Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Analytic Geometry/Аналитическая геометрия

Purpose of the course:

to provide students with foundations of analytic geometry that will help them to study advanced mathematical disciplines – differential equations, complex analysis, mathematical physics, functional analysis, analytical mechanics, theoretical physics, methods of optimal control, etc.

Tasks of the course:

- to provide students with theoretical knowledge and practical skills in geometry;

- to motivate students towards treatment of related mathematical disciplines;

- to equip students with skills to apply techniques of analytic geometry in physics and other natural sciences.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- definition of vectors and vector operations (dot, vector, and triple product), their properties;

- equations of straight lines, planes, conics, and second-order surfaces;

- properties of curves and second-order surfaces;

- properties of affine and orthogonal transformations of plane.

be able to:

- to apply vector algebra to solve geometric and physical problems;

- to solve geometric problems by the coordinate method, use linear transformations to solve geometric problems;

- to perform matrix operations, to invert matrices, to compute determinants.

master:

- general concepts and definitions related to vectors: linear independence, basis, plane and space orientation;

- orthogonal and affine classification of lines and second-order surfaces.

Content of the course (training module), structured by topics (sections):

1. Straight line and plane in space

1.1. A line in space. Vector and coordinate equations of a line in space. A plane in space. Types of equations of a plane in space. Positional and metric problems of lines and planes in space. Transition from one form of line or plane equation in space to another. Bundle of lines. Bundle of planes and sheaf of planes. Linear inequalities.

2. Lines and surfaces of the second order

2.1. Coordinate equations of lines in plane and surfaces in space. Algebraic lines and surfaces. Invariance of order of algebraic curves in plane under linear changes of variables. Coordinate equations of curves in space. Invariance of order of algebraic curves and surfaces in space under linear changes of variables. Coordinate equations of some geometrical objects in plane and bodies in space.

2.2. Conics in plane and their orthogonal classification. Reduction of a conic equation to a standard form. Center lines. Conjugate diameters. Asymptotic direction. Invariants.

2.3. Ellipse, hyperbola, and parabola. Their properties. Tangents to an ellipse, a hyperbola, and a parabola. Equations of an ellipse, a hyperbola, and a parabola in the polar coordinate system.

2.4. Ellipsoids, hyperboloids, and paraboloids. Their basic properties. Rectilinear generators. Cylinders and cones. Surfaces of revolution. Classification and standard equations of second-order algebraic surfaces.

3. Convert the plane

3.1. Mappings and transformations of the plane. Composition of mappings. Inverse mapping. One-to-one mapping. Linear transformations of the plane and their properties. The coordinate representation of linear transformations of the plane.

3.2. Affine transformations and their geometric properties. The main directions of an affine transformation. Geometric meaning of the modulus and the sign of the determinant of an affine transformation matrix. Affine classification of conics in plane.

4. n-th order determinant

Definition and basic properties of determinants. Minors and cofactors. Cofactor expansion of a determinant along a row or a column. Determinant of matrix product.

5. Matrixes

Multiplication and inversion of matrices. Orthogonal matrices. Elementary row operations on matrices. Representation of row operations as multiplication by specific matrices.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Applied Physical Education (Optional Sports)/Прикладная физическая культура (виды спорта по выбору)

Purpose of the course:

To form a worldview system of practical knowledge and attitude to physical culture.

Tasks of the course:

- To form an understanding of the social role of physical culture in the development of personality and its preparation for professional activities;

- to form the knowledge of the scientific, biological and practical foundations of physical education and a healthy lifestyle;

- to form a motivational-value attitude to physical culture, the attitude towards a healthy lifestyle, physical self-improvement and self-education, the need for regular exercise and sports.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

Scientific, practical and special foundations necessary for understanding the natural and social processes of the functioning of the physical culture of society and the individual, the ability to adapt and creatively use them for personal and professional development, self-improvement, and organizing a healthy lifestyle when performing educational, professional and sociocultural activities. Understand the role of physical culture in human development and specialist training.

be able to:

Use physical culture and sports activities to enhance their functional and motor capabilities, to achieve personal life and professional goals.

master:

A system of practical skills ensuring the preservation and strengthening of health, the development and improvement of psychophysical abilities and qualities (with the implementation of established standards for general physical and sports-technical training).

Content of the course (training module), structured by topics (sections):

1. General physical preparation

Education of physical qualities.

2. General physical preparation

Education of physical qualities.

3. General physical preparation

Education of physical qualities.

4. General physical preparation

Education of physical qualities.

5. General physical preparation

Education of physical qualities.

6. Special physical preparation

Special physical training

7. Special physical preparation

Special physical training

8. Special physical preparation

Special physical training

9. Special physical preparation

Special physical training

10. Special physical preparation

Special physical training

11. Professional and applied physical preparation

PROFESSIONAL'NO-PRIKLADNAYA FIZICHESKAYA PODGOTOVKA

12. Professional and applied physical preparation

PROFESSIONAL APPLIED PHYSICAL TRAINING

13. Professional and applied physical preparation

PROFESSIONAL APPLIED PHYSICAL TRAINING

14. Professional and applied physical preparation

PROFESSIONAL APPLIED PHYSICAL TRAINING

15. Professional and applied physical preparation

PROFESSIONAL APPLIED PHYSICAL TRAINING

16. Theoretical preparation

The material of the section provides for students to master the system of scientific, practical and special knowledge necessary to understand the natural and social processes of the functioning of the physical culture of society and the individual, their adaptive, creative use for personal and professional development, self-improvement, and the organization of a healthy lifestyle when performing educational, professional and socio-cultural activities.

17. Theoretical preparation

The material of the section provides for students to master the system of scientific, practical and special knowledge necessary to understand the natural and social processes of the functioning of the physical culture of society and the individual, their adaptive, creative use for personal and professional development, self-improvement, and the organization of a healthy lifestyle when performing educational, professional and socio-cultural activities.

18. Theoretical preparation

The material of the section provides for students to master the system of scientific, practical and special knowledge necessary to understand the natural and social processes of the functioning of the physical culture of society and the individual, their adaptive, creative use for personal and professional development, self-improvement, and the organization of a healthy lifestyle when performing educational, professional and socio-cultural activities.

19. Theoretical preparation

The material of the section provides for students to master the system of scientific, practical and special knowledge necessary to understand the natural and social processes of the functioning of the physical culture of society and the individual, their adaptive, creative use for personal and professional development, self-improvement, and the organization of a healthy lifestyle when performing educational, professional and socio-cultural activities.

20. Theoretical preparation

The material of the section provides for students to master the system of scientific, practical and special knowledge necessary to understand the natural and social processes of the functioning of the physical culture of society and the individual, their adaptive, creative use for personal and professional development, self-improvement, and the organization of a healthy lifestyle when performing educational, professional and socio-cultural activities.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Bioinformatics&System Biology/Биоинформатика и системная биология

Purpose of the course:

acquisition of practical skills in data analysis of proteomic and genomic experiments to build system models of biological processes.

Tasks of the course:

• mastering by students of basic means of analysis of genomic, structural and other biological information;

• application of bioinformatics methods to obtain new knowledge in the field of living systems;

• providing advice and assistance to students in conducting their own theoretical and experimental research in the field of bioinformatics.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

 fundamental'nyye ponyatiya, zakony, teorii postgenomnoy biologii;

 zadachi bioinformaticheskogo analiza i yego svyaz' s drugimi naukami;

 printsipy raboty sovremennykh baz dannykh po strukture genomov, belkov i drugoy biologicheskoy informatsii.

 fundamental concepts, laws, theories of post-genomic biology;

 tasks of bioinformatics analysis and its relationship with other sciences;

 operating principles of modern databases on the structure of genomes, proteins and other biological information.

be able to:

 to abstract from the irrelevant when modeling real biological processes;

 use your knowledge to solve fundamental and applied problems of post-genomic biology;

 create computer programs used in bioengineering and bioinformatics, and independently master new resources (databases and programs) and experimental methods;

 make qualitative conclusions when going to the limiting conditions in the studied problems;

 master new subject areas, theoretical approaches and experimental methods;

 to determine the relevance of goals and objectives and the practical significance of the research;

 to analyze the results and methodological experience of research in relation to the general fundamental problem in the chosen area;

 work on modern, including unique, computing equipment;

 effectively use information technology and computer technology to achieve the necessary theoretical and applied results.

master:

 skills of mastering a large amount of information;

 skills of independent work on the Internet;

 culture of modeling biological tasks;

 skills of competent processing of experience results and comparison with theoretical data;

 practice of research and solution of theoretical and applied problems of molecular medicine;

 the skills of theoretical analysis of the problems of genomics, transcriptomics, proteomics and metabolomics associated with the study of the properties of biological systems at the molecular and subcellular levels of structural organization.

Content of the course (training module), structured by topics (sections):

1. Assembly of genomes de novo

Assembler programs. Difference in assembly algorithms for short and long DNA reads.

2. Bioinformatic analysis of mass spectrometric information in proteomics

Comparison of genetic and protein sequences. Alignment methods: pair and multiple, local and global. Needleman-Wunsh global alignment algorithm. Smith-Waterman local alignment algorithm. Gibbs sampling.

3. Introduction to Bioinformatics

The history of the development of computer processing of biological data. The definition of bioinformatics. Basic concepts. General understanding of the tasks of bioinformatics analysis and its relationship with other sciences. Areas of use.

4. Visualization of experimental data in post-genomic biology

Visualization of biological experiment data. Visualization software.

5. Genomics

Definition of genomics. Structural and functional genomics. Common sequencing technologies and result formats. Software: Bowtie, samtools, MUMmer.

6. Genomic mapping

Single nucleotide polymorphisms and methods for their detection. Search for genomic translocations. Search for repetitions, complementarities and symmetries in sequences.

7. Transcriptomic data processing

Methods for recognizing promoters. Build sequences. Mapping sites of transcription start.

8. Presentation of genomic information

Sequencing Result Formats. Recognition of structural and functional motives in genetic texts. Consensus concept, weight matrix. Assessment of recognition accuracy.

9. Proteomics

Algorithms for identification of proteins by mass spectra. Proteomic analysis software packages.

10. Statistical analysis of genomic, proteomic and transcriptome data

Statistical analysis of genomic, proteomic and transcriptome data.

11. Technologies for reading biological texts

Methods for determining the DNA sequence. New generation sequencers. High throughput DNA sequencing approaches.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Bioorganic Chemistry/Биоорганическая химия

Purpose of the course:

study of the basics of modern biological chemistry (with elements of organic chemistry and molecular biology), preparing students to learn other courses of biological profile.

Tasks of the course:

- students ' acquisition of basic knowledge in the field of biological chemistry;

- acquisition of theoretical knowledge in the field of studying the most important processes of biological metabolism in a living cell, coordination and regulation of this exchange, and coupling of metabolic cycles;

- providing advice and assistance to students in the areas of molecular biology and biochemistry that are necessary for the implementation of their own theoretical and practical work;

- formation of students' skills of independent work with special scientific literature of biological orientation.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- fundamental concepts, laws, and theories of classical and modern biological chemistry;

- numerical values characteristic to structure of biomolecules;

- structures and functions of the main metabolites of energy and plastic metabolism of the cell;

- modern problems of biochemistry;

- modern approaches used in practical biology (biotechnology);

- experimental foundations of biological chemistry.

be able to:

- to relate the processes occurring in the living cell, with physical and chemical processes;

- navigate the structural formulas of the main components of the cell (carbohydrates, including polysaccharides, amino acids, proteins, nucleotides, nucleosides, nucleic acids (DNA, RNA), lipids, vitamins, steroid hormones);

- apply the obtained theoretical knowledge about experimental approaches in biological chemistry to solve specific experimental problems;

- use your knowledge to solve fundamental and applied problems and technological problems;

- draw correct conclusions from comparing the results of theory and experiment;

- make numerical order of magnitude estimates;

- make qualitative conclusions when moving to the limit conditions in the studied problems;

- recognise biochemical content of biological problems;

- develop new subject areas, theoretical approaches, and experimental techniques;

- get the best estimates of the measured values and correctly assess their reliability;

- work on modern, including unique, experimental equipment;

- effectively use information technology and computer technology to achieve the necessary theoretical and applied results.

master:

- skills to master a large amount of information;

- skills of independent work in the laboratory and on the Internet;

- culture of setting and modeling biological problems;

- skills for the proper processing of the results of the experiment and comparison with theoretical data;

- practice of research and solving theoretical and applied problems.

Content of the course (training module), structured by topics (sections):

1. Water as a solvent. Acid / base properties of biomolecules.

Water as a universal medium in biochemistry. Electrolytes and non-electrolytes, electrolytic dissociation, acid-base concepts. Acid/base properties of biomolecules.

2. Structure and properties of biologic molecules: amino acids, carbohydrates, fatty acids, nucleic acids.

The possibility of biological catalysis by proteins due to the presence of ordered self-organizing structures and a wide choice of functional groups (amino acid radicals).

The most important representatives of the class of carbohydrates (monosaccharides, disaccharides). Reducing and non-reducing sugars. Ring-chain tautomerism, optical isomerism of

sugars. Polysaccharides. Structural role of carbohydrate components of the cell. Energy metabolites based on phosphoric esters of glucose and fructose. The main reactions of carbohydrates: polycondensation and hydrolysis.

Basic structural and functional characteristics of nucleic acids. The main classes of nucleic acids found in the cell: DNA and RNA. Subclasses of nucleic acids. Nucleotides and nucleosides. Macroergic compounds as a single energy currency of the cell. Structures of nucleic acids in the cell, and interactions that stabilize them (hydrogen bonds, stacking interactions).

3. Protein structure and function.

Protein structure and function. Levels of structural complexity, analysis of protein structure, model proteins (hemoglobin/myoglobin).

The primary structure of a protein is its unique sequence of amino acids. Secondary structure, found in most proteins, consists of coils and folds in the polypeptide chain. Tertiary structure is determined by interactions among various side chains (R groups). Quaternary structure results when a protein consists of multiple polypeptide chains. Denaturation by pH, salt concentration, temperature, or other environmental factors.

Chaperonins. Diseases associated with misfolded proteins: Alzheimer's, Parkinson's, and mad cow diseases.

Main functions of proteins: structure (collagen, keratin - instead of cellulose in plants), catalysis (all enzymes except ribozymes), movement (motor and contractile proteins - actin, myosin, etc.),

transport (ion channels, transmembrane transporters, hemoglobin), hormones (insulin, erythropoetin, HGF), protection (antibodies, complement, fibrin), storage (casein, ovalbumin, transferrin), regulation (gene expression control). Important protein properties: UV light absorption, salting in/out, pH-dependent conformation. Sickle-Cell Disease: A Change in Primary Structure. Hemoglobin affinity to oxygen is dramatically reduced in acidic tissues. Bohr's effect.

4. Enzymes. Cell energetics.

Enzymes. Cell energetics. Biologic catalysts, active site properties. kinetics, inhibition and regulation. Cellular regulatory strategies.

The possibility of biological catalysis by proteins due to the presence of ordered self-organizing structures and a wide choice of functional groups (amino acid radicals). The concept of an enzyme as a catalyst of protein nature. The main classes of enzymes and the reactions they catalyze. Thermodynamics of enzymatic catalysis. Kinetics of enzymatic reactions, research methods, activators and inhibitors of enzymes. Molecular mechanism of action of enzymes on the example of urease. Protein denaturation, the effect of pH, ionic strength, and temperature on the activity and specificity of enzymatic reactions. Catalytic antibodies (abzymes). Enzymes of non-protein origin (ribozymes, telomerases). Coenzymes and vitamins.

5. Membranes and intracellular signal transduction.

Membranes and intracellular signal transduction. Membrane structure and composition, membrane transport

Basic lipids of biological membranes. Structure and composition of membranes. Interaction of proteins with membranes. Glycoproteins. Structure of the bacterial cell wall. Transmembrane proteins, their synthesis, folding and functions. Covalent interactions of membrane proteins with

the membrane. Posttranslational modification. The microphysics of membrane: viscosity, fluidity, asymmetry of the leaves. Membrane rafts. Receptor-induced and spontaneous endocytosis. Cell adhesion molecules. NO as a mediator. Diffusion through membranes: passive, lightweight, energy-dependent. Ion channel. Sodium-potassium ATPase and the occurrence of transmembrane ion potentials. Transporter proteins. Models of channel operation.

6. Glycolysis and pyruvate oxidation.

Glycolysis and pyruvate oxidation. Regulation, interface with other pathways, medical significance. Fermentations.

Fermentation type of carbohydrate metabolism. The ability to extract energy by anaerobic metabolism of substrates. Glycolysis as the basic way of glucose processing. Types of fermentation (homofermentative, heterofermentative), the main metabolites of the glycolytic pathway. Pyruvic acid as a donor of the C2 fragment, an acetyl derivative of coenzyme A. Further cleavage of acetyl-COA via the aerobic pathway.

7. Citric acid cycle, oxidative phosphorylation.

Citric acid cycle, electron transport chain, oxidative phosphorylation. Respiration. Regulation, interface with other pathways, medical significance.

Tricarboxylic acid cycle. TCA intermediates as raw materials for the synthesis of amino acids. ATP production by the cell during respiration. The role of reduced coenzymes (NADH, NADPH, FADH2) obtained in TCA. Electron transport chain. Conversion of the energy of the electrochemical gradient of protons into the energy of ATP.

8. Gluconeogenesis, glycogen metabolism.

Gluconeogenesis, glycogen metabolism. Regulation, interface with other pathways, medical significance. Minor carbohydrates (ribose, fructose, galactose).

9. Fatty acid and triglyceride metabolism.

Fatty acid and triglyceride metabolism. Fatty acid metabolism, mobilization and oxidation. Steroids and other lipids and lipid-related compounds.

10. Amino acid metabolism.

Amino acid metabolism. Ammonium production and urea cycle. Amino acid degradation and biosynthesis. Clinical significance of amino acid and related metabolism.

11. Integration of carbohydrate, lipid and amino acid/protein metabolism.

The need to coordinate metabolic processes in the cell. Integration of carbohydrate, lipid and amino acid/protein metabolism. Hormonal regulation: insuline, glucagone, epinephrine, glucocorticoids. Well-fed/fasting tarvation states, an overview of model metabolic disease – type 1 diabetes

Ways to synchronize metabolic processes in prokaryotic cells.

12. Purine/pyrimidine metabolism.

Purine/pyrimidine metabolism. Organisation, synthesis and repair of DNA. Recombinant DNA.

Purine synthesis. 5-Phosphoribosyl-1-Pyrophosphate Synthesis, Phosphoribosylamine Synthesis.

Production of AMP and GMP from a Common IMP Precursor. Purine Salvage.

Degradation of purines to uric acid. Pyrimidine synthesis.

Synthesis of Pyrimidine Nucleotides from Orotate. Pyrimidine Salvage.

Deoxyribonucleotide synthesis. Nucleotide phosphate interconversion.

Diseases related to nucleotide metabilism.

Lesch-Nyhan Syndrome. Adenosine Deaminase Deficiency.

13. RNA transcription and control of gene expression.

The Central dogma of molecular biology. The main vector of information, regulation of the process of gene expression. messenger rna. Synthesis and processing of mRNA as a way to regulate the number and composition of proteins synthesized by the cell. Promoters and their mechanism of action. Modular organization of prokaryotic RNA polymerases. Sigma factors, and other transcription factors. Attenuated promoters on the example of a tryptophan operon promoter. Enhancers of transcription. The operon hypothesis of Jacob and Mono. Differences in biology of the gene in prokaryotes and eukaryotes. Monocistronic and polycistronic organization. Mechanism of regulation of lactose operon genes. Antisense RNAs, the ability to control gene expression through RNA interference. Methods for analyzing gene expression, transcriptomics. Creating and applying libraries to DNA.

