5. To explain biophysical mechanisms of ultra- and infrasound influence on human body.

1. Initial level of students' knowledge on main notions of correlation and regression analysis is tested in written form.
2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:
   - acoustics, acoustic waves;
   - Physical (objective) characteristics of sound (sound pressure, intensiveness and its level, frequency, wave length, speed of propagation, acoustic spectrum);
   - Physiological (subjective) characteristics of sound (loudness, pitch, timbre), link between physical and physiological characteristics of sound;
   - Psychophysical Weber-Fechner law;
   - Curves of equal loudness; determining loudness of the sound with given frequency and intensiveness level, as well as intensiveness level with given frequency and loudness;
   - The method of sound examination in medicine (audiometry, auscultation, percussion, phonocardiography);
   - Ultrasound and its use in medicine;
   - Infrasound and its influence on human body;
   - Noise, its harmful influence on human body;
   - Biophysics of sounds perception by a human.

   Questions for self-study:
   - Doppler effect;
   - hygienic regulations of levels of noise, infrasound, vibration.
3. At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 1.

THEMATIC MODULE 2.

THEME 17.**Determination of spectrum characteristics of human hearing mechanism at absolute threshold of hearing.**

IMPORTANCE OF THE THEME: Audiographic method is one of the most widely used in diagnostics in finding pathologies in human hearing mechanism.

Objective (general): To acquire practical skills of determining spectrum characteristic of human hearing mechanism at absolute threshold of hearing.

Specific objectives:	The result knowledge and skills level:
1. To know how to analyze curves of equal loudness.	1. To know how to use the "Curves of equal loudness" placard.
2. Correctly analyze dependence between loudness, intensity and frequency of sound.	2. To know how to interpret an audiogram.
	3. To define frequency range of sound, to which the hearing mechanism of the student, whose audiogram was received, is the most sensible,.

1. At the beginning of the lesson goal and specific objective of the lesson are defined, initial level of students' knowledge on bioacoustics is determined in form of a written test.

2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

1. Sound intensity, level of sound intensity, units of their measurement.
2. Sound pressure, its link tosound intensity and their measurement.
3. Sound loudness. Weber-Fechner law. Units of sound loudness measurement.
4. Audiometry. Audiogram, Curves of equal loudness.
5. Zero level of sound and threshold of sensation of pain. Their dependence from frequency.
6. Order of making an audiogram in the present work. Objective of the work.

7. Physical basics of sound diagnostics methods (audiometry, auscultation, percussion, phonocardiography).

3. Then the students proceed to practical part of the laboratory work: taking measurements, building audiogram, making conclusions. The teacher marks completion of the practical part in students' notebooks

4. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

MODULE 2.

THEMATIC MODULE 4.

THEME10. **Biological thermodynamics. Elements of molecular biophysics.**

IMPORTANCE OF THE THEME: Studying vital functions of a body or of its parts needs quantitative description of processes of one type of energy transforming into another, connection between such transformations with work and heat transfer, studied in thermodynamics. And studying the structure as well as physical and chemical features of important macromolecules, such as proteins and nucleic acids, enables us to foresee their biological features.

Objective (general): To learn main notions and laws of thermodynamics and physics of macromolecules.

Specific objectives:	**The result knowledge and skills level:**
1.To interpret main theses of thermodynamics of open biological systems.	1. To be able to apply the thermo dynamical method in studying medical and biological systems.
2.To analyze intermolecular interactions in biopolymers.	2.To explain the meaning of thermodynamics and synergy.
3.To study the structural organization of proteins and nucleic acids.	3.To explain processes of sorting in physical, chemical and medical and biological systems.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.

2. After the test problems on the topic are solved. Main theoretic questions are considered in form of oral inquiry according to the following plan:

1. The notion of thermodynamics.
2. Open, closed and isolated systems. Steady and unsteady conditions.
3. Inner energy of the system. Quantity of heat. The first law of thermodynamics.
4. Sources of energy in human body. Hess's law.
5. Reversible and irreversible processes. The second law of thermodynamics.
6. Entropy. Thermodynamical potentials: entropy (H), Gibbs free energy (G) and Helmholtz free energy (F).
7. Prygozhyn theorem. Synergy.
8. Intermolecular interaction in biopolymers (covalent, electrostatic, dispersion.
9. Structural organization of proteins and nucleic acids (primary, secondary, tertiary, quaternary).

At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 2.

THEMATIC MODULE 5.

THEME 12. **Biophysics of membranes.**

IMPORTANCE OF THE THEME: Studying the structure of membranes, main types of through membranes transport and mechanisms of rest and action potential regeneration lets us understand electric properties of biological tissues, electric phenomena connected to human vital activity.

Objective (general): To learn the processes of transportation of substances in biological systems.