14. Protein synthesis and degradation. The genetic code, mutations.

Protein synthesis and degradation. The genetic code, mutations.

Protein molecules as effectors of genetic information. Implementation of three-dimensional structures based on information encoded by one-dimensional nucleic acids. Factors necessary for protein synthesis. Transport RNAS. Genetic code, its discovery, basic properties, and physical implementation of triplet code decoding. Ribosomes. Factors of protein synthesis. Protein processing and folding. Modular evolution of proteins. Antibiotics that affect translation. Posttranslational modification.

15. Nutrition and tissue biochemistry.

Nutrition and tissue biochemistry. Energy and matter requirements. Digestion, absorption. Nitrogen balance and essential amino acids. Micronutrients: vitamins, minerals, electrolytes, trace elements. Muscle contraction, blood clotting, liver metabolism of xenobiotics and ethanol.

16. General properties of aminoacids and proteins.

Laboratory work on the topic "General properties of aminoacids and proteins."

17. Methods of study of proteins.

Laboratory work on the topic "methods of protein research".

18. Separation of proteins.

Laboratoty work "Separation of proteins".

19. Enzimes and enzymatic kinetics.

Laboratory work on topic "Enzimes and enzymatic kinetics".

20. Methods for investiation of nucleic acids.

Laboratory work on topic "Methods for investiation of nucleic acids."

21. Carbohydrates.

Laboratory work on the topic "Carbohydrates".

22. Lipids.

Laboratory work on the topic "Lipids".

23. Glycolysis and the tricarboxylic acid cycle. Biological oxidation.

Laboratory work on the topic "Glycolysis and the tricarboxylic acid cycle. Biological oxidation".

24. Metabolism of nitrogenous compounds.

Laboratory work on the topic "Metabolism of nitrogenous compounds".

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Biostatistics/Биостатистика

Purpose of the course:

Give an idea of the mechanisms of the implementation of genetic information, biostatistics and practical skills in applying bioinformatics and statistical methods for analyzing and interpreting biological data.

Tasks of the course:

• give an idea of the basic methods of statistical analysis of biological data;

• make students familiar with modern understanding of statistical populational studies;

• teach how to use the main databases in the field;

• introduce basic algorithms and data formats for statistical genetics and biostatistics.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- the main methods of assessing statistical significance;

- methods for allowing for the multiplicity of comparisons;

- Meta-analysis methods;

- statistical characteristics of associative tests;

- ROC analysis;

- methods for assessing heritability and genetic risks;

- methods for reducing the number of variables when analyzing large data arrays;

- data classification methods;

- The basics of Bayesian data analysis.

be able to:

- use the Internet and reference books on scientific and applied biostatistics character to quickly find the necessary data and concepts;

- compare statistical processing methods and adequately evaluate them applicability;

- apply basic methods of biostatistics in scientific research;

- apply basic methods of biostatistics when working in the laboratory.

master:

- of conducting large scale data arrays;

- of computer analysis of the statistical significance of the results of genetic and medical/biological experiments.

Content of the course (training module), structured by topics (sections):

1. Biological data structure and descriptive statistics

File organization and data management in EXCEL, SPSS and STATISTICA. Descriptive statistics. Some tricks of fast statistical calculations. Statistical hypothesis testing. Exact and Mediated Criteria. I and II type eroors. Multiple comparison testing. Type I error control. Grouping and Simpson's Paradox. Parametric and non-parametric comparison criteria. Variance analysis.

2. Conjugacy analysis

Regression analysis. Residual analysis. Partial correlations and confounders. Contingency analysis of qualitative features. Odds ratio and relative risk. Biomarker statistics. Estimates of the test sensitivity and specificity. ROC analysis.

3. Multidimensional methods

Multiple regression analysis. Methods to reduce the number of predictors. Friedman paradox. Estimates of heritability and genetic risk. The “missing heritability” problem. Factor analysis. The principal component method. Classification methods. Cluster analysis. Discriminant analysis.

4. Bayesian statistics

Limitation of p-values. Reproducibility of experimental results. Bayesian factor. Priors. Statistics in epidemiology. Analysis of large samples. Bayesian frequency estimates of rare events.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Cellular Biology/Клеточная биология

Purpose of the course:

to acquaint students with the achievements of the last decade in the study of the functioning of the eukaryotic cell to provide an interface between information and biological sciences.

Tasks of the course:

• formation of basic knowledge about the biology of the eukaryotic cell;

• practical mastering by students of basic concepts used in modern cell biology;

• formation of students' basic skills in data retrieval and analytical processing of material for conducting independent research in the field of cell biology and genetics.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- the structure of eukaryotic cells - organelles and their functions;

- cell division, mitosis and meiosis, karyotype, chromosomal abnormalities. The cell cycle and its regulation in normal and tumor cells. Fundamentals of Embryology;

- the structure of the cell nucleus. Chromatin, chromatin packing. Epigenetic modifications of proteins and DNA;

- cell cultures as a model system for cell biology. The concept of stem cells Pluripotent and multipotent stem cells;

- the concept of modern omics technologies.

be able to:

- to use the literature and find the necessary information on cell biology.

master:

- categories and concepts used in cell biology;

- ideas about modern methods used in the study of cells;

- ideas about methods requiring bioinformatics analysis in cell biology.

Content of the course (training module), structured by topics (sections):

1. Introduction to Cell Biology

Prokaryotes and eukaryotes. The structure of the eukaryotic cell. Organnellas and their functions. Cell nucleus. Cell division. Mitosis and meiosis. Karyotype and chromosomal abnormalities.

2. Introduction to Embryology. Stem cells concept. Epigenetics

Early embryogenesis and its stages. Genes that determine embryonic development and tissue specialization. The concept of epigenetics, chromatin, epigenetic modifications of histones and DNA. Ways to study them.

3. Genetic and epigenetic features of reprogrammed somatic cells

Genetic and epigenetic features of reprogrammed somatic cells and methods for their analysis.

4. The use of reprogramming technology to study the mechanisms of diseases and the search for new methods of therapy. Using bioinformatics methods to develop criteria for reprogramming

Modeling of diseases in vitro, correction of mutations using TALEN and CRISPR / CAS systems. Directed differentiation problems for disease modeling. The use of bioinformatic methods for the development of criteria for reprogramming.

5. Cell reprogramming. Induced pluripotent cells

Pluripotency transcription factors. Reprogramming to a pluripotent state - methods, methods of analysis, significance for biomedicine. Direct Reprogramming and the Epigenetic Landscape.

6. Embryonic stem cells. Genetic knockout technology.

Cell culture. Methods for the genetic modification of organisms. Transgenesis. Nucleus transfer, genetic knockout. The concept of pluripotency.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

English I/Английский язык I

Purpose of the course:

the formation and development of intercultural, professionally-oriented communicative competence at the B2/C1 level on the Pan-European scale of foreign language proficiency levels for solving communicative tasks in the sociocultural, academic and professional-business areas, as well as developing professional and personal qualities of bachelor graduates.

Tasks of the course:

- linguistic competence: the ability to understand the speech of other people and express their own thoughts based on knowledge of the language system;

- socio-cultural competence: the ability to take into account in communication speech and nonverbal behavior adopted in the country of the language being studied;

- social competence: the ability to interact with communication partners, working knowledge of relevant strategies;

- discursive competence: knowledge of the rules for constructing of oral and written discourse messages, the ability to build such messages and understand their meaning in the speech of other people;

- strategic competence: the ability to use the most effective strategies in solving communication tasks;

- subject competence: knowledge of subject information in organizing one's own utterance or understanding the utterance of other people;

- compensatory competence: the ability to overcome the communication barrier through the use of well-known speech and meta-language means;

- pragmatic competence: the ability to choose the most effective and expedient way of expressing thoughts, depending on the conditions of the communicative act and the task.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic facts, realities, names, attractions, traditions of English-speaking countries;

- achievements, discoveries, events in the field of history, culture, politics, social life of English-speaking countries;

- Basic phonetic, lexical and grammatical, stylistic features of the English language and its difference from the native language;

- main differences between written and oral speech;

- basic characteristics of the language of a particular area of professional training.

be able to:

- generate adequate, oral and written texts in a specific situation of communication;

- realize the communicative intention with the aim of influencing the communication partner;

- adequately understand and interpret the meaning and intention of the author in perception of oral and written authentic texts;

- identify similarities and differences in native and English language systems;

- show tolerance, empathy, openness and friendliness when communicating with representatives of another culture.

master:

- intercultural professionally oriented communicative competence in various types of speech activity at the B2/C1 level;

- sociocultural competence for successful mutual understanding in terms of communication with representatives of another culture;

- various communication strategies;

- learning strategies for organizing their learning activities;

- strategies of reflection and self-esteem in order to self-improve personal qualities and achievements;

- different methods of memorizing and structuring digestible material;

- Internet technologies to select the optimal mode of obtaining information;

- presentation technologies for providing information.

Content of the course (training module), structured by topics (sections):

1. Change

Human activity and its changes in history. The main trends in doing business. Comparison of life yesterday and today.

Communicative tasks: describe and compare life styles in the 20th and 21st centuries from the point of view of: transport, communication, work, study, prepare a mini-presentation on changes

in the proposed company's work in modern business realities, discuss the main trends in the modernization and development of the city or countries, practice taking notes while reading the text, develop skills for transmitting graphic information in oral and written form.

Vocabulary: phrases, idioms that describe the time, terms used in the management of personal vocabulary, competent work with existing Internet sources to determine the necessary meaning of the searched word, speech cliches typical for describing graphics, histograms, working with phrasal verbs, determining the correct and necessary word meanings in the dictionary.

Grammar: ways and types of comparison of adjectives and adverbs, Continuous forms.

Writing: write a report on population growth in the three proposed countries based on graphs.

EAP (English for Academic Purposes): the use of adverbs, introductory constructions in a scientific and technical text.

2. Feats

Interesting and unusual creatures from the wild. Engineering achievements of the past and present. Informal messages on the topics of everyday life: relocation, successful career, maintaining the balance of work and personal life, acquisitions.

Communicative tasks: use adverbial expressions to describe unusual things in nature, conduct partner interviews on the subject of engineering achievements, determine the level of complexity of proposed communicative situations: a lecture, informal communication, participate in a formal conversation, be able to take notes while listening to an authentic text, discuss what was heard with a partner, briefly report personal achievements based on the vocabulary learned.

Vocabulary: collocations, speech clichés used to describe problems and ways to solve them, work with a dictionary and Internet resources to choose the right word in a phrase, phrases used in conducting interviews, surveys or interviews.

Grammar: noun phrases, phrases with adverbs, Perfect forms.

Writing: write a summary of what you have heard, be able to combine and summarize a concise message about information in the audition and the text.

EAP (English for Academic Purposes): the use of text-phrases, for-phrases in a scientific text.

3. Team

Discussion of human behavior in the proposed situations. Various ways of expressing attitudes towards circumstances and problems. Success and failure in work and personal life.

Communicative tasks: use idioms/phrases with fixed prepositions, discuss in pairs or mini-groups achievements in work and/or study, use auxiliary verbs with correct intonation to strengthen the statement, interview the partner on topics related to work, successes and failures.

Vocabulary: collocations used to describe success and failure, phrasal verbs synonymous in meaning of academic English verbs, associative correlation of synonyms based on context and without using a dictionary, definition of the phrase/collocation value, modified by the preposition used.

Grammar: auxiliary verbs for constructing interrogative/negative sentences and for affirmative sentences in order to strengthen the utterance.

Writing: write a proposal to improve the work of the company.

EAP (English for Academic Purposes): the use of complex sentences in a scientific and technical text.

4. Power

The power of individuals in society. The power and influence of natural phenomena on human activity. Dependence on the Internet, Internet technologies. The contribution of information technology in the development of human activities.

Communicative tasks: describe the advantages and disadvantages of urbanization, using the words and expressions proposed by the TMC (training and methodology complex) for quantitative and qualitative characteristics, use compound adjectives and nouns and then incorporate them into a discussion of statements in pairs and small groups, be able to have a conversation with a partner with the consent, disagreement, contradictions, outrage, resentment and other emotions.

Vocabulary: phrases that indicate the correct use of a union in a complex sentence, expressions with the preposition of for expressing the amount/number of something omeone, compound adjectives and nouns for describing innovation on the Internet.

Grammar: subordinate clauses in a series of complex sentences, quantifiers, emphasis.

Writing: write a forum post on the proposed topics with the obligatory use of the active grammar section.

EAP (English for Academic Purposes): the use of relative subordinates in a scientific and technical text.

5. Emotion and Reason

Discussion of emotions. Suggestion of hypotheses. Reaction to events. The use of linking words and constructions in the text or statement. Metaphorical description of events in academic English.

Communicative tasks: express probability in the past, present and future, make statements using adjectives and participles that describe the emotional coloring of the statement, be able to operate with speech cliches for an instant, as well as deliberate reaction to events, statements, analyze and understand metaphorical constructions.

Vocabulary: a set of phrases to participate in official negotiations on topics related to business, study and work, adverbs that support the statement of both negative and positive phrasal verbs, often used in the description of mental activity and emotional expressions.

Grammar: an expression of unreality, linkers.

Writing: write paragraphs for a website that present recommendations in difficult life situations.

EAP (English for Academic Purposes): the use of linkers in a scientific and technical text.

6. Plastic

Description of the properties of materials. Proper use of academic and spoken language, depending on the situation. The ability to concentrate on the main thing in listening. The reasoning, comparison and comparison of facts and details.

Communicative tasks: discuss differences in medicine, clothing and households in the past and present, talk with a partner using phrasal verbs, speculate with a partner about the importance of body language in a public speech, identify differences in the expression of probability and possibility.

Vocabulary: adjectives, describing the properties of materials, phrasal verbs to describe past habits, various colocations, characteristic of the spoken language, applicable in academic.

Grammar: participle clauses.

Writing: write a problem-solution essay.

EAP (English for Academic Purposes): the use of participles in scientific and technical texts.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Foundations of Programming I/Основы программирования I

Purpose of the course:

to give learners knowlege and experience of using Python programming language for solving numerical calculations tasks.

Tasks of the course:

• Statement of the basic principles of programming, their main applications in modern programming;

• Providing the student with guidelines for further independent study of individual issues in specialized sections of mathematical logic and programming.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• the role of programming in solving scientific problems;

• basic algorithms with their asymptotic complexity;

• simple part of Python language syntax.

be able to:

• develop software applications for solving tasks in a programming language;

• develop algorithms for solving programming problems.

master:

• to install development environment of Python;

• to use the set of programming tools for Python language;

• skill of coding given algorith on Python language.

Content of the course (training module), structured by topics (sections):

1. Programming Basics

Computer Architecture Fundamentals.

Algebra of logic and its connection with set theory.

Logic gates as digital elements of a computer.

The internal structure of the computer: CPU, RAM, motherboard, peripherals.

Operating system and applied computing processes.

What is an algorithm, its relationship with the executor and the programming language.

Python interpreter as a calculator:

Number types: integers, floating point, fractions, decimals, complex.

Mastering Python syntax with the Turtle:

loops, nested loops, decomposition into functions, variables, vector geometry.

2. Integer processing

Processing a sequence of numbers.

Working with text files.

Number systems.

Filtering the stream of numbers.

Statistical processing of the stream in one pass.

Integers and integer arithmetic.

Euclid's Algorithm.

Multiplicative group of integers modulo n.

Binary operations with numbers.

3. Arrays of numbers

Array filling tasks.

Element-wise copying of an array. Copying back and forth. Reverse an array.

Cyclic shift in the array.

Sieve of Eratosthenes.

Frequency analysis (counting method).

4. Recursion and combinatorics

Recursion.

The problem of the Hanoi towers.

Recursive numeric functions: factorial, fast exponentiation

Permutations, placement, combinations.

Generation of combinatorial objects by recursion.

The itertools library and iterables.

Iterable objects.

5. Dynamic programming

One-dimensional dynamic programming.

Calculation of Fibonacci numbers and the problem of recalculations.

Recursion with caching using the example of Fibonacci numbers.

Grasshopper problems.

Dynamic programming for strings.

Prefix function. Knuth-Morris-Pratt algorithm.

2D dynamic programming.

Levenshtein distance and Hamming distance.

Calculation of the editorial distance.

Longest common subsequence.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Foundations of Programming II/Основы программирования II

Purpose of the course:

to give learners knowlege and experience of using Python programming language for solving numerical calculations tasks.

Tasks of the course:

• Statement of the basic principles of programming, their main applications in modern programming;

• Providing the student with guidelines for further independent study of individual issues in specialized sections of mathematical logic and programming.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• the role of programming in solving scientific problems;

• basic algorithms with their asymptotic complexity;

• simple part of Python language syntax.

be able to:

• develop software applications for solving tasks in a programming language;

• develop algorithms for solving programming problems.

master:

• to install development environment of Python;

• to use the set of programming tools for Python language;

• skill of coding given algorith on Python language;

• skills in the basics of object-oriented programming.

Content of the course (training module), structured by topics (sections):

1. Python standard data containers.

Work with text.

Symbol code, encoding and text transpoding

Sections of string

Search in a string with standard Python tools.

Regular expressions

Lists, arrays, cortices, named cortices.

Slices of lists and assignment in them.

Standard lists methods.

Sort by key.

Massives with a fixed data type.

NamedTuple container from the Collections library.

Tasks for the use of lists and tuples.

Sets and dictionaries

Frequency analysis with a dictionary.

Collections library.

2. Working with tabular data.

Numpy library arrays

Tabular data in Pandas.

3. Overview of data visualization libraries.

Building graphs and charts in MATPLOTLIB.

Seaborn library.

NetworkX library.

Graphs and trees.

Storage of the graph in the memory of the computer.

4. Practical techniques for work on the software product

Git version control system.

Design of software product.

Automatic testing of programs.

5. Object-oriented and functional programming

Functional programming.

Function as an object of the first kind. Unnamed lambda functions.

Deferred calculations. Generators as a convey.

Decorators. Modification of the behavior of functions.

Objects and classes.

Constructor. Special methods.

Functors.

Generation and exception processing.

Standard hierarchy of exception classes.

Creating your exceptions.

Context manager with.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Fourier Analysis/Фурье анализ

Purpose of the course:

the formation of systematic knowledge about the methods of mathematical analysis, the expansion and deepening of concepts such as function and series.

Tasks of the course:

• formation of students' theoretical knowledge and practical skills in the theory of trigonometric Fourier series and the principles of functional analysis;

• preparing students for the study of related mathematical disciplines;

• acquisition of skills in the application of methods of mathematical analysis in physics and other natural science disciplines.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic facts of the theory of trigonometric Fourier series of absolutely integrable functions: sufficient conditions for pointwise and uniform convergence;

- theorems on term-by-term integration and differentiation, order of decreasing coefficients, a theorem on the summation of Fourier series by the method of arithmetic means and its application;

- definition of convergence in metric and linear normed spaces, examples of complete and incomplete spaces;

- examples of complete systems in normed linear spaces;

- basic concepts of the theory of Fourier series in an orthonormal system in an infinite-dimensional Euclidean space;

- definition of proper and improper integrals depending on a parameter, their properties; theorems on continuity, differentiation and integration with respect to the parameter of improper integrals, their application to the calculation of integrals;

- a sufficient condition for the representation of a function by the Fourier integral;

- Fourier transform of an absolutely integrable function and its properties;

- basic concepts of the theory of generalized functions, the Fourier transform of generalized functions, its properties.

be able to:

- to expand functions in trigonometric Fourier series, to investigate it for uniform convergence, to determine the order of decreasing of Fourier coefficients;

- to investigate the completeness of systems in functional spaces;

- investigate the convergence and uniform convergence of improper integrals with a parameter, differentiate and integrate them with respect to the parameter;

- to represent functions by the Fourier integral; perform Fourier transforms;

- operate with generalized functions.

master:

- thinking, methods of proof of mathematical statements;

- skills of working with Fourier series and integrals in various forms;

- the skills of applying the studied theory in mathematical and physical applications;

- the ability to use the necessary literature to solve problems.

Content of the course (training module), structured by topics (sections):

1. Summation of Fourier series by the method of arithmetic means.

Riemann's lemma. Trigonometric Fourier series for absolutely integrable functions, the tendency of their coefficients to zero. Representation of the partial sum of the Fourier series by an integral in terms of the Dirichlet kernel. Localization principle. Dini and Lipschitz tests for convergence of Fourier series, consequences of the Lipschitz test. Uniform convergence of Fourier series. Term-by-term integration and differentiation of Fourier series. Decreasing order of Fourier coefficients. Fourier series in complex form.

2. Metric and linear normed spaces.

Summation of Fourier series by the method of arithmetic means. Weierstrass' theorems on the approximation of continuous functions by trigonometric and algebraic polynomials.

3. Infinite-dimensional Euclidean spaces.

Metric and linear normed spaces. Convergence in metric spaces. Complete metric spaces, complete normed linear (Banach) spaces. Completeness of space Incompleteness of the space of continuous functions on an interval with integral norms. Comparison of norms: comparison of uniform convergence, convergence in mean and mean square. Complete systems in normed linear spaces.

4. Trigonometric Fourier series for functions absolutely square integrable.

Infinite-dimensional Euclidean spaces. Fourier series in the orthonormal system. Minimal property of Fourier coefficients, Bessel inequality. Parseval's equality. Orthonormal basis in infinite-dimensional Euclidean space. Hilbert spaces. A necessary and sufficient condition for a sequence of numbers to be a sequence of Fourier coefficients of an element of a Hilbert space with a fixed orthonormal basis. Relationship between the concepts of completeness and closedness of an orthonormal system.

5. Proper integrals and improper integrals.

Trigonometric Fourier series for functions that are absolutely square integrable. Completeness of the trigonometric system, Parseval's equality. Completeness of the system of Legendre polynomials.

6. Fourier integral.

Eigen integrals depending on a parameter and their properties. Improper integrals depending on a parameter; uniform convergence. Cauchy criterion for uniform convergence, Weierstrass test. Dirichlet test. Continuity, differentiation and integration with respect to the parameter of improper integrals. Application of the theory of integrals depending on a parameter to the calculation of definite integrals. Dirichlet and Laplace integrals. Euler's integrals - gamma and beta functions.

7. The space of basic functions and the space of generalized functions.

Fourier integral. Representation of a function by the Fourier integral. Fourier transform of an absolutely integrable function and its properties: continuity, tending to zero at infinity. Conversion formulas. The Fourier transform of the derivative and the derivative of the Fourier transform.

8. Fourier transform of generalized functions.

Space of basic functions and space of generalized functions. Regular and singular generalized functions. Delta function. Multiplication of generalized by infinitely differentiable. Convergence in the space of generalized functions. Differentiation of generalized functions.

9. Trigonometric Fourier series for absolutely integrable functions.

Fourier transform of generalized functions. The Fourier transform of the derivative and the derivative of the Fourier transform.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Functions of One Complex Variable/Теория функций комплексного переменного

Purpose of the course:

• studying methods and mastering the apparatus for analyzing functions of a complex variable for their application in solving problems of mathematical physics, hydrodynamics, aerodynamics, etc.

Tasks of the course:

• study of the properties of regular functions, expansion of regular functions in a ring in the form of a sum of a Laurent series;

• the ability to investigate isolated singular points of a function and apply the theory of residues to calculate integrals, including improper integrals of functions of a real variable;

• possession of the method of conformal mappings when solving problems of equations of mathematical physics on a plane.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- Cauchy-Riemann conditions, Cauchy integral theorem, Cauchy integral formula;

- criteria for the regularity of functions: the Morer and Weierstrass theorems, the representation of a regular function given in an annulus as a sum of a Laurent series; types of isolated feature points;

- the concept of a deduction at an isolated singular point;

- Cauchy's theorem on the calculation of integrals in terms of the sum of residues;

- the concept of a regular branch of a multivalued function;

- the concept of conformal mapping, linear fractional functions and Zhukovsky functions;

- Riemann's theorem on the conformal equivalence of simply connected domains;

- the solution of the classical Dirichlet problem for the Laplace equation on the plane by the method of conformal mappings.

be able to:

- represent a regular function defined in a ring as the sum of a Laurent series;

- find and investigate isolated singular points of a function;

- apply the theory of residues to calculate integrals, including improper integrals of functions of a real variable;

- find functions that carry out conformal mapping of given areas;

- to apply the method of conformal mappings when solving the Dirichlet problem for the Laplace equation on the plane.

master:

- methods of complex analysis used in calculating integrals using residues;

- methods of complex analysis used in solving problems of hydrodynamics, aerodynamics, mathematical physics, etc.

Content of the course (training module), structured by topics (sections):

1. Elementary functions of a complex variable, their differentiability and integrability along a contour. Cauchy-Riemann conditions. Inverse function theorem. Multivalued functions. Main regular branches of functions. Integral Cauchy theorem. Integral Cauchy formula.

1.1. Complex numbers. Extended complex plane. Riemann sphere. Sequences and Rows. The concept of a function of a complex variable. Continuous functions.

1.2. Differentiation with respect to a complex variable. Cauchy - Riemann conditions. The concept of a function that is regular in a domain. Conjugate harmonic functions of two variables.

1.3. Elementary functions of a complex variable: power, rational, exponential and trigonometric, their properties. Inverse function theorem (non-degenerate case). The concept of a multivalued function and its regular branches. Main regular branches of multivalued functions.

1.4. Integration over a complex variable. Integral Cauchy theorem for regular functions (proof for the case of a piecewise smooth contour in a simply connected domain). Cauchy integral formula (Cauchy integral). Integral of Cauchy type, its regularity.

1.5. Antiderivative. A sufficient condition for the existence of an antiderivative. Formula of Newton - Leibniz. Morer's theorem.

1.6. Increment of the argument z along a smooth contour, its integral representation and properties. Increment of the argument of the function f (z) along a continuous contour and its properties. General view of regular branches of multivalued functions in a simply connected domain that does not contain zero. Existence conditions and general form of regular branches of multivalued functions.

2. Power series. Taylor series for a regular function. Laurent series for a regular function in a ring.

2.1. Power series, Abel's first theorem, radius and circle of convergence. Expansion in a power series of a function regular in a circle. Weierstrass theorems for uniformly converging series of regular functions.

2.2. Laurent series and its ring of convergence. Laurent series expansion of a function regular in an annulus, its uniqueness and Cauchy inequality for the coefficients of the Laurent series. Uniqueness theorem for regular functions.

3. Isolated singular points. Deductions. Calculation of integrals.

3.1. Isolated singular points of an unambiguous nature, their classification. Determination of the nature of the singular point by the main part of the Laurent series.

3.2. Deductions. Calculation of integrals using residues. Lemma Jordan.

4. Entire and meromorphic functions. Their properties. The concept of analytic continuation. Singular points of analytic functions. The principle of argument. Rouche's theorem.

4.1. Entire functions. Liouville's theorem. The theorems of Sokhotskii-Weierstrass and Picard (the latter without proof) for entire functions.

4.2. Meromorphic functions. Expansion of meromorphic functions into a finite sum of elementary fractions.

4.3. The concept of the analytic continuation of elements into each other using a finite chain of circles and along a contour, the equivalence of these concepts. Uniqueness of the analytic continuation. The concept of an analytic function and its Riemann surface. The monodromy theorem (without proof).

4.4. Singular points of analytic functions, branch points. The Cauchy-Hadamard theorem on the presence of a singular point on the boundary of the circle of convergence of a power series.

4.5. The principle of argument. Rouche's theorem. The main theorem of algebra.

5. Geometric principles of regular functions. Conformal mappings in the extended complex plane.

5.1. Openness lemma. The principle of preserving the area. Univalence and multi-sheet in small. The principle of maximum modulus of a regular function. Principle of maximum and minimum of a harmonic function. Schwarz's lemma.

5.2. The geometric meaning of the modulus and argument of the derivative. The concept of conformal mapping in the extended complex domain.

5.3. Fractional linear functions and their properties.

5.4. Conformal mappings using elementary functions. Zhukovsky function and its properties. Riemann's theorem on the conformal equivalence of simply connected domains and the principle of boundary correspondence (without proof).

5.5. Cut erasure theorem. Symmetry principle for conformal mappings.

6. The classical Dirichlet problem for the Laplace equation in the plane.

6.1. The classical Dirichlet problem for the Laplace equation. Uniqueness of the solution. Poisson's integral for a circle. Existence of a solution to the Dirichlet problem for the Laplace equation.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Fundamentals of Financial and Economic Analysis and Planning/Основы финансово-экономического анализа и планирования

Purpose of the course:

- to introduce students to the methods of financial calculations to improve their financial literacy;

– formation of skills for analyzing financial and economic problems at micro and macro levels;

– acquisition of skills for making informed economic decisions in the areas of life.

Tasks of the course:

As a result of studying the course, the student must:

- know the main results of the financial aspects of micro- and macroeconomic theory

– have the skills of economic modeling to make informed economic decisions.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- the key provisions of the sections of micro- and macroeconomic theory related to financial analysis, as well as to have an idea of the possibilities of applying the theory to analyze the financial and economic consequences of decisions made;

be able to:

Be able to: - to model and analyze situations using micro- and macroeconomic financial tools, as well as to interpret the results obtained;

master:

- the logic of economic analysis and approaches to solving financial and economic problems.

Content of the course (training module), structured by topics (sections):

1. The basics of an individual's financial literacy

Efficiency of investing available funds in the banking sector: deposits, interest rates. Alternative options for investing money (bonds, stocks, promissory notes). Discounting as a financial computing tool. The behavior of an individual in conditions of uncertainty. The task of forming an optimal investment portfolio. Insurance demand model. The utility function of the consumer. Constructing a utility function based on indifference curves. Examples of utility functions for basic preference types. Consumer choice. The task of maximizing utility under budget constraints. Demand functions. The concept of revealed preference. A weak axiom of revealed preferences.

2. Macroeconomic aspects of financial activity Modern financial markets.

Capital markets and money markets. Financial market instruments. Global financial centers and exchanges. The demand for money and the supply of money. Money supply (aggregates H0, M0, M1, M2, M3). Creation of deposits in the banking system. Money multiplier. Banks and the banking system. Banks in the era of globalization and the digital economy. The Central Bank and its functions. Instruments the influence of the state on the supply of money (operations on the open market, changes in the key interest rate, changes in the reserve rate). Current trends in financial markets: Bitcoins. Inflation: causes, its types and impact on the economy of consumption and the economy of development. Exchange rates: how they are formed and their impact on economic dynamics. The problem of capital outflow for the Russian Federation.

3. State regulation of the economy and finance GNP as the sum of incomes of economic entities.

State regulation of the economy and finance GNP as the sum of incomes of economic entities. Investments and savings. Budget deficit. The equilibrium level of GDP. Keynes multipliers. The State budget of the Russian Federation: sources of replenishment and spending directions. Taxes and other mandatory payments. Economic models to demonstrate the consequences of government decisions. The AD-AS (closed economy) model. The formula of the country's trade balance. The balance of payments. The IS-LM-BP (Open Economy) model.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Biology/Общая биология

Purpose of the course:

- to create a common understanding of man as part of nature, the unity and value of all living things and the impossibility of the survival of humanity without preserving the biosphere, but also to teach the proper perception of practical problems related to biology, including human health, nature conservation, overcoming ecological crisis; to inculcate the skills of ecological culture.

Tasks of the course:

- to study the fundamental properties of living systems (self-renewal, self-regulation, self-reproduction) and the attributes of life: metabolism and energy, irritability, homeostasis, reproduction, heredity and variability;

to be familiar with the organization levels of the living and the manifestation of fundamental properties of the living on the main evolutionary-determined levels of organization: molecular, genetic, cellular, ontogenetic, population-species, biogeocenological biosphere. To study the structure and principles of functioning of structural components of an elementary unit of a living – cell. Get acquainted with the main metabolic processes occurring in the cell;

- get acquainted with the species of reproduction in living systems. To study the features of sexual reproduction, the formation of germ cells, fertilization, species and characteristics of individual development.

- to study the molecular level of the organization of the living: the structure and functions of the main biopolymers (proteins, fats, carbohydrates, nucleotides). Get acquainted with the molecular mechanism of heredity and variability of living organisms. To study the basics of plastic and energy metabolism. To study the basic genetic laws: Mendel's laws, non-Mendelian cleavage, sex genetics. To be able to link the laws of genetics with chromosomal theory and with the molecular foundations of heredity;

- to get acquainted with the laws and mechanisms of human life at evolutionarily determined levels of its organization. To study the principles of functioning of various systems of the human body: musculoskeletal, circulatory, respiratory, digestive, endocrine, nervous. To study the principles of regulation of body functions.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic laws of biology and General ecology;

- essence of life, levels and principles of biological organization;

- the main concepts, laws and laws relating to the structure, life and development of plant, animal and human organisms, the development of wildlife;

- features of man as a biological species, features of physiology, somatic, mental and social origin in human nature, health and environmental risk factors, the place of man in the evolution of the Earth;

- fundamentals of ecology (ecology of individuals, populations, communities, the doctrine of the biosphere, the interaction of nature and society, environmental problems of our time);

- basic biological concepts and terms;

- fundamentals of human structure and life;

- basics of General and organic chemistry;

- subject, purpose, objectives of the discipline and its importance for future professional activity;

- structure and functions of proteins, carbohydrates, fats and nucleic acids;

- main stages of cell energy;

- structure of biological membranes; mechanisms of transport of substances through membranes;

- structure and functions of cell organelles;

- classification of cells according to their specialization;

- regularities of structural and functional relationships in cells;

- types of intercellular contacts, structure and functions of synapse;

- the principle and stages of transmission of hereditary information in generations of organisms;

- stages of protein biosynthesis on ribosomes, regulation of these stages;

- the concept of homeostasis;

- basic fundamental approaches to the regulation of cell activity;

- mechanism of asexual reproduction; the essence of mitosis;

- the essence of sexual reproduction, gametogenesis, meiosis;

- stages of individual development of the body;

- origin of specialized body parts from germ leaves;

- regularity of regeneration;

distinguishing characteristics of the tissues of the animal body;

- regularities of the relationship between the organism and the environment from the position of adequate and inadequate reaction of the organism, adequate and inadequate environmental conditions;

- basic concepts of genetics and selection: dominance and recessiveness; chromosomal basis of splitting and independent redistribution of genes; molecular mechanisms and genetic control of recombination; gene interaction;

- basic genetics of sex; heredity linked to sex;

- biological basis of hereditary human diseases;

- social aspects of human biology;

- basic provisions of human ecology.

be able to:

- competently perceive theoretical and practical problems related to biology and ecology, including-human health, nature protection, overcoming the ecological crisis;

- to use the acquired knowledge in practice;

- defend your point of view;

- to assess the consequences of their activities in relation to the environment and their own health;

- to use the knowledge of the structure and functions of biomolecules of the cell to understand the physiological and pathological processes occurring in the cell;

- characterize cell organoids and their role in the implementation of cell life to maintain optimal regulation of cell functions;

- on the basis of knowledge of the stages of protein synthesis and the factors that determine it, to be able to regulate the mechanisms of long-term adaptation of the cell; to solve problems in molecular biology

- explain the patterns of structural and functional relationships in cells and be able to use this knowledge to intervene in the process of cell damage;

- to use the concepts of homeostasis, adaptation in application to specific life situations;

- identifying ways of regulating cell activity and managing this activity;

- establish fundamental differences between mitosis and meiosis to understand the role of these processes in evolution;

- to use the knowledge of inheritance patterns established by G. Mendel to solve genetic problems;

- to work independently with the literature on biology, as well as with educational, methodical and reference literature on medical and biological subjects;

- solve situational problems and test tasks for the formation of heuristic thinking;

- to evaluate the General biological patterns of life of the human body;

- to generalize and comprehend the data of various medical, pharmaceutical Sciences and General biological positions in order to further solve biological problems by methods of analysis.

master:

- methods of solving environmental problems;

- skills of working with literary sources;

- to present the results of their own activities using modern means, focusing on the needs of the audience, including in the form of reports, presentations, reports;

- ability to conduct experimental research, projects and tasks on the subject of the developed scientific problem;

biological terminology;

- understanding the laws of life of the human body, to connect the functions of organs and systems of organs of the body with the physiological processes occurring in them.

Content of the course (training module), structured by topics (sections):

1. Cell, cell types. Procariotic cell

Differences between eukaryotic and prokaryotic cells. The structure of prokaryotic cells. Basic cellular organelles.

2. Cell division. DNA replication. Transcription. Features of the genome of eukaryotes

Microfilaments, microtubules, intermediate filaments. The cell center. Mitotic cell division. Meiosis. DNA replication. DNA repair, recombination, restriction, and modification. Transcription. Features of the eukaryotic genome.

3. Protein biosynthesis

Этапы биосинтеза белка. Синтез полипептидной цепи из аминокислот. Трансляция. Роль рибосом, молекул мРНК и тРНК. Посттрансляционные модификации полипептидной цепи. Энергозатраты при биосинтезе белка.

4. Evolution. Phylogeny

Life cycles and life forms. Evolution. Phylogeny. Relatedness of organisms. The phylogenetic line of plants.

5. Phylogenetic lines

Phylogenetic line raznoschikova organisms. Phylogenetic line Alveolata. Phylogenetic lines of Rhizaria and Excavata

6. Mushrooms

Real mushrooms: Diversity, prevalence, life cycles

7. Multicellular animals: coordination and specialization of cells

Multicellularity: coordination and specialization of cells.

Practicum:

- Front and rear end of the body, animals (trichoplax and planaria);

- The axis of the body-type plants (plants cnidarian polyps)

8. Multicellular animals: General issues, coelenterates, worms, ecdysozoa, vtorichnaya

Multicellularity: coordination and specialization of cells.

Multicellular animals. Eumetazoa (”real " Metazoa) as a monophyletic group, their common features.

Groups of multicellular (1) Sponges and coelenterates, Lophotrochozoa.

Multicellular group (2) Lophotrochozoa, flat worms

Group of multicellular (3) Ecdysozoa (Ecdysozoa), vtorichnaya.

9. Multicellular animals: chordates

The origin of chordates and their General characteristics.

The exit vertebrates on land.

Variety of amniotes.

10. Structure and diversity of plants

Structure and diversity of plants

11. Microscopy

Microscopy light, fluorescent, confocal. Light microscope, viewing of ready-made preparations

12. Methods of staining preparations

Methods of staining products (classic, fluorescent dyes, immunogene). Identification of organelles, the preparation of their drugs

13. Practicum. The properties of the living: nutrition

- The types of food Hydra, fresh-water sponge, planaria, Daphnia;

- Power on the example of Sharovka, Suwalki, ciliates shoes;

- Nutrition of fungi, bacteria, plants.