Specific objectives:	The result knowledge and skills level:
1. To look at the structure of biological membranes.	1. To know the structure of cell membranes and their characteristics.
2. To learn main types of transportation of substances through membranes.	2. To learn main types of transportation of substances through membranes.
3. To learn the mechanisms of tranquility potential regeneration.	3. To explain Fick equation, describing diffusion of neutral substances.
4. To learn the mechanisms of regeneration and expansion of action potential.	4. To learn phenomenon of electrodiffusion and Nernst-Planck equation.
	5. To consider active transportation of substances through membranes.
	6. To understand the mechanism of tranquility potential regeneration.
	7. To understand the mechanism of regeneration and expansion of action potential.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.
2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:
   - structure of membrane, main types of transportation of substances through membranes
   - diffusion of neutral substances, Fick equation.
   - diffusion through pores of membranes, light diffusion, exchange diffusion
   - electrodiffusion, Nernst-Planck equation
   - active transportation of substances through membranes, sodium and potassium pomp
   - tranquility potential, Goldman-Hodgkin-Katz equation
   - action potential, its regeneration and expansion
3. At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE3.

THEMATIC MODULE 6.

THEME 14.**Effect of electric current and electromagnetic fields on biological objects. Magnetic phenomena. Elements of magnetobiology. Part 1.**

IMPORTANCE OF THE THEME: Studying this theme will help medical students to netter learn methods of diagnostics based on registration of magnetic fields. The effect of direct current is widely used in medical diagnostic and curing procedures.

Objective (general): To learn main notions and laws of magnetic phenomena and elements of magnetobiology. To know physical basics of effect of direct current on biological tissues and liquids, as well as diagnostic and treatment methods applying the direct current effect.

Specific objectives:	**The result knowledge and skills level:**
1. To learn physical basics of magnetic field effect.	1. To know how to explain physical basics of magnetic field effect.
2. To understand main laws and notions of magnetic phenomena.	2. To know how to classify main laws and notions of magnetic phenomena.
3. To consider the effect of magnetic field on biological objects.	3. To know the effect of magnetic field on biological objects.
4. To learn physical basics of the effect of direct electric current on biological objects.	4. To know main principles of the effect of direct electric current on biological objects.
	5. To know the principles under which the equipment using the direct current effect in

There is an initial test control of students' knowledge at the beginning of the lesson, then marks are announces and theoretical questions are considered under the following plan:

1. Magnetic field and its properties.
2. Ampere force.
3. Lorentz force.
4. Magnetic permeability. Magnetic properties of substances.
5. Magnetic field strength. Bio-Savart law.
4. Phenomenon f electromagnetic induction.Magnetic flow. Law of electromagnetic induction.Phenomenon of self-induction.
5. Magnetobiology. Effect of magnetic field on biological objects.
6. Biomagnetism.
7. Magnetocardiography.
8. Electric properties of biological tissues and liquids.
9. Direct electric current, its characteristics, mechanism of its effect on biological tissues. Galvanization and medical electrophoresis.

At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE3.

THEMATIC MODULE 6.

THEME 13.**Effect of electric currents and electromagnetic field on biological objects. Magnetic phenomena. Elements of magnetobiology. Part 2.**

IMPORTANCE OF THE THEME: Effect of electric currents and electromagnetic fields is widely used in medical diagnostic and treatment procedures.

Objective (general): To learn the physical basics of the effect of pulse and alternating currents and electromagnetic fields on biological tissues and liquids, as well as diagnostic and treatment methods based on the effect of these factors.

Specific objectives:	**The result knowledge and skills level:**
1. To learn the physical basics of effect on biological objects of: - pulse electric current; - alternating electric current; - alternating magnetic and electric fields; - electromagnetic waves; - constant electric and magnetic fields.	1. To know main principles of effect of pulse and alternating currents and each type of fields on biological objects.
2. To learn the principle of diagnostic and treatment procedure based on application of pulse and alternating currents and electromagnetic fields.	2. To know how equipment applying the effect of pulse and alternating currents and fields with treatment and diagnostic purposes function.
	3. To know how to write down main physical laws characterizing the effect of pulse and alternating electric currents.

There is an initial test control of students' knowledge at the beginning of the lesson, then marks are announces and theoretical questions are considered under the following plan:

1. Pulse electric current, its characteristics, mechanism of its effect on biological tissues. Dubois-Reymond law. Electrodiagnostics. Hoorweg-Weiss-Lapicque equation. Electrostimulation. Electric sleep. Electrogymnastics for muscles. Defibrillation.
2. Alternating electric current, its characteristics, mechanism of its effect on biological tissues. Nernst's law. Impedance (total resistance) of biological tissues. Rheography. Diathermy (therapeutic and surgical). Darsonvalization.
3. Effect of alternating magnetic field on biological tissues. Inductothermy.
4. Effect of alternating electric field on biological tissues. UHF-therapy.
5. Influence of electromagnetic waves on biological objects. SHF-therapy (MW- and DMW–therapy).
6. Influence of direct electric field on biological objects. Franklinization (electrostatic shower). Aeroionotherapy.
7. Influence of constant magnetic filed on biological objects. Magnetotherapy.
8. Hygienic regulations of electric and magnetic currents.