14. Practicum. The properties of the living: motion

- Movement on the water surface: Basilisk, water meter, pond: movement on water + change in surface tension

- Movement on a solid surface (Gecko and tree frog)

- Movement due to flow of water (flagellates, ciliates, rotifers); swimming (leeches); pacing (leeches)

15. Practicum. Properties of the living: communication

Communication

- sound (cricket song)

- visual (movie reptile)

- chemical transmission of the effects of crowding and stress (crustaceans)

- protective aggregation of E. coli in a semi-liquid medium under the action of hydrogen peroxide

- behavior (courtship of fruit flies of different types)

16. Hormonal regulation

Hormonal regulation

• quorum effect in bacteria

• dictiostelium

• calli (initiating the growth of stems and roots)

• ethylene

17. Human physiology

Measurements of various parameters: ECG, EEG, polygraph, breathing, pulse, etc.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Chemistry/Общая химия

Purpose of the course:

The main goal is theoretical and practical development of the main sections of General chemistry, taking into account modern trends in the development of chemical science. This will allow:

- to understand the logic and possibilities of chemistry, especially the chemical approach to the study of the world;

- understand and use the language of chemical formulas and equations;

- predict the structure and properties of substances, their ability to interact with other substances;

- to understand the driving forces of chemical reactions, especially their course and ways to manage them.

The course of General chemistry is designed to form students studying in the direction of "Biotechnology" ideas about the basic concepts and laws of chemistry, chemical reactions and properties of inorganic substances. The course represents the basics of chemical literacy, shows the place of chemistry in modern natural science, especially the chemical approach to the study of the world, gives an idea of the methodology and approaches of chemistry to the study of chemical properties of matter, makes it clear that chemistry, being closely related to physics and biology, is an independent science.

In the study of this course, the student for the first time receives information about the quantum theory of the electronic structure of atoms and molecules, on the basis of which the chemical properties of matter are explained. Therefore, students must accept this information without the justification that they will later receive in the study of General and theoretical physics. This once again demonstrates that chemistry, based on fundamental physical laws, is an independent scientific discipline, which has the subject of its study of the structure, properties and transformations of matter.

The course consists of lectures, seminars and laboratory work. This enables the full development of the curriculum and the active use of knowledge in the further study of disciplines such as chemical physics, biochemistry and biophysics.

Tasks of the course:

The objectives of General chemistry course is to study:

* modern ideas about the structure of the substance, the relationship of the structure and properties of substances from the position of their constituent elements in the Periodic table and the nature of the chemical bond

* basic principles determining the properties of chemical reactions, kinetic and thermodynamic approaches to the description of chemical processes in order to optimize the conditions for their practical implementation

* the most important properties of inorganic compounds and patterns of their changes depending on the position of their constituent elements in the Periodic table.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic concepts of chemistry: substance, chemical element, atom, molecule, relative atomic and molecular masses, ion, allotropy, isotopes, chemical bond, electronegativity, valence, oxidation degree, mole, molar mass, molar volume, solutions, electrolyte and nonelectrolyte, electrolytic dissociation, acid, base, oxidation and reduction, thermal reaction effect, chemical reaction rate, catalysis, chemical equilibrium;

- basic laws of chemistry: the law of conservation of mass and energy, multiple ratios, constancy of composition, volume ratios; kinetic and thermodynamic law of acting masses;

- General information about the chemical element (name, chemical symbol, relative atomic mass);

- the position of the chemical element in the Periodic system (serial number, period, group, subgroup);

- structure of the element atom (nucleus charge; number of protons and neutrons in the nucleus; number of electrons;

- electronic configuration, electron distribution over energy levels, sublevels and atomic orbitals;

- properties of a simple substance formed by this element (metal, nonmetal, aggregate state under normal conditions, type of chemical bond in the substance);

- higher oxide and its corresponding hydroxide (formulas, valence and oxidation state of the element in the compound), their acid-base properties;

- hydrogen compound (formula, valence and oxidation state of the element in the compound); other compounds of the element (formula, cationic or anionic form).

be able to:

- call inorganic substances by "trivial" or international nomenclature;

- determine: the valence and oxidation degree of chemical elements, the type of chemical bond in the compounds, ion charge, the nature of the medium in aqueous solutions of inorganic compounds, oxidative and reducing properties of the compound;

- make structural formulas of molecules and predict their geometry;

- to characterize: elements in periods and groups according to their position in the Periodic table of D. I. Mendeleev; General chemical properties of metals, nonmetals, main classes of inorganic compounds;

- explain: the dependence of the properties of substances on their composition and structure; the nature of the chemical bond (ionic, covalent, metallic), the dependence of the rate of chemical reaction and the position of chemical equilibrium on various factors;

- write the equations and diagrams of chemical reactions and lead the stoichiometric calculations;

- perform a chemical experiment to recognize the most important inorganic substances and obtain the simplest substances;

- to conduct an independent search for chemical information using various sources (scientific publications, computer databases, Internet resources).

master:

- methods for determining the possibility of chemical transformations in different conditions and assessing their consequences;

- theoretical methods of describing the properties of simple and complex substances based on the position of their constituent elements in the Periodic system of chemical elements;

- methods of safe handling of combustible and toxic substances;

- basic skills of working with laboratory equipment;

- methods of preparation of solutions of a given concentration.

Content of the course (training module), structured by topics (sections):

1. Subject and tasks of chemistry, basic concepts and laws of chemistry.

Chemistry as one of the natural Sciences. Interrelation of chemistry, physics and biology. Features of chemistry as a science. Structure and language of chemistry. Substance. Classification of chemicals. Chemical element. Atom, atomic number, relative atomic mass, isotopes. Prevalence of chemical elements in nature. Periodic table of chemical elements. D. I. Mendeleev's table structure, groups, periods and blocks. Metals and nonmetals. Chemical compounds and their characteristics: structure, composition, property. Simple and complex connections. Stoichiometric relations, empirical and molecular formula of the compound. Valence of elements. Non-stoichiometric compounds. Allotropes and polymorphs. The main classes of inorganic compounds: oxides, acids, bases, salts, binary compounds. Transformation of chemical compounds. Reaction equations. Stoichiometric calculations on reaction equations. Chemical variable. Formal recording and reaction mechanism. Energy curve of chemical reaction. An elementary act of chemical reaction.

2. The structure of the atom and the periodic law.

Hydrogen-like atoms and ions. Electronic energy levels, wave functions, spatial distribution of electron density, radial and angular dependence of wave functions. The quantum number of the electron. Many-electron atoms. One-electron approximation. Effective charge. Hydrogen-like

orbitals. Principles of filling orbitals. Diagram of the energy levels of the atom. Periodic properties of elements: atomic and ionic radii, ionization energy and electron affinity, electronegativity on Milliken

3. Chemical bonds. Types of chemical bond.

Formation of chemical bonds between atoms. Covalent bond. Valence. Octet rule. Lewis Structures. Resonance structure. Formal charge and oxidation state of the element in the compound. Chemical bond characteristics-bond order, length, energy, polarity. Geometry of molecules. Model of repulsion of electronic pairs of valence orbitals and its limitations. Theory of hybridization and directionality of bonds. Electronic states of the molecule. Molecular orbitals method. Electronic configuration of the molecule. Molecular orbitals method in the approximation of LCAO. Correlation diagrams, linking, non-binding and loosening orbitals, communication order. Electronic structure of diatomic molecules. The concept of the construction of MO heteronuclear diatomic molecules. Intermolecular interaction. Hydrogen bond, its nature, properties and role in liquids, molecular crystals and macromolecules. Van der Waals bond, various types of dipole-dipole interactions.

4. Fundamentals of chemical thermodynamics and kinetics, equilibrium.

Classification of chemical reactions. Stoichiometric description of the chemical reaction. Energy curve of elementary chemical reaction. Direct and reverse reactions. The first law of thermodynamics and its application to chemical reactions. Enthalpy. Heat of chemical reactions at constant volume and at constant pressure. Thermochemical equations of reactions. Hess's Law. Enthalpy of formation, combustion, dissolution. Thermochemical cycles. Entropy. The second law applies to chemical processes. Gibbs energy, enthalpy and entropy factors. Reversible reaction. Chemical equilibrium-definition and General properties. Equilibrium constant and its relation to thermodynamic functions. Le Chatelier Principle. Thermodynamic reference data on individual substances and chemical reactions.

Characteristic times of chemical reactions. Energy barrier of chemical reaction. Activation of the reagents. The concept of the mechanism of chemical reaction. The rate of chemical reaction and its dependence on various factors. The law of acting masses. Rate constant. Arrhenius equation. The limiting stage of a complex reaction. Catalysis, its role in chemistry. The main mechanisms of catalysis. General properties of catalysts.

5. Solutions. Methods of concentration expression, colligative properties of solutions.

Solutions, their classification. Methods of expressing the composition of the solution-molar and mass fraction, molar concentration. Polar and nonpolar solvents. Solubility and its dependence on temperature and pressure. The difference between the properties of solutions from the properties of individual substances. Colligative properties of electrolyte and nonelectrolyte solutions. Osmotic pressure. Raoult's Law. Isotonic coefficient. Increasing the boiling point and lowering the freezing point of solutions from the standpoint of colligative properties.

6. Solutions, electrolytic dissociation

Electrolytic dissociation, electrolytes and nonelectrolytes. Strong weak electrolytes. Degree of dissociation, dissociation constant. Dissociation of acids, bases and salts. Interaction between ions in solution, ion equations of reactions. Ion binding, direction of ion exchange reactions.

7. Acid-base equilibria in solutions.

Acids and bases according to Arrhenius. Strong and weak acids and bases. Acidity and basicity constants. Step dissociation on the example of phosphoric acid. Brensted acidity, conjugate acids and bases. Water as acid and base. Autoionization of water, hydroxonium ion. the pH of the solutions. Calculation of pH solutions of weak acids and bases. Hydrolysis of salts. Buffer solution. Lewis acids and bases. Solubility product.

8. Redox reactions.

Concepts of oxidation and reduction. Typical reducing agents and oxidizers. Preparation of equations of redox reactions: methods of electronic and electron-ion balance. Redox potentials. Conjugate oxidizers and reducing agents. nernst equation. The Latimer Diagram. The relationship of EDS with the thermodynamic properties. Chemical current sources, their classification. Electrolysis of solutions and melts.

9. Chemistry of hydrogen and halogens.

The position of hydrogen and Halogens in the Periodic table. Typical properties and oxidation States of Halogens. Feature of hydrogen. Hydrogen isotopes; preparation and properties. Hydronium ion. Hydrides. Industrial and laboratory methods for producing hydrogen and Halogens. Chemical and physical properties of Halogens. Hydrogen halides. Interaction of Halogens with water. Oxygen compounds of Halogens. Preparation and chemical properties of oxygen-containing compounds of Halogens.

10. Chemistry of chalcogens.

General characteristics of the elements of the group 16 of the Periodic table of elements. Distinctive properties of oxygen and ozone. Chemical properties of simple substances. Chalcogenides-preparation and chemical properties. Hydrogen compounds of the chalcogens. Oxides and oxygen acids of sulfur and selenium. Preparation and chemical properties of oxygen-containing compounds of sulfur, selenium and tellurium.

11. Chemistry of pnictogens and nonmetals in13 and 14 groups of the Periodic table of elements.

General characteristics of the elements of the group 15 Periodic table of elements. Typical oxidation States of nitrogen, phosphorus, arsenic and antimony compounds. Hydrogen compound pnictogens – methods of getting and chemical properties. Ammonium salt. Oxides 15 of the group of the Periodic table of elements. Preparation and chemical properties of oxygen acids of nitrogen and phosphorus, arsenic and antimony. Carbon, silicon and boron. Features of the structure, physical and chemical properties. Carbon oxides, carbonic acid and carbonates. Silicon and boron oxides, silicates, borates.

12. Chemistry of alkaline and alkaline earth metals and metals of main subgroups.

Position of metals in the Periodic table of elements. General physical and chemical properties of metals of main subgroups. Preparation and chemical properties of alkaline and alkaline earth metals. Alkalis are chemical properties. Basic properties of p-metals. Features of aluminum chemistry: interaction with water, alkalis and acids, reducing properties. Chemical properties of tin and lead.

13. Chemistry of coordination compounds.

Concept of complex connection. Werner coordination theory. Types of Central atoms and ligands. Geometric structure, coordination numbers and isomerism of complexes. Crystal field theory. Spectra, coloring and magnetic properties of complexes. Stability of complexes in solutions.

Conditions of formation and destruction of complex compounds. The instability constant of complex compounds. Typical complex compounds of chromium, iron and cobalt.

14. Chemistry of transition metals.

Position of d-metals in the Periodic table. Electronic configuration of transition metals. Three rows of transition metals. Features of metals of the first transition series. Basic chemical properties: interaction with Halogens, oxygen, dissolution in acids. Transition metals of the second and third rows. Typical oxidation States and chemical properties. Features of molybdenum chemistry: change in redox and acid-base properties when changing the degree of oxidation. Chemistry of f-elements. Lanthanides and actinides. Basic properties and oxidation state.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Electricity and Magnetism/Общая физика: электричество и магнетизм

Purpose of the course:

Development of students' basic knowledge in the field of physics of electromagnetic phenomena for further study of other branches of physics and in-depth study of the fundamentals of electricity and magnetism.

Tasks of the course:

Tasks of the Discipline:

•formation of students ' basic knowledge in the field of electricity and magnetism;

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems;

• the formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processes.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• fundamental laws and concepts of physics of electromagnetic phenomena, as well as the limits of their applicability:

• the law of conservation of charge, Coulomb's law, superposition principle, theorem Gaussa integral and differential form;

• the concept of potential and its relation to field strength;

• basic concepts in the calculation of the electric field in a substance: field vectors and electric induction, polarizability and dielectric permeability;

• Ohm's law in integral and differential forms, Kirchhoff's rules, Joule-Lenz's law;

• the law of Biot–Savart, the theorem of circulation of magnetic field in integral and differential form;

• basic concepts in the calculation of the magnetic field in matter: magnetic induction and field strength, magnetization vector, conduction currents and molecular currents;

• the law of electromagnetic induction, Lenz's law;

• basic concepts of oscillation theory: free damped oscillations, damping coefficient, logarithmic decrement and q-factor, forced oscillations, resonance, parametric excitation of oscillations, self-oscillations;

• Maxwell's equations in integral and differential form;

• the law of conservation of energy and Poynting's theorem;

• basic concepts of plasma and waveguides.

be able to:

• apply the studied General physical laws to solve specific problems of electricity and magnetism:

• apply the Gauss theorem to find the electric field in vacuum and in matter;

• to write and solve the equations of Poisson and Laplace;

• apply the circulation theorem to find the magnetic field in vacuum and in matter;

• use the "image" method to calculate electrical and magnetic fields;

• apply the energy method of calculating the forces in the electric and magnetic field;

• calculate electrical capacity and self - and mutual-induction coefficients;

• use a complex form of representation of oscillations and vector diagrams in the calculation of oscillatory circuits;

• analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;

• apply various mathematical tools to solve problems based on the generated physical laws, and carry out the necessary analytical and numerical calculations.

master:

• the main methods of solving problems of physics of electromagnetic phenomena;

• basic mathematical tools specific to the problems of electricity and magnetism.

Content of the course (training module), structured by topics (sections):

1. Electric field. Superposition principle. The field of a dipole. gauss theorem.

Application of the principle of superposition for calculation of electrostatic field of systems of point charges and the Gauss theorem to the symmetrical systems.

2. Potential. Conductors in an electric field. The method of images.

Calculation of the potential of electrostatic field. Accounting for induced charges on the surface of conductors by the method of images.

3. The electric field in the substance. Vectors →E and→D.

Problems on electrostatic phenomena in continuous media. Application of the Gauss theorem for the vector of electrical induction D to the calculation of the electric field of dielectrics.

4. The energy of the electric field. Energy method for calculating forces. Currents in non-confined environments.

Application of energy approach to calculation of forces resulting from the action of electrostatic field. The distribution of current in an infinite medium.

5. Magnetic current field. Circulation theorem. Magnetic moment.

Calculation of magnetic field produced by electrical currents using the principle of superposition and Ampere's circuital law.

6. The magnetic field in the substance. Vectors →B and →H.

Calculation of magnetic field in continuous media (paramagnetics,diamagnetics and ferromagnetics).

7. Test.

Written test on the material of previous seminars.

8. Analysis of control work. Delivery of the 1st task.

Feedback session. Submission of the first assignment.

9. Movement of charged particles in electric and magnetic fields. Electromagnetic induction. The theorem of reciprocity.

Study of motion of charged particles in the crossed electrical and magnetic fields. Electromagnetic induction.

10. Magnetic energy. Forces in a magnetic field. Superconductors in a magnetic field.

Calculation of the energy of magnetic field and forces, caused by magnetic field. Study of the behavior of superconductors in magnetic field.

11. Transients in electrical circuits. Free vibrations.

Problems related to transient processes and free oscillations in electrical circuits.

12. Forced oscillations. The method of complex amplitudes.

Study of stimulated oscillations and summation of oscillations using the method of complex amplitudes.

13. Modulated oscillations. Spectral analysis in linear systems. Para-metric fluctuations. Self-oscillation.

Analysis of the response of linear systems on the external influence, spectrum of the response. Modulated, parametric oscillations, self-oscillations.

14. Maxwell equation. Bias current. The Theorem Of Poynting.

Application of Maxwell’s equations to calculation of characteristics of electromagnetic waves and scattering amplitudes (the Fresnel equations).

15. Electromagnetic waves in waveguides. Resonators. Plasma.

Determination of modes of electromagnetic field in waveguides and resonators. Basicsof plasma physics.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Introduction to Physics/Общая физика: введение в физику

Purpose of the course:

Development of students ' basic knowledge of General physics for further study of other branches of physics.

Tasks of the course:

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems

• formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processesTasks of the Discipline.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

- to understand the essence of algorithmic requirements and the ability to act in accordance with the proposed algorithm;

- know the basic methods of experimental study of nature

- have an idea of the basic mathematical concepts (number, geometric figure, equation, function);

- have an idea of the basic physical concepts (material point, reference system, system of units);

be able to:

Be able to:

- be able to understand and use mathematical means of visualization (charts, diagrams, tables, diagrams, etc.).);

- have the skills of oral, written, instrumental calculations;

- be able to use the simplest means of measurement

master:

To be in command of:

- to master the techniques of performing identical transformations of rational expressions, solving equations, systems of equations, the ability to use the idea of coordinates on the plane for the interpretation of equations, inequalities, systems; the ability to apply algebraic transformations, apparatus of equations and inequalities for solving problems,

- to know the system of functional concepts, functional language and symbols; the ability to use functional and graphical representations for the description and analysis of real dependencies;

- possess the skills of geometric constructions, perform drawings, make drawings, diagrams on the condition of tasks;

Content of the course (training module), structured by topics (sections):

1. Kinematics of uniform motion and accelerated motion.

The subject and role of physics. Limits of applicability of physical laws. Measurement of physical quantities. Uniform rectilinear motion and curvilinear motion. Uniformly accelerated motion. Reference frames.

2. Dynamics of point particle

Forces in nature. Newton's laws and dynamics of rectilinear and curvilinear motion.

3. System of bodies.

Momentum of a body and impulse of force. Law of momentum conservation. Collisions.

4. Work and energy.

Work done by force. Potential energy and kinetic energy. The law of conservation of energy.

5. Gravitation

Law of universal gravitation. Orbital velocity and escape velocity. Geostationary earth orbit satellite.

6. Statics and dynamics of rigid bodies

Torque and general condition of equilibrium. Hydrostatics. Dynamics of rigid bodies.

7. Ideal gases.

Equation of state of an ideal gas. Dalton’s law and Avogadro’s law.

8. Conservation of energy in various processes

First law of thermodynamics. Adiabatic and isothermal processes.

9. Properties of liquids and vapors

Surface tension. Capillary phenomena. Mutual conversion of liquids, solids, and vapors.

10. Electrostatics.

Electric charges and electric fields. Capacitors. Potential difference. Energy of electric field.

11. Electric current

Ohm's Law. Resistivity. Series and parallel connection of resistors.

12. Magnetic field of a current.

Action of magnetic field on an electric current and moving charge. Electromagnetic induction.

13. Alternating current

Induced current. Faraday law. Transformers.

14. Geometric optics

Reflection and refraction of light. Thin lens equation and optical instruments.

15. Physical optics

Wave properties of light. Interference and diffraction of light. Diffraction grating. Dispersion of light and colors of bodies. Polarization of light.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Laboratory Practicum/Общая физика: лабораторный практикум

Purpose of the course:

formation of basic knowledge of physics and the ability to work in the laboratory for further use in other disciplines of natural science content; formation of the culture of experiment, research skills and the ability to apply knowledge in practice.

Tasks of the course:

Tasks of the Discipline:

ormation of students ' basic knowledge of physics;

- formation of experiment culture: ability to work in the laboratory, to know the basic methods of experiment, to establish logical connections between concepts;

- formation of skills and abilities to apply the knowledge gained for the formulation of the experiment, self-analysis of the results.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- methodology of the experiment;

- methods of processing the results.

be able to:

- work with modern measuring equipment;

- correct processing of the experimental data.

master:

 skills to work with modern instrumentation;

 basic mathematical tools typical of the mechanical problems.

Content of the course (training module), structured by topics (sections):

1. Determination of systematic and random errors in measurement of specific resistance of nichrome

Systematic and random errors are studied on the example of nichrome wire resistivity measurement. The lab assignment includes studies of instrumental errors of analog and digital devices, laws of error addition, and errors in direct line parameters obtained by the least square method.

2. Measurement of radiation background intensity

Using the cosmic background radiation recorded by a Geiger counter as an example, this lab investigates the main methods of statistical data processing. Basic properties of normal distribution and Poisson distribution are studied. The dependence of the RMS deviation of data on the number of measurements is studied.

3. Test 1.

Test 1.

4. Study of electronic oscilloscope

The principle of operation of electronic oscilloscope is studied. Parameters of simplest oscillations, like amplitude, phase, and frequency, are measured. The influence of amplitude-frequency and phase-frequency characteristics on the result of measurements with the oscilloscope is underlined.

5. Determination of principal moments of inertia of rigid bodies by means of trifilar torsion suspension

Torsional oscillation periods of rigid bodies of different shape are measured with the aid of trifilar suspension. The measured periods are used to calculate the moments of inertia of the bodies, which are compared with those obtained by calculations based on geometric dimensions of the studied bodies. The additivity of inertia moments and the Huygens-Steiner theorem are checked experimentally.

6. Experimental verification of the dynamical law of rotational motion using the Oberbeck pendulum

With the help of a cross-shaped pendulum, the basic law of rotational motion is studied. The cylinder moments of inertia and the relationship between inertia moments and the distance to the axis of rotation are checked experimentally. The influence of air drag on the distortion of experimental results is studied.

7. Test 2

Test #2

8. Measurement of gravitational acceleration by means of Kater’s pendulum

Basic laws of oscillatory motion are investigated with a long rod-shaped physical pendulum and a revolving pendulum with movable loads. Pendulum oscillation periods are measured, and the

dependence of the period on the amplitude of oscillation and attenuation is studied. The measured period of oscillation is used to calculate the acceleration of free fall with high accuracy.

9. Test 3

Test 3

10. Determination of Young's modulus based on measurements of tensile and bending strain

Small elastic deformations of tension/compression, bending and torsion of different materials, like steel, brass, different types of wood, etc. are studied. The deformation value is used to calculate the Young's modulus of corresponding material using different calculation methods.

11. Study of gyroscope precession

Laws of motion of a fast rotating axisymmetric top (i.e. a gyroscope) are studied. The top rotation speed is determined by the precession rate under the influence of constant torque. The moment of inertia of the top is determined by the method of comparison of the top torsional oscillation period with the period of reference body oscillation. The friction torque in the gyroscope axis is measured by the tilting rate of the gyroscope axis.

12. Study of string oscillations

This lab investigates the excitation of standing waves in a stretched steel string with fixed ends. Resonance frequencies are measured as functions of the force of string tension, from which the speed of wave propagation in the string and its linear density are determined. Oscillations are recorded by means of an electromagnetic sensor connected to an electronic oscilloscope. The resonance width measures the quality factor of the oscillating system.

13. Study of oscillations of coupled pendulums

The oscillation pattern in a system consisting of two coupled pendulums is investigated. The natural frequencies of oscillations are measured and the natural modes of oscillation are investigated. The dependence of oscillation pattern on the coupling constant of pendulums is studied.

14. Determination of pellet velocity by means of ballistic pendulum

The flight velocity of a pellet fired from a pneumatic gun is measured using the ballistic pendulum method. The velocities are calculated from the amplitude of deviation of ballistic and torsional pendulums using the laws of conservation of momentum, energy and angular momentum.

15. Test 4

Test #4

16. Study of stationary flow of liquid through pipe

Properties of stationary flow of liquids and gases are studied. Liquid flow rate is measured by Pitot and Venturi flowmeters. Gas viscosity is measured based on the dependence of gas flow rate on the pressure drop in the pipe section. The deviation from Poiseil law determines the critical value of Reynolds number corresponding to the transition from laminar flow to turbulent flow.

17. Determination of activation energy of liquid via temperature dependence of its viscosity

The viscosity coefficient of liquid as a function of temperature is measured by dropping the test balls in a vertical flask filled with glycerol. The Stokes formula for the viscosity of liquid is

checked at a constant rate of falldown. The temperature dependence of viscosity determines the activation energy for the liquid molecules. The activation energy is compared to the bonding energy, evaporation heat and surface tension energy.

18. Test 1

test 1

19. Creation and measurement of vacuum

Basic methods of obtaining and measuring vacuum are studied. The law of viscous mode pumping and the law of pumping in Knudsen mode at high vacuum (with the help of diffusion oil or turbo-molecular pumps) are studied. Low vacuum measurement is performed with oil, thermocouple and thermoresistor vacuum gauges. High vacuum is measured with ionization and magnetron vacuum gauges.

20. Experimental study of molecular diffusion of gases

Mutual diffusion of air and helium through a thin tube connecting two vessels is investigated. The concentrations of gases are measured by a thermistor sensor by the difference in thermal conductivity of gas mixture. The applicability of Fick law and the dependence of mutual diffusion coefficient on pressure are studied.

21. Measurement of thermal conductivity of air at various pressures

This lab is designed to investigate the dependence of heat conductivity coefficient of air on temperature and pressure. Measurements are carried out by the heating of wire, enclosed in a cylindrical air shell. The temperature of the outer jacket is controlled by a thermostat while the temperature of the wire is determined by the dependence of wire resistance on temperature. The phenomenon of temperature jump near the wire surface is investigated at low pressure.

22. Experimental study of ion pump

Molecular processes in low-pressure gases are investigated. The process of electric pumping, i.e. absorption of gas particles by anode as a result of ionization by electron impact, is studied. The pressure of saturated vapor of refractory metals is measured by the pressure change when heating a metal sample in vacuum by electric current.

23. Test 2

Test #2

24. Determination of Cp/Cv ratio of gas by measuring the speed of sound in it

The adiabatic index is measured by an acoustic resonance method and Kleman-Desorm method. The value of sound velocity is calculated. Adiabatic parameters and their dependence on temperature for air and carbon dioxide are measured in this lab.

25. Phase Transitions: measurement of vaporization heat of liquid

The dependence of saturated vapor pressure on temperature of water or alcohol is measured using a mercury pressure gauge and thermostat. The vaporization heat of the corresponding liquid is calculated on the basis of the obtained dependence.

26. Test 3

Test #3

27. Real Gases: The Joule-Thomson effect

The Joule-Thomson effect in gas diffusion through a porous membrane for carbon dioxide is studied. The temperature difference is measured by a thermocouple. Joule-Thomson coefficients and Van-der-Waals gas parameters are calculated. The measured parameters are used to assess critical gas parameters and the temperature of effect inversion.

28. Measurement of surface tension of liquid

The surface tension coefficient of different liquids (water and alcohol) is measured as a function of temperature by the Rebinder method. The total free energy and the heat of surface formation are determined.

29. Measurement of specific heat of solids

The heat capacity of solids is measured, as well as the heat capacity of gases at constant pressure for different flow rates. The temperature of the solid body is measured by the dependence of the heater resistance on temperature. The gas temperature is measured by a thermocouple.

30. Test 4

Test #4.

31. Magnetometer. Absolute voltmeter. Modeling of electric fields.

Measurement of the Earth's magnetic field horizontal component and establishment of a quantitative ratio between the units of measurement of electric current and voltage in the SI and CGS systems of units. Observation of electrostatic fields of rectangular cable, flat capacitor, four charged cylinders on conductive paper.

32. Spectra of electrical signals. Waveguide. Synthesis of electrical signals.

Study of spectral composition of periodic electrical signals. Synthesis of periodic signals using a limited set of spectral components. Electromagnetic wave propagation in a waveguide, equipment and methods of measuring the main characteristics of processes that take place in this case.

33. Test 1

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

34. Magnetron (and focusing). Law three second. Milliken's Experience.

Determination of the ratio of electron charge to its mass by magnetic focusing and magnetron methods. Determination of the specific charge of the electron on the basis of three-halves-power law for a vacuum diode. Measurement of elementary charge by the method of oil droplets movement in air under the influence of gravity and vertical electric field.

35. Phase shift in the AC circuit. The voltage resonance. A resonance of currents.

Investigate how the resistance, inductance and capacitance influence the phase shift between current and voltage in the AC circuit. Study of voltage and current resonances in the serial and parallel oscillation circuits with variable capacitance. Obtaining the amplitude-frequency and phase-frequency characteristics, determining the basic parameters of the circuits.

36. Hall effect in semiconductors. Hall effect in metals. Magnetoresistance of semiconductors.

Investigation of the Hall EMF dependence on the magnitude of magnetic field at different currents through the sample to determine the Hall constant. Measurement of mobility and concentration of charge carriers in semiconductors and metals. Measurement of resistance of semiconductor samples of different shapes as a function of magnetic field induction.

37. Test 2

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

38. Free vibrations. Forced oscillations. Shot noise. Oscillatory circuit with nonlinear capacitance.

Investigation of free and forced oscillations in the oscillating circuit. Electron charge measurement by shot noise. Study of resonance properties of the nonlinear oscillatory circuit.

39. Dia - and paramagnetic. Skin-effect.

Measurement of magnetic susceptibility of diamagnetic and paramagnetic samples. Study of temperature dependence of magnetic susceptibility of ferromagnetic materials above the Curie point. Study of penetration of a variable magnetic field into a copper hollow cylinder.

40. Test 3

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

41. Ballistic galvanometer.

Study of operation of a highly sensitive mirror galvanometer of magneto-electric system in the modes of measuring direct current and electric charge.

42. Relaxation generator. Glow discharge. High-frequency discharge.

Research of relaxation generator on voltage-stabilizing tube. Study of volt-ampere characteristic of normal glow discharge. Study of high-frequency gas discharge plasma properties in the air by probe characteristics.

43. Defense of Lab Results

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

44. Hysteresis loop (dynamic method). Hysteresis loop (static method). Parametron. Double yoke.

Study of hysteresis loops of different ferromagnetic materials in variable fields. Measurement of the initial magnetization curve of ferromagnetic materials and the final hysteresis loop for toroidal specimens made of pure iron or steel. Investigation of parametric oscillations in the electrical circuit.

45. Test 4

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

46. Newton's Rings. The Jamin Interferometer. The Rayleigh Interferometer.

Measurement of glass surface curvature using interference in the form of Newton rings. Interference measurements of refractive index of gases by means of Jamin interferometer and Rayleigh interferometer.

47. Centered optical systems. Modeling of optical devices. The Abbe Refractometer.

Study of methods for determining the focal length of a lens or complex optical system. Determination of characteristics of optical system consisting of thin lenses. Study of spherical and chromatic aberrations. Study of Kepler telescope and Galileo telescope, as well as microscope models. Measurement of refractive indices of solid and liquid bodies in monochromatic light by means of Abbe refractometer.

48. Laser study.

Studying the basic principles of helium-neon laser operation, laser radiation properties and laser tube gain measurement. Investigation of polarization state of laser radiation. Observation of modal structure of laser radiation.

49. Test 1

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

50. Diffraction of light.

Investigation of Fresnel and Fraunhofer diffraction phenomena by slits. Study of diffraction influence on the resolution of optical instruments.

51. Polarization.

Familiarization with the methods of obtaining and analyzing polarized light. Determination of refractive index of ebonite by measuring the Brewster angle. Investigation of the nature of light polarization in the refracted and reflected beams. Investigation of interference of polarized rays. Determination of the direction of rotation of field vector in an elliptically polarized wave.

52. Interference of microwave waves.

Study of interference of electromagnetic waves in millimeter range using two optical interference schemes. Experimental determination of radiation wavelength and dielectric refractive index. Experimental check of Malus Law.

53. Test 2

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

54. Diffraction gratings (goniometer).

Study of operation and adjustment of goniometer and determination of spectral characteristics of amplitude grating. Investigation of radiation spectrum of mercury lamp. Determination of spectral characteristics of phase lattice (echelette).

55. Birefringence.

Measurement of the refractive index of extraordinary wave as a function of propagation direction in the birefringent crystal. Determination of main refractive indices of the crystal.

56. Test 3

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

57. Diffraction on ultrasonic waves.

Study of light diffraction on sinusoidal acoustic grating and observation of phase grating by dark field method.

58. Resolution of the microscope (Abbe method).

Determination of diffraction limit of resolution of the microscope lens by the Abbe method. Determination of lattice period using its spatial spectrum, or its image magnified by a microscope model, or using the microscope resolution estimate. Spatial filtration and multiplication.

59. Pockels effect

Study of interference of scattered light that has passed through the crystal. Observation of changes in the character of light polarization when applying an electric field to the crystal.

60. Test 4

Processing of experimental data obtained. Error analysis and calculation of measurement errors. Presentation of work in the form of a scientific report. Defense of the obtained results. Discussion of question of choice.

61. Resonant absorption of gamma-quanta (The Moessbauer effect).

Using the Doppler shift method in the Moessbauer absorption line, the resonance absorption of gamma-quanta emitted by tin nuclei is investigated. Students determine the position of maximum resonant absorption, its value, as well as the experimental line width of gamma-radiation.

62. The Compton effect.

With the help of a scintillation spectrometer, the energy spectrum of gamma-quanta scattered on graphite is studied. The energy of quanta depending on the scattering angle is determined, as well as the rest energy of the particles on which the Compton scattering takes place.

63. Measurement of total activity of a sample of Co-60 by method of gamma-gamma coincidence.

Absolute activity of Co-60 is measured by gamma-gamma coincidence method. After that, the energy of gamma-quanta emitted by the unknown radioactive specimen is determined.

64. Determination of energy of alpha-particles by measuring their range in air.

There are two ways to measure the alpha-particle range in the air: using a scintillation counter and a Geiger counter. The energy of alpha-particles is determined based on the measured range in the air.

65. Measurement of angular distribution of hard component of cosmic rays.

A telescope consisting of two scintillation counters measures the angular distribution of the hard component of cosmic radiation. Based on the data obtained, the muon's lifetime is estimated.

66. Test 1

Test #1

67. Study of cosmic ray showers.

The probability of formation of showers of secondary charged particles in lead is measured as a function of the observation level depth (cascade curve). The results are used to estimate the average particle energy in a shower.

68. Experimental verification of Einstein's equations for photoelectric effect and measurement of Planck's constant.

The photocurrent is measured as a function of the reverse potential and the frequency of incident radiation. Based on the results, the Planck constant is calculated.

69. Spectra of hydrogen and deuterium.

The optical spectrum of hydrogen atom radiation is investigated. The results are used to calculate the Rydberg constant for two isotopes, their ionization potentials, and isotopic line shifts.

70. Scattering of slow electrons by atoms of noble gas (the Ramsauer-Townsend effect).

The energy dependence of probability of scattering of slow electrons by xenon atoms is studied. The size of the outer electron shell of xenon atom is estimated based on the results of measurements.

71. Test 2

Test #2

72. Measurement of flux attenuation coefficient of gamma-rays in medium and determination of their energy.

Linear coefficients of flux attenuation of gamma-rays in lead, iron, and aluminum are measured with the help of a scintillation counter. The results are used to determine the energy of gamma-quanta.

73. Measurement of energy spectrum of beta-particles and their end-point energy by means of magnetic spectrometer.

A magnetic spectrometer is used to study the energy spectrum of beta-particles produced in the decay of caesium nuclei. The spectrometer is calibrated by the energy of electrons of internal conversion.

74. Franck-Hertz experiment.

The electron excitation method is used to measure the energy of the first level in helium atom. The results obtained in dynamic and static modes are compared.

75. Measurement of cross-section of electron-positron pair production on lead nuclei.

With the help of a telescope consisting of two scintillators and a Cherenkov detector, the cross section of electron-positron pair production in lead is measured. Radiation length and absorption length are measured.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Mechanics/Общая физика: механика

Purpose of the course:

Students master basic knowledge in the field of mechanics for further study of other branches of physics and in-depth study of the fundamental foundations of mechanics.

Tasks of the course:

Tasks of the Discipline:

• formation of students ' basic knowledge in the field of mechanics

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems

• * the formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processes

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

fundamental laws and concepts of mechanics, as well as the limits of their applicability:

 fundamentals of kinematics: radius-vector, velocity, tangential and normal acceleration, radius of curvature of the trajectory

 Newton's laws in inertial and non-inertial frames of reference

 laws of conservation of momentum, energy, momentum

 laws of motion of bodies in the gravitational field (Kepler's laws)

 laws rotational motion of a rigid body about a fixed axis and planar movement

 basis of the approximate theory of gyroscopes

 basic concepts of the theory of oscillations: the equation of harmonic oscillations and its solution, attenuation, q-factor of the oscillatory system

 basic concepts of the theory of elasticity and hydrodynamics

 fundamentals of special relativity: basic postulates, Lorentz transformations and their consequences, expressions for momentum and energy of relativistic particles

be able to:

Be able to:

 apply the studied General physical laws to solve specific problems of mechanics:

 record and solve the equations of motion of the particle and the particle system, including the reactive motion

 to apply the conservation laws to solutions of problems of dynamics of particles, systems of particles or rigid bodies

 apply conservation laws in the study of elastic and inelastic collisions of particles, including relativistic ones

 calculate the parameters of orbits when moving in the gravitational field for the two-body problem

 apply the laws of mechanics to different reference systems, including non-inertial ones

 calculate the moments of inertia of symmetric solids and apply to them the laws of rotational motion

 to count the oscillation periods of various mechanical systems with one degree-new freedom, including fluctuations in solids

 analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;

 apply various mathematical tools for solving problems based on the formulated physical laws, and carry out the necessary analytical and numerical calculations;

master:

To be in command of:

The main methods for solving problems in mechanics;

Basic mathematical tools pertaining to the problems in mechanics.