At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 3.

THEMATIC MODULE 6.

THEME 15.**Determining ion mobility by electrophoresis.Studying the function of the apparatus for UHF-therapy.**

IMPORTANCE OF THE THEME: effect of direct and alternating current on human body is applied in medicine in physiotherapeutic rooms with treatment purpose.

Objective (general): To know how to determine ion mobility with the help of electrophoresis. To learn physical basics of effect of electromagnetic field of UHF on issues and organs, principle of UHF-therapy apparatus functioning and methodology of working with it

Specific objectives:	**The result knowledge and skills level:**
1. Tointerpretionmobilityindifferenttissuesofhumanbodywhenplacedwithinan electricfield.	1. To know the initial effect of direct current on tissues of the body.
2. To consider the methodology of electrophoresis.	2. To master electrophoresis.
3. To interpret the effect of alternating electric field of UHF on tissues of the body.	3. To know how to practically determine ion mobility with the help of electrophoresis method.
4. Tolearn how a UHF apparatus works.	4. To know how alternating electric field of UHF effects tissues of the body.
	5. To be able to prepare a UHF-therapy apparatus for work.

I. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test

II. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

1. Electrophoresis, medical electrophoresis, galvanization.
2. Electrolysis, ion mobility, initial effect of direct current on biological tissues.
3. Electromagnetic field.
4. Electric properties of biological tissues, impedance of biological tissues.
5. Conduction currents and displacement current, dielectric loss tangent.
6. Heat release in tissues with different electric properties.

III. Then the students proceed to practical part of the laboratory work: to prepare a UHF-apparatus for work in accordance with instructions in "Laboratory Session Manual"). To take necessary measurements and enter them in the table. To build a graph of dependence $t^0C=f(t, min.)$.

To make the scheme for determining ion mobility by electrophoresis method, as shown on the picture in the methodical manual" Laboratory Session Manual", then make all necessary measurement and calculations. Enter them in the chart and build a graph of dependence V=f(E).

IV. At the end of the lesson the laboratory work is summarized, marks, received by the students, are announced and home task is given for the next time.

MODULE 3.
THEMATIC MODULE 3.
THEME 16. PART1 Medical electronics. (workshop)
THEME 17. PART 2 Studying electric properties of biological tissues (laboratory work)

Objective (general):

PART 1 . To learn the notions referred to electronics applied in solution of medical and biological tasks.

PART 2 To know physical and biophysical properties of biological tissues.

Specific objectives:	**The result knowledge and skills level:**
PART 1	
1. To classify medical electronics.	1. To know the notions referred to medical electronics, its classification and purpose.
2. To explain purpose of main blocks of medical electronics, requirement as to them and safety issues.	2. To know how main components of medical electronics are built, as well as requirements to it and issues of electronic safety.
3. To know the notions connected to reliability and faultiness of medical electronics, as well as classification of it according to reliability criteria.	3. To know the notions of reliability and probability of faultless work, intensity of medical electronics failure. 4. To be able to classify medical electronics according to reliability criteria.
4. To know principles of functioning and characteristics of main components of medical electronics (electrodes, sensors, amplifiers and generators)	5. To know what principles of electrodes and sensors work are, what an indicator transoforamation function is, sensor's sensitivity and phenomenon of hysteresis. 6. To know what are the principles of work of amplifiers of alternating and direct current, to know what amplification coefficient is, what amplitude and amplitude and frequency characteristics are, as well as bandwidth of an amplifier. 7.To know what generators are, how they are classified and where they are used. 8. To know what reflection and registration devices are.
PART 2	
1. To know what impedance (total resistance) of biological tissues is.	1. To know how impedance of biological tissues depends on frequency of alternating current and condition of biological tissues themselves. 2. To know what is electric equivalent of biological tissue.
2. To know the methods based on registration of impedance change.	3. To know what methods of rheography and rheodentography, rheoencephalography, rheocardiolgraphy are.

PART 1

I. Introductory part.
II. Determining initial level of students' knowledge on issues provided in the methodical manual.
III. Considering theoretic questions on the topic:

1. Tasks of medical electronics. Classification of medical electronics and its structure.
2.Electrical safety of medical electronics.
3.Reliability of medical electronics.
4. Metrological service of healthcare.
5. Electrodes and sensors.
6. Amplifiers of electric signals, their main characteristics. Bandwidth of an amplifier.
7. Generators, devices of reflection, registration and the saving of information.
Summarizing Part1.

PART 2

1. Considering theoretical material of the topic in accordance with the list of questions to lavoratory work.
2. Students performing the task.
3. Summarizing the lesson, giving home task.

MODULE 3.