Content of the course (training module), structured by topics (sections):

1. The subject and role of physics

Limits of applicability of physical laws. Measurement of physical quantities. Units of measurement. The International System (SI), Gaussian System (CGS), and off-system units.

Basics of kinematics. Frame of reference and coordinate systems (Cartesian, polar, and spherical coordinate systems). Radius vector, linear and angular velocity, acceleration. Normal, tangential, and total acceleration. Description of motion along a flat curve, the radius of curvature of a trajectory.

2. The dynamics of point particle.

A state of particle in classical mechanics. The main task of the dynamics. Inertial and non-inertial reference frames. Newton's first law. Force and impulse of force. Inertial mass and gravitational mass. Newton's second law. The equation of motion of a particle, the role of initial conditions. Newton's third law. The law of conservation of momentum.

The motion of a variable-mass system. Jet propulsion. The Tsiolkovsky rocket equation.

3. Work done by force. Power. Conservation of energy.

Conservative and non-conservative forces. A force field. Potential energy, a field potential. Kinetic energy of a particle. The law of conservation of energy in mechanics. The general physics law of conservation of energy.

Dynamics of a system of particles. The center of mass (center of inertia). The law of motion of the center of mass. The center-of-mass frame of reference. Energy transformation under switching between reference frames. Koenig's theorem. The two-body problem, the reduced mass. Two-particle analysis of absolutely elastic and inelastic collisions. Construction and application of vector diagrams. The threshold energy for inelastic collision of particles.

4. Angular momentum of material point.

The connection of angular momentum of material point with its sectorial velocity. The angular momentum of a system of material points. Torque. The equation of torque. The law of conservation of angular momentum. The motion of a body in a central field.

5. Newton's law of universal gravitation.

Potential energy in a gravitational field. Kepler's laws. Classification of trajectories in the field of central gravitational forces, finite motion and infinite motion. The criterion of finite motion. The orbital velocity and escape velocity. The connection of the planet orbit parameters with the total energy and angular momentum of a planet. Gauss's theorem and its application for calculating gravitational fields.

6. Rotation of solid body about a fixed axis.

Moment of inertia. Calculation of moment of inertia of a solid body. Huygens–Steiner theorem. The equation of rotation about a fixed axis. The kinetic energy of rotating body.

7. Kinematics of rigid body.

Euler's rotation theorem. Instantaneous axis of rotation. Angular velocity as a vector, addition of rotations. Independence of angular velocity of a rigid body on a position of the rotation axis. The

equation of rotation relative to the moving coordinate origin and to the moving rotation axis. Planar motion of a rigid body. Rolling motion. Rolling of a rigid body along an inclined plane.

8. General case of rotation of a rigid body.

The inertia tensor and the inertia ellipsoid. Centrifugal moments of inertia. Principal axes of inertia. Regular precession of a free rotating symmetric top. Gyroscopes. Motion of a free gyroscope. The equation of motion of a gyroscope under the action of forces (approximate theory). Gyroscopic forces. Gyro applications.

9. Non-inertial reference frames.

Forces, relative acceleration, drag acceleration, and the Coriolis acceleration. Centrifugal force. The Coriolis force. Newton's second law in a non-inertial reference frame. Potential energy of centrifugal forces. A body weight and weightlessness. A deviation of a falling body from the plumb line. Geophysical manifestations of the Coriolis forces. Foucault's Pendulum.

10. Harmonic oscillations of a material point.

A spring pendulum and a simple gravity pendulum. Frequency, circular frequency, and oscillation period. The role of initial conditions. Oscillation energy, the relationship between the average kinetic energy and average potential energy of a harmonic oscillator. Mechanical oscillations of a rigid body. Physical pendulum. Huygens' theorem on the physical pendulum.

11. Free damped oscillations.

Attenuation (decay) coefficient, logarithmic decrement, quality factor. Forced oscillations of a material point under the action of sinusoidal force. Resonance. Resonance curves, amplitude-frequency and phase-frequency characteristics of oscillator. Phase plane and phase trajectory of oscillator. Superposition of oscillations: The Lissajous figures, oscillation beats. Parametric buildup of oscillations. The concept of self-oscillations.

12. Elements of elasticity theory and hydrostatics.

Solid body equilibrium conditions. Normal and tangential stress. Elastic and plastic deformations. Stretching and compression of rods. Elasticity coefficient, Young's modulus and Poisson’s ratio. The energy density of elastic deformation. Uniform and uniaxial strain and compression. Shear deformation and rotational deformation. Hydrostatics: Pascal's law, Archimedean force, the equation of fluid equilibrium.

13. Propagation of longitudinal elastic perturbations in a continuous medium.

The wave equation. Wavelength, wave number, and phase velocity. Plane wave and standing wave. Reflection of waves on a free boundary and on a rigidly fixed boundary. The condition for standing waves. The wave energy flow density. The Doppler Effect.

14. Elements of special theory of relativity.

Principle of relativity. The independence of interaction propagation velocity (or speed of light) on the reference frame. Galilean and Lorentz transformations. The interval and its invariance under a change of reference frame. Relativity of simultaneity. Time dilation, the proper lifetime of a particle. Lorentz contraction, proper length. Velocity addition. The Relativistic Doppler effect.

15. Momentum and energy of relativistic particle.

Equation of motion of relativistic particle under the action of external force. The kinetic energy of a relativistic particle, the rest energy, and the total energy. Invariance of the mass of a system of particles. Energy–momentum invariant. Particle accelerators.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Optics/Общая физика: оптика

Purpose of the course:

Development of students ' basic knowledge in the field of optical phenomena for further study of other branches of physics and in-depth study of the fundamental principles of optics.

Tasks of the course:

Tasks of the Discipline:

• Form the basic knowledge in the field of optics;

• Develop skills and ability to apply the studied theoretical laws and mathematical tools in solution of various physical problems;

• Cultivate the general culture in physics, i.e. the ability to focus on the essential physical phenomena and neglect non-essential ones; ability to assess physical quantities; skills to build the simplest theoretical models describing physical processes.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

o Fermat's principle and the laws of geometric optics;

o wave equation, plane and spherical waves, superposition principle and interference of monochromatic waves;

o temporal and spatial coherence of the source;

o Huygens–Fresnel principle, Fresnel diffraction:

o Fraunhofer diffraction at the slit;

o spectral instruments and their main characteristics;

o principles of Fourier optics, spatial Fourier decomposition, the effect Zamora-production;

o Abbe theory of optical image formation, double diffraction principle;

o principles of holography, Bragg–Wolfe condition.

o light dispersion, phase and group velocities, classical dispersion theory;

o polarization of light, natural light, the phenomenon of Brewster;,

o dichroism, Polaroids, Malus law.

o double refraction in uniaxial crystals, interference phenomena in crystalline plates, Faraday effect and Kerr effect.

o nonlinear optical phenomena, nonlinear polarization of the medium, second harmonic generation (frequency doubling), phase synchronism, self-focusing.

be able to:

Be able to:

• apply the studied General physical laws to solve specific problems in optics:

o apply the laws of geometric optics in the construction of images in optical systems;

o solve Helmholtz equations for the cases of plane and spherical waves;

o use the concept of Fresnel zones and Fresnel spiral in solving diffraction problems on the screen with axial symmetry

o use of Rayleigh's method of solving the problem of diffraction: wave field as a superposition of plane waves of different directions (the spatial Fourier-decomposition);

• analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;

• apply various mathematical tools to solve problems based on the formulated physical laws, and carry out the necessary analytical and numerical calculations;

master:

To be in command of:

• the main methods of solving the problems of optics;

• basic mathematical tools typical for optics problems;

Content of the course (training module), structured by topics (sections):

1. Fermat's principle. Geometric optics and photometry elements. Optical instruments.

Geometrical optics. Fermat's principle, laws of refraction and reflection, boundary conditions, Fresnel equations, Brewster’s angle. Geometric aberrations. Modern applications of geometrical optics in the short wavelength limit: X-ray microscopy, X-ray projection lithography, X-ray astronomy, spatial resolution microanalysis. Fundamentals of photometry.

2. Propagation of electromagnetic waves. Reflection laws, Fresnel for-mulas. Energy flow.

. Wave optics. Wave equation, monochromatic waves, complex amplitude, Helmholtz equation, plane and spherical waves, refractive index, phase velocity of propagation, complex dielectric constant and complex refractive index, con-nection of the imaginary part with the absorption of light by the medium. Non-relativistic Doppler effect, search for exoplanets.

3. Dispersion. Phase and group veloci-ties

The refractive index dispersion, classical theory of dispersion, normal and anom-alous dispersions. Damped waves, Booger's law. Refractive index of plasma. Ra-dio waves in the ionosphere and long-distance radio communications. Metamate-rials - media with negative ε and μ, advances in the creation of metamaterials. Group speed. Various wavelength ranges, their features.

4. Interference of monochromatic waves. The width of the bands.

Principle of superposition and interference of monochromatic waves. Band visi-bility, band width. Antireflection coating. The statistical nature of emission of a quasi-monochromatic wave. Temporal coherence, temporal coherence function, relationship with spectral intensity (Wiener–Khinchin theorem) and visibility. Re-striction on the permissible path difference in two-beam interference schemes, uncertainty relation.

5. Non-monochromatic light, temporal coherence. Wave interference when using extended sources. Spatial coherence

Extended sources interference. Spatial coherence, radius of coherence, spatial coherence function, connection with the radiation intensity distribution over the source I(x) (Van Cittert–Zernike theorem). Limitations on the permissible size of a source and interference aperture in two-beam schemes. Lasers as sources of radi-ation with high temporal and spatial coherence.

6. Fresnel diffraction, zone plates.

Diffraction of waves. Huygens–Fresnel principle. Diffraction by thin screen. Kirchhoff's approximation. Wave parameter. Fresnel diffraction. Axial symmetry problems, Fresnel zones, Fresnel spiral. Zone plates, lens. The use of zone plates for focusing X-ray radiation. Diffraction by additional screen, Poisson spot. Dif-fraction by a system of additional screens, Babinet's theorem. Edge diffraction, the Cornu spiral.

7. Fraunhofer diffraction. Resolution of optical instruments.

Fraunhofer diffraction. Light field in the Fraunhofer zone as the Fourier trans-formation of boundary field. Fraunhofer diffraction by slit, diffraction diver-gence. Diffraction limit of resolution of telescope and microscope. Field in focal plane of lens, transverse and longitudinal dimensions of focal spot.

8. Resolution of spectral instruments.

Spectral instruments: prism, diffraction grating, Fabry–Perot interferometer. Characteristics of spectral devices: resolution, dispersion area, angular dispersion. Interference in thin films and multilayer structures, mirrors with a high reflectance. Artificial multilayer structures for soft X-ray reflection. Diffraction gratings for radio waves.

9. Intermediate test.

Principles of Fourier Optics. Rayleigh's method for solving the diffraction problem: wave field as a superposition of plane waves of different directions (spatial Fou-rier expansion), uncertainty relation. Fresnel diffraction by periodic structures (self-replication effect). Abbe's theory of optical imaging, the principle of double diffraction. Aperture, bandwidth of spatial frequencies of optical system, relation to resolution. Resolution for coherent and incoherent lighting.

10. Feedback Session. Presentation of the first home assignment

Principles of holography. Gabor's hologram. Hologram with an oblique reference beam. Resolution of hologram. Bragg–Wolfe condition. Volume hologram, vol-ume lattice in the recording medium. Concept of holographic microscopy of bio-objects and holographic interferometry.

11. Diffraction on sinusoidal gratings. Spatial Fourier transform.

Crystal optics: light polarization. Natural light. Dichroism, polaroids, Malus's law. Double refraction in uniaxial crystals, ordinary and extraordinary waves. Mutual orientation of vectors k, E, D, B, direction of Poynting vector, side drift of light beams in crystals. Interference phenomena in crystal plates. The concept of arti-ficial anisotropy. Faraday, Kerr and Pockels effects and their applications.

12. Elements of Fourier optics and holography.

Propagation of electromagnetic waves in waveguides and optical fiber. Gradient optical fiber and optical fiber with a sharp change in the refractive index. Permis-sible angular aperture. Types of waves. Singlemode and multimode optical fibers. Optical fiber application for high-speed communication. Zero dispersion area.

13. Light polarization. Elements of crystal optics.

Scattering of light. Effective scattering cross section, directional diagram, their dependence on wavelength and on the size of scattering particles, Rayleigh scat-tering (scattering on density fluctuations). The polarization of scattered light. Rayleigh scattering as the main cause of light wave attenuation in optical fibers.

14. Propagation of light in matter. Elements of nonlinear optics.

Nonlinear optical phenomena. Nonlinear polarization of medium. Estimates of intensity of a light wave at which non-linear effects are observed based on the values of intra-atomic fields. Induced birefringence. Second harmonic generation, phase matching. Symmetry factor, impossibility of generating a second harmonic in media with an inversion center. Self-focusing, critical self-focusing power, small-scale self-focusing.

15. Presentation of the second home assignment.

Extended sources interference. Spatial coherence, radius of coherence, spatial coherence function, connection with the radiation intensity distribution over the source I(x) (Van Cittert–Zernike theorem). Limitations on the permissible size of a source and interference aperture in two-beam schemes. Lasers as sources of radi-ation with high temporal and spatial coherence.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Quantum Physics/Общая физика: квантовая физика

Purpose of the course:

Development of students ' basic knowledge in the field of quantum physics for further study of the relevant sections of theoretical physics, as well as in-depth study of the fundamental foundations of modern physics.

Tasks of the course:

Tasks of the Discipline:

• formation of students ' basic knowledge and concepts in the field of quantum mechanics and physics

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools for solving problems of quantum physics

• formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processes;

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

 fundamental laws and concepts of quantum mechanics, as well as the limits of their applicability:

 basic ideas and concepts: wave-particle dualism, de Broglie waves, Heisenberg uncertainty principle, wave function, probabilistic interpretation of the wave function

 fundamental quantum experiments: photoelectric effect, Compton effect, di is the fraction of x-ray radiation and electrons reflected from the crystal chandelier-ray structures, electron interference (including single-particle), linyca-tide spectra of emission and absorption of atoms, the tunneling radiation of absolutely black body.

 characteristic time and spatial scales on which quantum phenomena are manifested.

 Bohr postulates for the hydrogen atom and the quasi-classical Bohr-Sommerfeld approximation.

 the schrödinger wave equation for the evolution of the wave function over time, as well as for the determination of stationary energy levels of the quantum system.

 laws of quantization of frequently occurring types of motion: one-dimensional harmonic oscillator, quantum rotator, electron in a hydrogen atom.

 features of interaction of quantum particles with potential wells and barriers. Tunneling.

 gyromagnetic ratio and the coupling between the mechanical and the magnetic moment mi

 what is the orbital and spin moments, the connection of thin splitting in the spec-Trach radiation of atoms with the spin-orbital interaction

 what is hyperfine splitting and spin of an atomic nucleus

 communication statistics of fermions with Pauli exclusion rule and the exchange interaction. Hund rule of filling of atomic shells

 basic laws of the Zeeman effect. Complex and simple Zeem-on effects. Magnetic resonance phenomena. (EPR and NMR)

 what is the droplet and shell model of the atomic nucleus. Have an understanding of the strong interaction. Know the characteristic size of atomic nuclei and the magnitude of the binding energies of nuclei.

 what is the quark composition of a proton and neutron

 what is radioactive decay. Alpha, beta and gamma decay. Have an idea of the biological danger of radioactive decay.

 What is the weak interaction, the features of beta decay, the life time Neutro-on, the concept of an antineutrino.

 the main provisions of the theory of neutron scattering by heavy nuclei (resonance and nonresonance interaction, the concept of a composite nucleus)

 basic provisions of quantum optics: photons, forced and spontaneous emission, physics of lasers, Planck's formula for radiation of an absolutely black body.

be able to:

Be able to:

 apply the studied laws of quantum physics to solve specific problems:

 apply the Bohr-Sommerfeld approximation to solve problems on the motion of a particle (electron) in a given static potential

 apply the schrödinger equation to determine the energy levels of the STA-tional States, as well as to determine the transmission and reflection coefficients of potential barriers and potential wells.

 calculate the value of the spin-orbital splitting of the energy levels of an atom in the framework of the LS-coupling model

 calculate the value of the splitting of spectral lines in the Zeeman effect taking into account the selection rules

 determine the binding energy of the atomic nucleus within the droplet and shell of the nucleus.

 calculate the probability of neutron scattering by atomic nuclei

 apply the laws of blackbody radiation in thermal radiation problems

 analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;

 apply various mathematical tools for solving problems based on the formulated physical laws, and carry out the necessary analytical and numerical calculations;

master:

To be in command of:

 the main methods of solving problems of quantum physics;

 basic mathematical tools characteristic of quantum physics problems;

Content of the course (training module), structured by topics (sections):

1. Ultraviolet catastrophe. Planck's hypothesis. Black body radiation laws.

The main unsolved problems of classical physics at the turn of the XIX-XX centuries. Counting the number of field states in a given volume; phase volume per one quantum state, density of states. Rayleigh-Jeans formula and ultraviolet catastrophe, Wien's formula. Planck's hypothesis, Planck's distribution. Wien's displacement law. Equilibrium radiation as an ideal gas of photons. Absolutely black body. Kirchhoff, Lambert and Stefan-Boltzmann laws.

2. Corpuscular properties of electromagnetic waves.

Main experimental results on the external photoelectric effect. Einstein's hypothesis regarding light quanta (photons). Einstein's equation and explanation of the photoelectric effect. Photon momentum. Compton's experiment on scattering of X-rays by light nuclei, the formula for changing the wavelength of quanta when scattered by free electrons, Compton wavelength.

3. Wave properties of particles. The ratio of uncertainties.

De Broglie's hypothesis about the wave properties of material particles - wave-particle dualism. De Broglie wavelength of a nonrelativistic particle. Experiments of Davisson-Jermer and Thomson on electron diffraction. The criterion for the quantumness of the system. Uncertainty relations (coordinate-momentum; energy-time). Virtual particles. Interaction radius for the exchange of virtual particles (fundamental bosons). Wave function of a free particle (de Broglie wave). Born's probabilistic interpretation of the wave function. The concept of hidden parameters (Einstein's hypothesis) and Bell's inequalities.

4. Formalism of quantum mechanics.

The concept of operators of physical quantities. Operators of coordinate, momentum, potential and kinetic energy of the system, Hamiltonian. Eigenfunctions and eigenvalues. Schrödinger equation. Properties of the wave function of stationary problems: continuity, finiteness, uniqueness,

continuity of the derivative. Superposition principle of quantum states. Formula for the average value of a physical quantity in a given state. Probability conservation law, probability flux density vector. Process of quantum measurement of a physical quantity is an ability to obtain only its eigenvalues in the process of ideal measurement. Reduction of the wave function during the measurement. The need for a series of identical measurements. The criterion for the possibility of simultaneous measurement of several physical quantities.

5. Potential barriers. Potential holes. Oscillator.

Scattering of particles at a potential step of finite height, passage of a particle over wells and barriers of finite width, Ramsauer effect. Passage of a particle through a rectangular potential barrier of finite width (tunnel effect), derivation of a formula for the transparency of a barrier of arbitrary shape in the semiclassical approximation. An infinitely deep potential pit. Bound states of a particle in a one-dimensional symmetric potential well of finite depth. Energy levels of a one-dimensional harmonic oscillator (no derivation).

6. Movement in the central field. Vibrational and rotational spectra of molecules.

The angular momentum operator. Quantization of the eigenvalues of the projection of the angular momentum onto the selected axis and the square of the angular momentum. Motion in a central field, centrifugal energy, radial quantum number, degeneracy multiplicity. s-states in a three-dimensional spherically symmetric well of finite depth, the condition for the existence of a bound state. Adiabatic approximation in molecular theory. Rotational and vibrational spectra, energy scales of the corresponding excitations.

7. Hydrogen-like atoms. Magnetic moment. Spin. Fine and hyperfine structure of the hydrogen atom.

Thomson and Rutherford's models of the atom. Regularities of optical spectra of atoms. Motion in the Coulomb field. Bohr's phenomenological theory. Spectrum of hydrogen atom and hydrogen-like atoms, principal quantum number, degeneracy multiplicity, isotopic shift. Mesoatoms. Wave function of the ground state of the hydrogen atom. The qualitative nature of the behavior of the radial and angular parts of the wave functions of excited states. Magnetic orbital moment of electrons, gyromagnetic ratio, Bohr magneton. Stern-Gerlach experiment, Uhlenbeck and Goudsmit hypothesis on the electron spin, spin g-factor. Einstein-de Haas experiment. Vector model of addition of spin and orbital moments of an electron, operator of total angular momentum, Lande g-factor.

8. Identity of particles. Exchange interaction. Complex atoms.

Particle identity, wave function symmetry with respect to particle rearrangement, bosons and fermions, Pauli's principle. Exchange interaction. Self-consistent field in complex atoms, electronic configuration of an atom. Madelung-Klechkovsky rule. Periodic table. Atomic terms, a method for finding terms for a given electronic configuration, spectroscopic recording of the state of an atom. Hund rules. Characteristic X-ray radiation (Moseley's law).

9. Spin-orbital interaction. Atom in a magnetic field. Zeeman effect. Radiation, selection rules.

Spin-orbital interaction. Bond types: Russell-Saunders (LS) and j-j. Fine structure of the term for the case of LS-connection. The Zeeman effect for cases of weak and strong magnetic fields by the example of 3P – 3S transitions. Superfine interaction. The concept of the spin (helicity) of a photon, its connection with polarization. Classification of photons by total angular momentum and

parity (E- and M-photons). Intensity of electric dipole radiation, the ratio of the radiation intensities of photons of various types and multipoles. Natural level width.

10. EPR and NMR. Spontaneous and stimulated emission. Lasers.

Nuclear and electronic magnetic resonance (quantum mechanical interpretation). Strict and lax selection rules for absorption and emission of photons by atoms (for example, the Zeeman effect and NMR). Two-level quantum system in the field of equilibrium radiation, the principle of detailed equilibrium, spontaneous and induced transitions, Einstein's relations. Transmission of radiation through a medium, amplification condition (inverse population of levels). The principle of operation of the laser and its structure.

11. Nuclear models.

Experiments of Rutherford and Geiger on the scattering of α-particles in gases. The discovery of the neutron by Chadwick. Experimental dependence of the specific binding energy of a nucleus on the mass number A. Properties of nuclear forces: radius of action, depth of potential, saturation of nuclear forces, spin dependence. Nuclear forces as a manifestation of strong interaction. Yukawa's model. Model of a liquid charged drop. Weizsacker's formula for the binding energy of a nucleus. Shell model and magic numbers in the oscillatory potential. Single-particle and collective excited states of the nucleus.

12. Test.

Test.

13. Radioactivity. Alpha, beta, gamma decays.

Radioactivity. The law of radioactive decay, decay constant, half-life, average lifetime, secular equation. Alpha decay, Geiger – Nettol law and its derivation (Gamow's formula). Beta decay, energy spectrum of beta decay, neutrino hypothesis and its experimental detection, internal conversion of electrons, K-capture. Gamma radiation, isomerism of nuclei. Spontaneous fission of nuclei, the mechanism of formation of a fission barrier - the dependence of the Coulomb and surface energies on deformation, the fission parameter, the energy released during fission of nuclei, the limit of stability of nuclei with respect to fission.

14. Nuclear reactions. Cross-section estimation.

Nuclear reactions: exothermic and endothermic reactions, reaction threshold, reaction cross section (total and partial cross sections), reaction channels, channel widths. Bohr's compound nucleus model: classical geometric cross section, corrections for the wave character of particle motion, Bethe's law on the example of particle penetration into a rectangular well. Resonant reactions, Breit – Wigner formula. Fission of nuclei under the action of neutrons, prompt and delayed neutrons, chain fission reaction. The role of delayed neutrons in the operation of a nuclear reactor. Thermal reactor diagram.

15. Fundamental interactions and particles. Elementary particles.

Methods for registration of elementary particles. Discovery of W and Z bosons, t quark and Higgs boson. Standard model. Conservation laws and internal quantum numbers. The quark structure of hadrons - mesons and baryons. Resonances. Hadronic jets. Elements of quantum chromodynamics: asymptotic freedom, hypothesis of confinement of quarks and gluons, quark potential. Estimation of hadronic cross sections at high energies. Parity nonconservation with weak interaction, Wu's experiment. The problem of solar neutrinos, neutrino oscillations

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

General Physics: Thermodynamics and Molecular Physics/Общая физика: термодинамика и молекулярная физика

Purpose of the course:

Development of students ' basic knowledge in the field of mechanics for further study of other branches of physics and in-depth study of the fundamentals of statistical physics and physical kinetics.

Tasks of the course:

• formation of students ' basic knowledge in the field of thermodynamics and molecular physics

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems

• formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; the ability to build the simplest theoretical model describing physical processes

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

 fundamental laws and concepts of thermodynamics and molecular physics, as well as the limits of their applicability:

 basic laws of thermodynamics (1, 2, 3 "beginnings»)

 the concept of equilibrium and nonequilibrium processes, thermodynamic definition of entropy, the law of increasing entropy, the entropy of an ideal gas

 basis of molecular-kinetic theory (the basic equation of molecular-kinetic theory, the mean free path, Boltzmann distribution, Maxwell)

 fundamentals of statistical physics (statistical meaning of entropy, the concept of Gibbs distribution)

 basis of quantum theory of heat capacity (degrees of freedom and exhilaration, ha racteristics temperature, the law Dulong-PTI)

 fundamentals of the theory of phase transitions (phase diagrams, heat of transitions, equation Clapeyron Clausius-)

 the basic laws of surface tension (the surface tension, the Laplace's equation, the internal energy per unit of surface)

 fundamentals of the theory of transport processes: diffusion, thermal conductivity, viscosity. Transport co-efficients in gaseous media. Brownian motion, Einstein-on-Smoluchowski law. Relationship between mobility and diffusion coefficient.

be able to:

Be able to:

 apply the studied General physical laws to solve specific problems of mechanics:

 to apply the conservation laws to calculate the processes of compression/expansion of gases, including for the gas to expand into the void; the flow of gases from small openings; the flow in terms of the effect of Joule-Thomson

 calculate the efficiency of the equilibrium cycles of heat and refrigeration machines, including those specified in the coordinates TS

 calculate the change in entropy in nonequilibrium processes, as well as the maximum and minimum operation of systems

 calculate thermal processes taking into account the presence of phase transitions and surface tension effects

 calculate thermal processes for non-ideal gases (for the van der Waals equation)

 use probability distributions, be able to calculate mean values and standard deviations of parameters for the cases of Boltzmann and Maxwell distributions.

 calculate statistical weight and entropy based on statistical theory for the simplest systems with discrete energy levels

 calculate the velocity of mass transfer (or heat) for the diffusion (or heat of provodnosti) in the stationary and quasistationary cases

 analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;

 apply various mathematical tools for solving problems based on the formulated physical laws, and carry out the necessary analytical and numerical calculations;

master:

To be in command of:

 the main methods of solving problems of thermodynamics and molecular physics;

 basic mathematical tools characteristic of the task thermodynami-CI and molecular physics.

Content of the course (training module), structured by topics (sections):

1. The first law of thermodynamics. Heat capacity. Adiabatic and polytropic processes.

Solving problems via the use of the thermal equation of state of an ideal gas, the first law of thermodynamics in integral and differential forms. Solving differential equations via the variable separation, derivation of adiabatic and polytrope equations.

2. Heat engines. The second law of thermodynamics. Entropy.

Determination of the efficiency of heat engines and the coefficient of performance of refrigerators. Application of the second law of thermodynamics to reversible processes. Calculation of the change in entropy in processes with constant heat capacity.

3. Entropy changes in irreversible processes. Surface phenomena.

Evaluating the change in entropy in irreversible processes. Solving problems on the mechanical and thermodynamic properties of liquid surfaces.

4. Thermodynamic potentials. Transformations of thermody-namic functions.

Application of the method of thermodynamic potentials for calculation of thermodynamic derivatives. Obtaining of thermal and caloric equations of state from the canonic equation of state.

5. Phase transitions. The Clausius–Clapeyron relation.

Solving problems on the phase equilibrium of single-component systems. Calculation of the saturated vapor pressure using the Clausius-Clapeyron relation.

6. Elements of the hydrodynamics. Bernoulli equation. Viscous flow.

Discussion of problems on the flow of ideal (Bernoulli principle) and viscous (Poiseuille equation) liquids and gases.

7. Real gases. The Joule–Thomson effect.

Determination of phase transition parameters of real gas described by the van der Waals equation. Evaluation of critical parameters and the temperature change in Joule-Thomson process.

8. Test #1

Test #1. Written test on the material of seminars 1-7.

9. Feedback Session.

Feedback session. Discussion on mistakes made in written test.

10. Basics of the kinetic theory of gases. The Maxwell distribu-tion.

Solving problems on the basics of kinetic theory of gases. Calculation of average speeds and related values in systems composed of molecules having Maxwell distribution for velocities.

11. The Boltzmann distribution.Theory of heat capacity.

Solving problems on the behavior of gases in the conservative force field. Calculation of heat capacity using the basics of quantum theory.

12. Statistical meaning of entropy. Fluctuations.

Determination of statistical weight of thermodynamic systems. Calculation of fluctuations of volume, particle number etc.

13. Collisions, mean free path. Molecular transport phenomena

Study of molecular transport phenomena in gases, such as diffusion, viscosity and heat conduction.

14. Brownian motion. Phenomena in rarefied gases.

Problems on application of Brownian motion laws. Phenomena in rarefied gases, i.e. the gases whose molecules have mean free path comparable with the size of the vessel in which they are contained.

15. Test #2

Test #2. Preparation to the written exam. Submission of second assignment.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Geometry/Геометрия

Purpose of the course:

to provide students with foundations of analytic geometry that will help them to study advanced mathematical disciplines – differential equations, complex analysis, mathematical physics, functional analysis, analytical mechanics, theoretical physics, methods of optimal control, etc.

Tasks of the course:

- to provide students with theoretical knowledge and practical skills in geometry;

- to motivate students towards treatment of related mathematical disciplines;

- to equip students with skills to apply techniques of analytic geometry in physics and other natural sciences.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- methodical foundations of study and use of mathematical statements;

- foundations of the course.

be able to:

- develop, use and apply definitions and theorems;

- study and form systems of mathematical knowledge;

- prove main theorems of the course;

- solve standard problems on topics covered in the course.

master:

- the essential concept of the course.

Content of the course (training module), structured by topics (sections):

1. The initial geometric information

Points, lines, line segments. Ray. Angle. Comparison of segments and angles. Measurement of segments. Measurement of angles. Adjacent and vertical angles. Perpendicular lines. Parallel lines.

2. Triangle

Signs of equality of triangles. Medians, bisectors and heights of a triangle. Properties of an isosceles triangle. Sum of the angles of a triangle. Equilateral triangles. Area of a triangle. Pythagorean theorem. Similar triangles. Law of sines. Law of cosines.

3. Polygons

Convexpolygon. Quadrilateral. Parallelogram. Characteristics of a parallelogram. Trapezoid. Rectangle. Rhombus. Square.

4. Circle

Tangent to a circle. Degree measure of an arc of a circle. Inscribed angle theorem. Inscribed circle. Circumscribed circle. Length of a circle and area of a circle.

5. Elements of stereometry

Polyhedron. Parallelepiped. Prism. Cylinder. Cone. Sphereandball. Bodyvolume.

6. Matrixes

Operations of addition of matrices and multiplication of matrices by numbers. Matrix multiplication and inversion. Determinants of square matrices of 2-nd and 3-rd orders. Solving systems of linear equations by the Cramer method.

7. Vector space

Linear spaces and their basic properties. Directed segments and actions on them. Operations of adding directed segments and multiplying them by numbers. Their property. Commutativity, associativity and distributivity of vector operations.

8. Basis

Linearly dependent and linearly independent systems of vectors. Basis, coordinates of vectors in the basis. Coordinate representation of vectors. Operations with vectors in coordinate representation. Changing the coordinates of the vector when replacing the basis. Necessary and sufficient condition for linear dependence of vectors in coordinate form.

9. Cartesian coordinate system

Linearly dependent and linearly independent systems of vectors. Basis, coordinates of vectors in the basis. Coordinate representation of vectors. Operations with vectors in coordinate representation. Changing the coordinates of the vector when replacing the basis. Necessary and sufficient condition for linear dependence of vectors in coordinate form.

10. Scalar product

Orthogonal projections of vectors and their properties. Scalar product: properties, coordinate expression. Formulas for the distance between two points and the angle between two directions.

11. Vector product

Oriented set of vectors. Vector product, its properties, expression in orthonormal basis. Geometric meaning of the vector product. Expression of a vector product in an arbitrary basis.

12. Mixed product

Triple product of vectors, its properties, expression in arbitrary and orthonormal bases. The geometric meaning of the triple product. Conditions of collinearity and coplanarity of vectors. The formula of a double vector product. Derivation of the double vector product formula.

13. Algebraic lines and surfaces

Coordinate equation of lines on the plane, surfaces in space. Invariance of the order of algebraic lines on the plane when replacing the Cartesian coordinate system. Coordinate equation of a lines in space. Invariance of the order of algebraic lines and surfaces in space when replacing the Cartesian coordinate system. Coordinate equations of figures on the plane and bodies in space.

14. Straight and planes

A line on a plane. Vector and coordinate equations of a line. Positional and metric problems on lines on a plane. Translation of one form of description of lines on a plane into other form.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Health Concepts & Strategies/Физическая культура

Purpose of the course:

To form a worldview system of practical knowledge and attitude to physical culture.

Tasks of the course:

- To form an understanding of the social role of physical culture in the development of personality and its preparation for professional activities;

- to form the knowledge of the scientific, biological and practical foundations of physical education and a healthy lifestyle;

- to form a motivational-value attitude to physical culture, the attitude towards a healthy lifestyle, physical self-improvement and self-education, the need for regular exercise and sports.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

Scientific, practical and special foundations necessary for understanding the natural and social processes of the functioning of the physical culture of society and the individual, the ability to adapt and creatively use them for personal and professional development, self-improvement, and organizing a healthy lifestyle when performing educational, professional and sociocultural activities. Understand the role of physical culture in human development and specialist training.

be able to:

Use physical culture and sports activities to enhance their functional and motor capabilities, to achieve personal life and professional goals.

master:

A system of practical skills ensuring the preservation and strengthening of health, the development and improvement of psychophysical abilities and qualities (with the implementation of established standards for general physical and sports-technical training).

Content of the course (training module), structured by topics (sections):

1. General physical preparation.

Education of physical qualities.

2. Special physical preparation.

Special physical training

3. Professional and applied physical preparation

PROFESSIONAL APPLIED PHYSICAL TRAINING

4. Theoretical preparation.

The material of the section provides for the students to master the system of scientific, practical and special knowledge necessary for understanding the natural and social processes of the functioning of the physical culture of society and the individual, the ability to adapt and use them creatively for personal and professional development,

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

History/История

Purpose of the course:

The formation of a comprehensive understanding among students about the historical development of Russia, its place in world and European civilization, systematic knowledge of the basic laws and features of the world-historical process, with an emphasis on studying the his-tory of Russia.

Tasks of the course:

• Knowledge of the driving forces and patterns of the historical process; a person’s place in the his-torical process, political organization of society; • understanding of citizenship and patriotism as devotion to their Fatherland, the desire to serve its interests with its actions, including and protect-ing the national interests of Russia;

• formation of the spirit of morality and toler-ance;

• understanding the diversity of cultures and civilizations in their interaction, the multivariance of the historical process;

• understanding of the place and role of the graduate's field of activity in social development, interconnection with other social institutions;

• development of skills for obtaining, analyzing and summarizing historical information, the ability to think logically;

• creative thinking, independent judgments, interest in domestic and world cultural and scientific heritage, its preservation and enhancement.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

The basic laws of the historical process;

 stages of historical development of Russia, periodiza-tion and chronology of its history;

 the place and role of Russia in the history of mankind and in the modern world;

 the main facts, events, phenomena and processes, key dates, geographical realities and personalities of the history of Russia in their relationship and in chrono-logical sequence;

 concepts and terms related to the history of Russia;

 the main problems and historiographic concepts of domestic history.

be able to:

 Analyze the problems of the history of Russia, establish causal relationships;

 analyze and evaluate social and economic infor-mation;

 plan and carry out their activities taking into account the results of this analysis;

 make essays on a given topic;

 correctly evaluate and select the necessary infor-mation, analyze, systematize and generalize it.

master:

 General scientific and special historical methods, ways and means of research in the field of domestic history;

 ideas about the events of Russian and world history, based on the principle of historicism;

 skills of analysis of historical sources;

 skills of written reasoned presentation of their own point of view;

 skills of critical perception of information;

 basic terminology and conceptual apparatus in the field of Russian history.

Content of the course (training module), structured by topics (sections):

1. History in the system of social sci-ences and humanities. Foundations of the methodology of history

The place of history in the system of sciences. The object and subject of historical science. The role of theory in the knowledge of the past. Theory and methodology of his-torical science. The essence, forms, functions of histori-cal knowledge. The history of Russia is an integral part of world history: general and special in historical devel-opment. The main directions of modern historical sci-ence. The formation and development of historiography as a scientific discipline. Sources on domestic history. Methods and forms of obtaining, analyzing and preserv-ing historical information. Factors of historical develop-ment: climatic, ethnic, economic, cultural and political.

2. Eastern Slavs. Ancient Rus

Settlement of Eastern Europe. Northern Black Sea Coast in the 1st millennium BC - beginning of I millennium AD Slavs and the Great Migration of Peoples (IV – VI centuries). Slavic tribes in Europe and their neighbors. Byzantium and the peoples of Eastern Europe. Life and economy of the Eastern Slavs. Public relations and be-liefs. Slavic pantheon and pagan rites. Problems of eth-nogenesis and the early history of the Slavs in historical science.

The formation of Russian state. Formation of tribal un-ions. Veche and its role in ancient Slavic society. Prince and “druzhina”. The trade route "from the Vikings to the Greeks." The legend of the calling of the Varangians and its historical foundations.

The first Russian princes and their activities: military campaigns and reforms. Tributes.

The formation of the Old Russian state. The evolution of Old Russian statehood in the XI – XII centuries: from au-tocracy to civil strife. Old Russian city. Military, diplo-matic and trade contacts of Russia and Byzantium in the IX – X centuries. St. Vladimir. The introduction of Christianity and its cultural and historical significance.