THEMATIC MODULE 6

THEME 15. **PHYSICAL BASICS OF ELECTROCARDIOGRAPHY.**

<table>
<tr><td colspan="2">Objective (general): To present main thesis of the theory of forming normal EKG to the students.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Specific objectives:</td><td>The result knowledge and skills level:</td></tr>
<tr><td>1. To understand main notions and laws of the chapter “Electromagnetic phenomena in tissues of human body”</td><td>1. To know how to explain phenomena of electric current running through body tissues.</td></tr>
<tr><td rowspan="2">2. To consider how electric current runs through human body tissues.</td><td rowspan="2">2. To know how to explain electric phenomena in human body due to the running of current.</td></tr>
<tr><td></td></tr>
<tr><td>3. To interpret the model of forming normal EKG, proposed by Einthoven.</td><td>3. To understand how a normal EKG is formed from biophysics point of view.</td></tr>
</table>

I. Students’ knowledge on the topic is controlled at the beginning of the lesson in form of a written test.

II After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

1. Electric filed and its characteristics. Principle of fields superposition.
2. Electric dipole. Dipole moment of electric dipole. Electric field of electric dipole.
3. Electric properties of biological liquids and tissues.
4. Current dipole. Dipole moment of current dipole. Electric field of current dipole. Current dipole – generator of electric field in living tissues.
5. Physical basics of electrocardiography. Einthoven theory.
6. Standard leads. Registration of normal electrocardiogram, its analysis.
7. Chest leads..
8. The notion of electroencephalography, electroretinography, electromyography
9. The notion of vector-cardiography.

III At the end of the lesson the work is summarized, marks are announced and task for the next time is given.

MODULE 3.

THEMATIC MODULE 7. Optical methods and their use in biology and medicine.

THEME 16. Elements of geometric optics. Optical refractometry.

Objective (general): To learn main notions of geometric optics. To study the structure of human eye, conduction and perception of light by it. To acquire the skills of determining refraction indicator and concentration of the studied solution with the help of refractometer.

Specific objectives:	**The result knowledge and skills level:**
1.To know how to explain basic notions of geometric optics.	1. To know the laws of light reflection and refraction. Total internal reflection.
2. To consider important characteristics of lenses: focal distance, focal power, the magnification . To examine how a subject is reflected in a lens. To learn the thin lens formula and kinds of lenses aberration.	2. To know that there are following characteristics of collective?? And diverging lenses: а) main axes, points/dots, planes; б) focal distance, focal power of a lens; в) the magnification of a lens. To be able to build reflection of a subject in lenses. To know the formula of thin lens. To know the kinds of lenses aberration.
3. To study the structure of human eye.	3. To know how human eye is built, what light conducting and light perceiving systems of the eye are, weaknesses of eye optical system and ways of strengthening them. To understand how an image is built in human eye optical system. To understand the process of human eye adaptation and accommodation. To know how to define acuity of vision.
4. To explain the method of refractometry.	5. To know how a refractometer is built and how it functions. To know how to take measurements of refraction of a studied solution. To be able to build a calibration graph of dependence between refraction indicator of a studied solution and its concentration. To know how to define concentration of a studied solution based on such graph.

Stages of the lesson and their duration (all faculties, except stomatological) (first 2 hours):

1. Teacher's introductory word.

2. Initial test control of students' knowledge on the topic.

3. Oral inquiry on theoretic material

1) The laws of reflection and refraction of light. Absolute and relative indicators of light refraction, their correlation. Phenomenon of refraction. Threshold refraction angle. Internal reflectance. Threshold angle of internal reflectance

2) Collective and diverging lenses:

a) main axes, points/dots, planes;

b) focal distance, focal power of a lens;

c) the thin lens formula and the magnification of a lens;

d) building of an image in the lens;

e) kinds of lenses aberration.

3) Human eye optical system. Light perceiving apparatus of an eye. Eye's photosensitivity. Eye'e focal power. Accommodation. Shortages of human optical system and ways of their removal.

4) Image of an object in human eye optical system. Visual angle. Eye's resolution. Acuity of vision. Adaptation.

4. Summarizing the lesson, giving home task.

Stages of the lesson and their duration (all faculties, except stomatological) (last 2 hours):

1. Teacher's introductory words.
2. Initial test control of students' knowledge on the topic.
1) Structure of a refractometer and principles of its functioning (explain according to the scheme).
2) Practical determination of solution concentration with the help of refractometer.
3) Use of refractometer in medicine.
3. Experimental part of laboratory word and registration of measurements.
4. Summarizing the lesson, giving home task.

Stages of the lesson and their duration
(2 hours for stomatological faculty):

1. Teacher's introductory words.
2. Initial test control of students' knowledge on the topic
3. Oral inquiry on theoretic material
1) The laws of reflection and refraction of light. Absolute and relative indicators of light refraction, their correlation. Phenomenon of refraction. Threshold refraction angle. Internal reflectance. Граничний angle of internal reflectance
2) Collective and diverging lenses:
a) main axes, points/dots, planes;
b) focal distance, focal power of a lens;
c) the thin lens formula and the magnification of a lens;
d) building of an image in the lens;
e) kinds of lenses aberration.
3) Human eye optical system. Light perceiving apparatus of an eye. Eye's photosensitivity. Eye's focal power. Accommodation. Shortages of human optical system and ways of their removal.
4) Image of an object in human eye optical system. Visual angle. Eye's resolution. Acuity of vision. Adaptation.
5) Structure of a refractometer and principles of its functioning (explain according to the scheme).
6) Practical determination of solution concentration with the help of refractometer.
7) Use of refractometer in medicine.
4. Experimental part of laboratory word and registration of measurements.
4. Summarizing the lesson, giving home task.

MODULE 3.

THEMATIC MODULE 7. Optical methods and their application in biology and medicine.

THEME 17. Optical microscopy. Wave optics. Interaction of light with a substance.

Objective (general: To study the principles of functioning of a microscope. The lean special techniques of microscopy. To learn the mechanism of light interacting with a substance. To acquire skills of getting the spectrum of light absorption in solutions of substances, as well as to learn the methods of measuring substances concentration in solution with the help of photoelectrocoloremeter.

Specific objectives:	**The result knowledge and skills level:**
1. To explain principles of optical appliances functioning based on the laws of geometric optics.	1. To know main characteristics of a microscope: magnification, resolution.
2. To consider important characteristics of a microscope: magnification, resolution.	2. To understand basic principles of the functioning of optical devices.
3. To consider special techniques of optical microscopy.	3. To know that there are following special techniques of microscopy: a) microproection and microphotography; b) method of the dark field; c) method of phase contrast; d) polarization microscope.
4. To explain physical basics of light interference and diffraction.	4. ЗTo know physical basics of light interference and diffraction.
5. To explain physical basics of light dispersion, absorption and light scattering.	5. To know physical basics of light dispersion, absorption and light scattering. To study the mechanism of light interaction with a substance.
6. To explain the method of concentration colorimetry.	6. To how a photoelectrocolorimeter is build and how it functions. To know how to take the spectrum of solution absorption and its graphical formation. To know how to build a calibration graph of dependence of optical density at λ_{max} from concentration. To be able to determine concentration of the studied solution.

Stages of the lesson and their duration (all faculties, except stomatological) (first 2 hours):

1. Teacher's introductory word.

2. Initial test control of students' knowledge on the topic.

3. Oral inquiry on theoretic material

1) Optical system of a microscope, ray path in it.
2) Angular magnification of a microscope. Resolution. Limit of the resolution.
3) Ways of decreasing the threshold of microscope розрізнення (numeric aperture, immersion liquid, UV-microsope).
4) Special techniques of optical microscopy:

a) microproection and microphotography;
b) method of the dark field;
c) method of phase contrast;
d) polarization microscope.

4. Summarizing the lesson, giving home task.

Stages of the lesson and their duration (all faculties, except stomatological) (last 2 hours):

1. Teacher's introductory word.

2. Initial test control of students' knowledge on the topic.

1) Light absorption by a substance. Bouguer law. Absorption indicator.
2) Light absorption by solutions. Bouguer-Lambert-Beer law. Absorption indicators.
3) Transmission coefficient and optical/transmission density of a solution.

4) Substance absorption spectrum.
5) The principle of photoelectrocolorimeter work.
6) Receiving absorption spectrum in coloured solution and determining substance concentration in a solution.

3. Experimental part of laboratory word and registration of measurements.

4. Summarizing the lesson, giving home task.

Stages of the lesson and their duration
(2 hours for stomatological faculty):

1. Teacher's introductory word.

2. Initial test control of students' knowledge on the topic.

3. Oral inquiry on theoretic material

1) Optical system of a microscope, ray path in it.
2) Angular magnification of a microscope. Resolution. Limit of the resolution.
3) Шляхи зменшення межі розрізнення мікроскопа (numeric aperture, immersion liquid, UV-microscope).
4) Special techniques of optical microscopy:
a) microproection and microphotography;
b) method of the dark field;
c) method of phase contrast;
d) polarization microscope.
5) Light absorption by a substance. Bouguer law. Absorption indicator.
6) Light absorption by solutions. Bouguer-Lambert-Beer law. Absorption indicators.
7 Transmission coefficient and optical/transmission density of a solution.
8) Substance absorption spectrum.
9) The principle of photoelectrocolorimeter work.
10) Receiving absorption spectrum in coloured solution and determining substance concentration in a solution зчині.

4. Experimental part of laboratory word and registration of measurements.

5. Summarizing the lesson, giving home task.

THEME: **Main notions and formulae of wave optics.**
FORM OF WORK: self-study (outside of the class).
TIME: 6 hours (only for medical faculties)

The elements of the current topic for student's self-study outside of the class:

1. Light interference. Holography
2. Light diffraction.

MODULE 3.

THEMATIC MODULE 7.

THEME 20. Hours 1 and 2: **«LIGHT POLARIZATION».**

IMPORTANCE OF THE THEME: Polarized light is the necessary basis for making certain laboratory research and studies of biological tissues.

Objective (general): To study the phenomenon of light polarization and its use in medicine.	
Specific objectives: 1. To consider methods of getting ordered orientation of electric and magnetic vectors in light waves; 2. To learn the properties of polarized light.	The result knowledge and skills level: 1. To know the nature of plane-polarized light and ways of getting it; 2. To know how to apply plane-polarized light in medical practice.

1) There is a test control of students' knowledge at the beginning of the lesson.
2) Oral inquiry is conducted according to the following plan:

a) Nature of light. Light wave and its characteristics.
b) Polarization of light. Plane-polarized light.
c) Polarization of light if reflected and refracted at the border of two dielectrics. Brewster law.
d) Polarization of light in conditions of double refraction of a ray. Nicol prism.
e) Dichroism.

MODULE 3.

THEMATIC MODULE 7 .

THEME 20. Hours 3 and 4: laboratory work **«DETERMINATION OF SUGAR CONCENTRATION IN A SOLUTION WITH THE HELP OF POLARIZATION SACCHARIMETER»**

IMPORTANCE OF THE THEME: having the basic knowledge on light polarization will allow the students to apply physical mechanisms on which concentration polarization is based.

Objective (general**)**: To master the methods on concentration determination of optically active substances based on measurement of rotation angle of polarization plane of plane-polarized light.

Specific objectives:	The result knowledge and skills level:
1. To interpret physical mechanisms which are basis for concentration polarimetry.	1. To master knowledge on light polarization.
2. To demonstrate skills of working with the saccharimeter.	2. To know how to explain physical mechanisms on which concentration polarimetry is based. 3. To acquire skills of working with the saccharimeter.

At the beginning of the lesson the students show notes on laboratory work to the teacher. Then questions of the teacher are to be answered.

Oral inquiry is held according to the plan:

1) Polarizer and analyzer. Malus' law.

2) Receiving plane-polarized light in conditions of reflection and refraction. Brewster law. Stoletov's packet.

3) Double ray refraction. To draw and explain ray path in a crystal with anisotropic properties. Ordinary and non-ordinary rays, their properties.

4) Optically active substances. Dextrorotatory and laevorotatory substances. Racemic mixture.

5) Phenomenon of polarization plane rotation by optically active substances.

6) To draw and explain how a sacchatometer is built and how it functions.

7) How can sugar percentage in a solution be practically measured by a polarization saccharimeter?

9) Use of polarized light in medical and biological research. S

After these question are considered, measurements are to be taken, as it is shown in the order of performance of the laboratory work, and report is to be written in laboratory works notebook.

MODULE 3.

THEMATIC MODULE 8.

THEME 19. **«Basic notions and laws of quantum physics. Spectroscopy. Heat radiation, its characteristics».**

Objective : 1. To study basic notions and theses of quantum physics. To know the methods of research in medicine based on quantum and mechanical phenomena. 2. To know main laws of heat radiation, to consider general principles of heat radiation application in diagnostics and therapy.	
Specific objectives: 1. To understand basic notions and theses on quantum physics. 2. To explain quantum and mechanical model of hydrogen atom (energetic states, quantum numbers, Pauli principle). 3. To explain main types and fields of application of spectroscopy. 4. To explain main laws of heat radiation. 5. To explain heat radiation of human body and physical basics of thermography method.	**The result knowledge and skills level:** 1. To know the most important notions and theses of quantum physics. 2. To understand how quantum and mechanical phenomena are reflected in such research method as spectroscopy. 3. To know main physical quantities that are characteristics of heat radiation and their measurement units. 4. To know main laws of solids heat radiation. 5. To be able to explain heat radiation of human body and physical basics of thermography method.

1. Introduction

2. Defining initial level of students' knowledge based on question attached to methodical materials.

3. Solving study tasks of the theme by considering theoretic issues on the topic "Basic notions and theses on quantum physics. Spectroscopy":

3.1. Main notions of quantum physics.

3.2. Main theses of quantum physics.

3.3. The application of Schroedinger equation to hydrogen atom.

3.4. Energetic levels in the atom. Pauli principle.

3.5. Atomic and molecular spectra. Spectrophotometry.

4. Performance of topical tasks by considering theoretic questionz on the theme "Heat radiation of solids, its characteristics":

4.1. Main characteristics of heat radiation

4.2. The laws of a black body radiation

4.3. Heat radiation of human body. The notion of thermography.

5. Determining the result knowledge and skills level.

Summarizing the lesson.

MODULE 3.

THEMATIC MODULE 9.

THEME 20. **Luminescence. Elements of photobiology. Electonic microscope.**

Objective (general): To know main types of luminescence, types and stages of photobiological processes, as well as know basic principles of electronic microscope functioning.

Specific objectives:	The result knowledge and skills level:
1.To know what luminescence is, as well as its types.	1.To know what luminescence is, what types it is classified into depending on reasons for it.
2.To consider what fluorescence and phosphorescence is.	2. To understand the difference between fluorescence and phosphorescence.
3. To consider Stokes' law	3. To understand the Stokes' law, as well as what the anti-Stokes luminescence is.
4. To consider what luminescence analysis is and what it is applied and conducted for.	4. To know what luminescence analysis, what it is used and conducted for.
5. To consider main tasks of photobiology.	5. To know main kinds of photobiological processes.
6. To consider main types of photobiological processes.	6. To understand main stages of photobiological processes.
7. To learn main stages of photobiological processes.	7. To know positive and negative photobiological processes in human body.
8. To consider main notions of biophysics of visual perception.	8. To understand the mechanism of photosensibilized photobiological processes.
9. To consider main principles of work of electronic microscope.	9. To understand the mechanism of biophysics of visual perception.
	10. To understand what was the theoretical ground for creation of the electronic microscope.
	11. Limit of the resolution of the electronic microscope.
	12. The principle of work of the electronic microscope.

1. Introductory part.
2. Defining initial level of students' knowledge based on questions attached to methodical materials
3. Question for consideration of at the lesson:

Luminescence

- What is luminescence, what are its types (photo-, iono-, cathode luminescence etc.)
- reasons of photoluminescence, its types (fluorescence and phosphorescence)
- difference in the mechanisms of fluorescence and phosphorescence appearance/emerging.
- Stokes' law and deviation from it (anti-Stokes luminescence)
- Information provided by luminescence spectra.
- Luminescence analysis, what it is applied and conducted for.

Elements of photobiology

- Tasks of photobiology.
- The effect of light on living organisms.
- Classification of photobiological processes.
- Typical stages of photobiological processes.
- The spectra of photobiological effect.
- Photosensibilized photobiological processes.
- Biophysics of visual perception..

Electronic microscope

- Theoretical ground for creation of the electronic microscope
- Limit of the resolution of the electronic microscope.
- The principle of work of the electronic microscope

4. Determining the result knowledge and skills level

MODULE 3.
THEMATIC MODULE 8.
THEME 21. **«Resonance methods of quantum mechanics. Induced radiation».**

Objective: 1. To learn main notions and laws of quantum mechanics, as well as phenomena, based upon these laws. 2. To know modern methods of medical research, applying phenomena of quantum mechanics.

Specific objectives:	**The result knowledge and skills level:**
1. To understand main notions and theses of quantum physics. 2. To explain main types and fields of spectroscopy application. 3. To understand what quantum and mechanical essence of spectroscopy, ESR and NMR. 4. To know how to explain the basics of medical application of electronic and nuclear magnetic resonances. 5. To know how to explain physical basics of laser work, principle of its work and fields of application in medicine.	1. To be able to explain main notions of quantum physics. 2. To understand how quantum and mechanical phenomena are reflected in such research methods as spectroscopy and luminescence analysis. 3. To know how to explain the importance of medical application of electronic and nuclear magnetic resonances. 4. To understand physical basics of laser work. To know where and what for it is applied in medicine.

1. Introduction
2. Визначення Defining initial level of students' knowledge based on question attached to methodical materials
3. Question for consideration of at the lesson::
3.1. Main principles of quantum physics. зики
3.2. Pauli principle. Selection rules. Relations of uncertainty.
4. The method of electronic paramagnetic resonance.
5. Nuclear magnetic resonance.
6. The method of NMR – introscopy. NMR – tomography.
7. Induced radiation
8. The principle of work of helium-neon laser.
9. The use of induced radiation in medicine.
10. Determining the result knowledge and skills level.
Summarizing the lesson.

MODULE 3.
THEMATIC MODULE 9.
THEME 22. «**Photometry».**

IMPORTANCE OF THE THEME: Human perception of light depends both on characteristics of luminous fluxes, calling visual sensing, and on particular features of human optical system. In order to characterize the visual senses, it is necessary to know basic numeric characteristics of photometry and general principles of application of photometers.

Objective (general): To know main numeric characteristics of photometry, consider general principles of photometers application.

Specific objectives:

1.To interpret main physical quantities of photometry and the notion of photometers.

The result knowledge and skills level:

1. To know how to explain main physical quantities of photometry and units of their measurement.
2. To know basic notions and formulae of photometry.
3. To understand general principles of work of photometers.

I. There is initial test control of students' knowledge on the topic, after objective of the theme, general purpose and specific purposes are outlined.

II. After the test, the tasks of the theme are fulfilled by consideration of main theoretical questions in form of oral inquiry according to the following plan.:

1. Definition of photometry. Main photometric quantities.
2. Main characteristics of photometry and laws of lighting:

а) radiation flow, measurement unit;
б) spectral luminous efficacy and luminance function;
в) spectral density of radiation flux;
г) light intensity, measurement unit;
д) the notion of solid angle;
е) light flux, measurement unit;
ж) main laws of lighting, luminous excitance, luminosity, their measurement units.

3. The notion of Lambert sources of light..
4. Luminosity of the Sun and other artificial sources.
5. The notion of physical and visual photometers. Lummer-Brodhun photometer.

III. At the end of the lesson the work is summarized, marks are announced (based on written test and oral inquiry results) and task for the next time is given.

THEME22. «**Photometry».**

FORM OF THE STUDY: self-study (outside of the classroom).

TIME FOR STUDY: 3 hours

Questions for self-study of the students:

6. Definition of photometry. Main photometric quantities.
7. Main characteristics of photometry and laws of lighting:

а) radiation flow, measurement unit;
б) spectral luminous efficacy and luminance function;
в) spectral density of radiation flux;
г) light intensity, measurement unit;
д) the notion of solid angle;
е) light flux, measurement unit;
ж) main laws of основні laws of lighting, luminous excitance, luminosity, their measurement units.

8. The notion of Lambert sources of light..
9. Luminosity of the Sun and other artificial sources.
10. The notion of physical and visual photometers. Lummer-Brodhun photometer.

MODULE 3.

THEMATIC MODULE 8.

THEME 23. **X-radiation.**

IMPORTANCE OF THE THEME: X-radiation is of great importance for medical diagnostics of condition of human viscera, as well as for treatment with radiodiagnostics methods.

Objective (general): To find out the mechanisms and laws of interaction of X-radiation with a substance. To understand methods applying X-radiation in medicine.	
Specific objectives:	The result knowledge and skills level:
1. To explain initial mechanisms of X-radiation interaction with a substance.	1. To know the mechanisms underlying the interaction of X-radiation with a substance.
2. To understand main directions of X-radiation application in medicine.	2. To understand physical basics of medical methods applying X-radiation.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.

2. After the test problems on the topic are solved. Main theoretic questions are considered in form of an oral inquiry according to the following plan:

- Ionization. Types of ionizing radiations.
- Deceleration and characteristics radiation.
- X-ray tubes.
- Mechanisms and laws of interaction of X-radiation with a substance.
- Protection from X-radiation.
- Application of X-radiation in medicine.

3. At the end of the lesson the work is summarized, marks, received by the students during the lesson, are announced and task for the next time is given.

MODULE 3.

THEMATIC MODULE 8.

THEME 24. **Radioactivity. Ionizing radiations and their dosimetry. Elements of radiobiology.**

IMPORTANCE OF THE THEME: Due to wide use of ionizing radiation in medicine, it is necessart to study the particular features of radiobiological damages, dosimetric characteristics and allowable exposure rate, measurement and application of ionizing radiations.

Objective (general): To know main types of ionizing radiation, the methods of measuring them and use of ionizing radiation in medicine.

Specific objectives:	The result knowledge and skills level:
1. To consider main types of ionizing radiation.	1. To know main types of ionizing radiation.
2. To study the law of radioactive decay/disintegration.	2. To learn the mechanisms of the emerging of ionizing radiations.
3. To learn the mechanisms of ionizing radiation interaction with a substance	3. To know how to interpret the law of radioactive decay/disintegration.
4. To learn quantity characteristics of the effect of ionizing radiation on biological objects.	4. To learn the mechanisms of ionizing radiation interaction with a substance/MATTER??.
5. To know the devices for registration and measurement of ionizing radiation characteristics.	5. To know quantity characteristics of the effect of ionizing radiations.
6. To explain biophysical basics of radiobiological processes.	6. To know the regulation of radiation exposure.
	7.To know the devices for registration and measurement of ionizing radiation characteristics.
	8. To consider application on ionizing radiation in medicine for diagnostics and therapy.

1. Students' knowledge on the topic is controlled at the beginning of the lesson in form of a written test.
2. After the test, problems on the topic are solved. Main theoretic questions are considered in form of oral inquiry according to the following plan:
   - Ionizing radiation and its classification.
   - Mechanisms of ionizing radiations (the flux of charged particles and γ- radiation) on the matter???
   - Numeric characteristics of flows of charged particles.
   - Radiobiological effects of radiation. The subject and objectives of dosimetry.
   - Doses, kinds of doses, units of their measurement.
   - Regulation of radiation exposure.
   - Detectors and dosimeters of ionizing radiations. Measuring radiation background with "Prypyat" radiometer.
   - Radionuclide diagnostics and therapy.
3. At the end of the lesson the work is summarized, marks, received by the students during the lesson, are announced and task for the next time is given.