The Middle Ages as a stage of the historical process in Western Europe, the East and Russia: technologies, in-dustrial relations and methods of exploitation, political systems. Feudalism of Western Europe and the socio-economic system of Ancient Russia: similarities and dif-ferences. Dominant traditions and institutions in the states of Eastern, Central and Northern Europe in the ear-ly Middle Ages. Neighbors of Ancient Russia in the 9th – 12th centuries: Byzantium, Slavic countries, Western Europe, Khazaria, Volga Bulgaria. International relations of the ancient Russian lands. Cultural influences of East and West.

The Ancient Russian state in the assessments of modern historians. Discussion on the nature of socio-economic formation in domestic science.

Yaroslav the Wise. "Russian truth." Power and property. The main categories of the population. Prince and boyars. The origins of Russian culture. The formation of national culture. Folklore. Slavic writing. Ancient Russian litera-ture.

The reasons for the divisions in independent principali-ties. The internecine strife of the princes. The largest lands and principalities of Russia, their features. Velikiy Novgorod. Economic, social and political development. Vladimir-Suzdal principality. The role of cities and crafts. Political structure. Galicia-Volyn principality. Ag-riculture, cities and crafts. The role of the boyars. The unification of the principalities under Roman Mstislavich and Daniil of Galich.

3. Mongol conquest and yoke. Rus-sian lands in the XIII-XIV centu-ries and European Middle Ages

The socio-economic system of the Mongol tribes. The formation of the Mongol power. Reasons and directions of Mongolian expansion. Ulug Ulus. Horde invasion of Russia. The formation of the Golden Horde, its socio-economic and political structure. Russia under the rule of the Golden Horde. Alexander Nevsky and Daniil Galitsky. Imperial order. The mongol yoke and the dis-cussion of its role in the formation of the Russian state. Islamization of the Horde and the position of the Ortho-dox Church.

Aggression of the crusaders in the Baltic lands. Knightly orders. The struggle of the peoples of the Baltic and Rus against the crusaders. The defeat of the Swedes on the Neva. Battle on the Ice. The unification of Lithuanian lands and the formation of the Lithuanian state. Russian lands as part of the Grand Duchy of Lithuania.

Recovery of the economic level after the invasion of the Mongol-Tatars. Forms of ownership and population cat-egories. Prince and nobility. City and craft. Church and clergy, heretical movements.

Russia and the Golden Horde in the 14th century: the struggle for a great reign. Economic and political strengthening of the Moscow principality. The struggle of Moscow and Tver. Ivan Kalita. Dmitry Donskoy and the beginning of the struggle for the overthrow of the Horde yoke. Battle on the Vozha river. The Kulikovo battle and its significance. Separation of the western terri-tories of Russia. Grand Duchy of Lithuania and Poland. The special situation of the Novgorod Republic. Rela-tions with Moscow.

4. Russia in the XV-XVII centuries in the context of the development of European civilization

Strengthening the Moscow state. The completion of the process of collecting eastern Russian lands. Ivan III. Ac-cession of Novgorod and other lands. Great Stand on the Ugra river. The formation of a single Russian state. Polit-ical system. Formation of central and local authorities. Judicial Code of 1497 Boyar Duma. Sovereign Court. Orders. Compensation as a form of remuneration for "of-ficials". Organization of the troops. Church and Grand Duchy. The struggle between the Josephites and non-possessors. Neil Sorsky and Joseph Volotsky. Church Council of 1503

The territory and population of Russia in the XVI centu-ry. Vasily III and his politics. Elena Glinskaya. Boyar rule. The coronation of Ivan the Terrible, the formation of autocratic ideology. The «Chosen Council» and its re-forms. Zemsky Council. Judgment book of 1550. Church and state. The Stoglavy Synod. Military reform.

The main directions of foreign policy of Ivan IV. The in-clusion of Kazan, Astrakhan Khanate in Russia and the beginning of the annexation of Siberia. Strengthening Russia's position in the Caucasus. Relations with the Crimean Khanate. "Wild field." Cossacks. The struggle for access to the Baltic Sea. Livonian war (1558-1583). Formation of the Commonwealth (1569).

Oprichnina and the reasons for its introduction. Oprich-nina and terror. Socio-economic and political conse-quences of the oprichnina.

Fedor Ioannovich. Russian foreign policy at the end of the 16th century The establishment of the patriarchate. The construction of fortifications on the southern and western borders. The problem of succession. Boris Go-dunov and his politics. The establishment of the patriar-chate.

Ecological crisis and uprisings of the beginning of the XVII century. XVII century - the era of the general Euro-pean crisis. The synchronism of crisis situations in dif-ferent countries. The beginning of the Troubles. Impos-tors. The participation of Poland and Sweden in the Time of Troubles. Seven Boyars. Intervention. The first and second militias. Kuzma Minin and Dmitry Pozharsky. Zemsky Council in 1613 and the beginning of the Ro-manov reign.

The territory and population of Russia in the XVII centu-ry. Domestic and foreign policy of the first Romanovs. Cathedral Code of 1649. Legal registration of serfdom and estate functions. Urban uprisings of the middle of the XVII century. The political system of Russia. The devel-opment of the command system. The fall of the role of the Boyar Duma and Zemsky Council. Features of the es-tate-representative monarchy in Russia. Discussions on the genesis of autocracy. Nikon reforms and church schism. Cultural and political significance. Peasant war led by Stepan Razin.

The main directions of Russian foreign policy in the XVII century. Joining of the Left-Bank Ukraine. Wars with Sweden and Turkey. The development of Siberia and the Far East.

The "secularization" of Russian culture in the 17th centu-ry Expanding of cultural ties with Western Europe. Crea-tion of schools. Slavic-Greek-Latin Academy. New gen-res in literature.

5. Russia and the outer world in the XVIII-XIX centuries: attempts of modernization and the industrial revolution

The process of modernization of the Western world. The emergence of a new economic structure in the economy. Peter I: the struggle for the transformation of traditional society in Russia. The main directions of "Europeaniza-tion" of the country. The evolution of the social structure of society. The development of heavy and light industry. Creation of the Baltic Fleet and regular army. Church re-form. Proclamation of Russia by the empire. The assimi-lation of European technical culture and the principles of effective public administration. The foreign policy of Russia under Peter I. Azov campaigns. Great Embassy. The participation of Russia in the Northern War. Treaty of Nystad. Prut campaign. Strengthening of Russia's po-sition in the Black Sea region. Views on Peter's reforms in modern Russian historiography.

The era of palace coups. Catherine I. Supreme Privy Council. Peter II. "The Plan" of the leaders and the reign of Anna Ioannovna. Bironovschina. The political strug-gle and the palace coup of 1741. Socio-economic policy of Elizabeth Petrovna. Russia's participation in the Seven Years War. The reign of Peter III. The palace coup of 1762 and the accession of Catherine II to the throne.

"Enlightened absolutism" and its features in Austria, Prussia, and Russia. Russia's participation in pan-European conflicts - wars for the Polish and Austrian in-heritance, in the Seven Years War. "Ottoman factor" of European politics; Russia's contribution to the fight against the Turkish threat. Strengthening of the interna-tional authority of the country.

Catherine II: the origins and essence of the "dualism" in her domestic politics. "Enlightened absolutism." The up-rising led by Emelyan Pugachev. The nature and orienta-tion of the reforms of Catherine the Great. The new legal status of the nobility. Sections of Poland. The annexation of Crimea and a number of other territories in the south. Domestic and foreign policy of Paul I. Russian culture in the middle of the XVIII century. Enlightenment ideas and "Enlightened society" in Russia. Achievements of architecture and fine art. Baroque and classicism in Rus-sia.

The territory and population of the Russian empire. Fea-tures of Russian colonization. The role of the geograph-ical factor in the socio-economic and political develop-ment of Russia. The national question. Social structure. Nobility. Clergy. Urban population. Peasantry. Cossacks. Social and cultural gap between estates. Aristocratic cul-ture and the "culture of the silent majority."

Reforms of the beginning of the reign of Alexander I. Ideological struggle. M.M. Speransky, N.N. Novosiltsev, N.M. Karamzin. The French Revolution and its influence on the political and sociocultural development of Euro-pean countries. World War 1812. Russia in 1815–1825. Constitutional drafts. The reasons for the failure of the reforms of Alexander I. A.A. Arakcheev. Military settle-ments. Social movements and the Decembrist uprising. The significance of Russia's victory in the war against Napoleon and the liberation campaign of Russia in Eu-rope to strengthen Russia's international position. Rus-sian autocracy and the "Holy Union". Change in political course in the early 1820s: causes and consequences.

Nicholas I. Change of political priorities. The role of bu-reaucracy. Official nationalism. Conservatism in the state legal and ideological spheres. Domestic policy of Nicho-las I. Russian legal system. Code of laws of the Russian Empire. State. Features of the Russian monarchy. The system of ministries. Russia and the Christian peoples of the Balkan Peninsula. Russian Empire

and Muslim peo-ples of the Caucasus. Caucasian war. Transcaucasia in the politics of the Russian Empire; struggle with Iran for territory and influence. The entry of Transcaucasia into Russia. Russia and the European Revolutions of 1830–1831, 1848–1849. The Crimean War and the collapse of the "Vienna System".

Reforms of Alexander II. Peasant question: stages of so-lution. Reasons for the abolition of serfdom. Discussion on the economic crisis of the system of serfdom in Rus-sia. The abolition of serfdom and its outcome: economic and social aspects. Judicial and military reforms. Zem-stvo. Financial reforms. Reforms in the field of education and the press. The results of the reforms, their historical significance. Liberals and conservatives. Socialist ideas in Russia. Russian radicals: from nihilists to rebels, propagandists and conspirators. From Narodniki circles to "Narodnaya Volya". Government repressions and rev-olutionary terror. The assassination of Alexander II.

The industrial revolution in Europe and Russia: general and special features. Approval of a multi-ethnic and mul-ti-confessional state. The Russian economy of the late XIX - early XX centuries: booms and crises, their causes. The share of foreign capital in the Russian mining and manufacturing industries. The completion of the indus-trial revolution. Changes in the social structure of society in the context of industrial development. The crisis of the nobility and peasantry. The formation of new social stra-ta. The bourgeoisie and the proletariat.

Conservative course of Alexander III. Restriction of re-form. Tighter censorship. Estates and national govern-ment policies. Social movement: recession and new rise.

Cancellation of the conditions of the Paris peace agree-ment. "Union of the Three Emperors." Russia and the East. Russia and the Slavic question. The Russo-Turkish War of 1877–1878 and its results. Russia and the Euro-pean powers. Annexation of Central Asia.

The search for national-political identity. Slavophiles. Westerners. Government ideology and the birth of the of-ficial theory of “national identity”. The development of science and technology in Russia in the first half of the XIX century. Discoveries and technical inventions. Liter-ature and book publishing. Styles and trends in literature: sentimentalism, romanticism, realism. Musical culture.

Painting: from classicism to romanticism and realism. Architecture. Theatre. Great reforms and Russian culture. Changes in the education system: Church schools, gym-nasiums, universities. The development of science and technology. The Golden Age of Russian Literature. En-lightened nobleman and "wild" landowner. The value of the nobility culture in the history of Russia.

6. Russia and the outer world in the XX century.

Russia in the early twentieth century. The contradictions of "Russian capitalism". Russian-Japanese war. Public life. Liberalism and conservatism. The revolution of 1905-1907. The formation of Russian parliamentarism. Political parties in Russia at the beginning of the century: genesis, classification, programs, tactics. State Duma and State Council. Regional management structure. Local government. Strengthening government regulation of the economy. Economic reforms S.Yu. Witte and P.A. Sto-lypin.

Russia in the system of international relations. Problems of catching up in modernization. "Eastern Question" in the foreign policy of the Russian Empire. Capitalist wars of the late XIX - early XX centuries for sales markets and sources of raw materials. The completion of the division of the world and the struggle for the colonies.

Russia in the First World War. The origins of a nation-wide crisis. The crisis of power during the war years and its origins. February revolution. The Provisional Gov-ernment and the Petrograd Soviet. Socio-economic poli-cy of the new government. Crises of power. Bolshevik strategy: reasons for victory. October 1917. The econom-ic program of the Bolsheviks. Civil war and the interven-tion. The first steps of Soviet power. Transformation of the pre-revolutionary ideas of the Bolsheviks: public ad-ministration, army, economy. The formation of a one-party system. The formation of a new legal system: from the first decrees to the Constitution of 1918.

Government structure. "Soviet democracy" and party bodies. Replacing constitutional authorities with extraor-dinary ones. Centralization of power. Economic, social and political aspects of the policy of "war communism". The crisis of "war communism." New Economic Policy (NEP): essence and directions.

Civil war: reasons, actors, political programs of the par-ties. Red and white terror. The reasons of the defeat of the anti-Bolshevik forces. Russian emigration. Soviet Russia in the international arena. Brest peace. Military intervention of the Entente. Isolation of Soviet Russia. Comintern. Anti-Comintern Pact.

The main directions of socio-political and state develop-ment of the USSR in the 1920-30s. Intra-party struggle: discussions about the ways of socialist modernization of society. Political ascent of I.V. Stalin. The economic foundations of the Soviet political regime. The World Economic Crisis of 1929 and the Great Depression. Dis-cussions about totalitarianism in modern historiography. Forced industrialization: prerequisites, sources of accu-mulation, method, tempos. The policy of total collectivi-zation of agriculture, its economic and social conse-quences. Attempts to return to the borders of the Russian Empire: the Soviet-Finnish war; annexation of the Baltic states, of Bessarabia and Northern Bukovina, of the Western Ukraine.

USSR in the Second World War and the Great Patriotic War. Society during the war. Partisan movement. The main stages of hostilities. Soviet military art. The hero-ism of Soviet people during the war. The role of the So-viet rear. Political system. The militarization of the appa-ratus. Economic management in wartime. The influence of pre-war modernization of the economy on the course of hostilities. The decisive contribution of the Soviet Un-ion to the defeat of fascism. Conferences in Tehran, Yal-ta, and Potsdam.

The restoration of the national economy and the elimina-tion of the atomic monopoly of the United States. The in-fluence of the international situation on the direction of economic development. Military-industrial complex. Power and society in the first post-war years. The strug-gle for power after the death of I.V. Stalin. The coming to power of N.S. Khrushchev. Attempts to update the so-cialist system. Economic reforms of the 1950-1960s, the reasons for their failures. Industry: slowdown in modern-ization. "Thaw" in the cultural realm. The significance of the XX and XXII congresses of the CPSU.

Place of the USSR in the post-war world. Turning the USA into a superpower. The beginning of the Cold War and its impact on the economy and foreign policy. The collapse of the colonial system. Creation of NATO and the Warsaw Pact. The formation of the socialist camp and the police department. Creation and development of international financial structures (World Bank, IMF, IBRD). Politico-military crises as part of the Cold War. Socialist camp. Conflicts due to differences in the per-ception of the “de-Stalinization” course: Hungary and Poland versus China and Albania. Liberalization of for-eign policy of the USSR. Attempts of dialogue with the West. International crises. The transformation of neoco-lonialism and economic globalization. Integration pro-cesses in post-war Europe. The Caribbean Crisis (1962).

USSR in 1964-1985. The theory of developed socialism. The role of raw materials. Stagnation in the USSR econ-omy and pre-crisis phenomena in the late 1970s - early 1980s. Dependence on Western high technology. The de-pendence of agriculture on public investment. Attempts of modernization: reform of A.N. Kosygin. Tensions in relations with Western countries. Yu.V. Andropov and an attempt to administratively solve the crisis problems.

The international situation. The war in Vietnam. Arab-Israeli conflict. The socialist movement in the countries of the West and East. Attempts to preserve the existing world order in the early 1970s. "Relaxation of tensions". Improving relations with the West. Helsinki Agreements. The aggravation of relations with the West in the late 1970s - early 1980s. The war in Afghanistan. The final stage of the “Cold War”.

Reasons and first attempts of the comprehensive reform of the Soviet system in the 1980s. Goals and main stages of "perestroika". "New political thinking" and a change in the geopolitical position of the USSR.

Foreign policy of the USSR in 1985–1991. The end of the Cold War. The withdrawal of Soviet troops from Af-ghanistan. The collapse of the Warsaw Pact and the crisis of the world socialist system. The collapse of the bipolar world. State Emergency Committee and the collapse of socialist reformism in the USSR. The collapse of the USSR. The creation of CIS.

7. Russia and the outer world in the end of XX and the beginning of XXI century

Changes in the economic and political system in Russia in the 1990s. The liberal concept of Russian reforms: the transition to a market, the formation of civil society and the rule of law. “Shock therapy” of economic reforms in the early 1990's. The sharp polarization of society in Russia. Deterioration of the economic situation of a sig-nificant part of the population. The role of raw materials. Russian economy in the global economic system.

The constitutional crisis in Russia in 1993 and the dis-mantling of the power system of the Soviets. 1993 Con-stitution of the Russian Federation. System of separation of powers. The president. The State Duma. The princi-ples of federalism. Science, culture, education in market conditions. The first results of reforms and their social consequences.

The military-political crisis in Chechnya. Foreign policy of the Russian Federation in 1991–1999.

Political parties and social movements of Russia at the present stage. Presidential Elections of 2000, 2004, 2008 and 2012. The course of strengthening the interests of the state, economic recovery, social and political stability, and national security.

Russia in world integration processes and the formation of a modern international legal system. Relapses of the Cold War. Russia's place in international conflicts at the beginning of the 21st century. Russia and the CIS. Rus-sia in the system of world economy and international re-lations. Globalization of the world economic, political and cultural space. The end of the unipolar world. The increasing role of China in the global economy and poli-tics. EU expansion to the east. The role of the Russian Federation in the modern world community. Regional and global interests of Russia. The reunification of Cri-mea with Russia and the growth of international tensions in the 2010s.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Immunology/Иммунология

Purpose of the course:

- creation of students' foundations of fundamental knowledge in the field of molecular immunology.

Tasks of the course:

- getting an idea of the anatomical structure, cellular composition and patterns of functioning of the immune system in humans and other mammals; - study of modern concepts of the molecular and cellular mechanisms of immune recognition of pathogens;

- getting an idea of the genetic and biochemical mechanisms of immune reactions;

- consideration of the role of the immune system in the development of socially significant diseases;

- familiarization with the mechanisms of action of the main classes of drugs that affect immunity;

- understanding of the evolution of molecular mechanisms of immunity in various species;

- study of examples of the use of knowledge about the immune system in biotechnology and genetic engineering;

- getting an idea of modern approaches to the study of immunity in humans and experimental animals;

- the formation of the fundamental foundations necessary to increase the creative and research potential of students.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- fundamental foundations of the functioning of the immune system;

- modern level of knowledge and problems of immunology;

- the possibilities of applying the acquired knowledge in medicine, pharmacology, biotechnology and other related fields.

be able to:

- formulate and set the research task and its stage-by-stage implementation;

- master the technique of searching and analyzing information found on the Internet;

- present the results of research in oral and visual form;

- draw correct conclusions from the comparison of the results of theory and experiment;

- use your knowledge to solve fundamental and applied problems and technological problems.

master:

- skills of mastering a large amount of information;

- skills of independent work in the laboratory and the Internet;

- skills of competent processing of experience results and comparison with theoretical data;

- practice of research and solving theoretical and applied problems.

Content of the course (training module), structured by topics (sections):

1. History of immunology, humoral and cellular theory of immunity. Principles of immunological recognition. The main stages of the immune response, features of the immune response to various types of pathogens. Effector mechanisms of innate immunity.

History of immunology, humoral and cellular theory of immunity. Principles of immunological recognition. The main stages of the immune response, features of the immune response to various types of pathogens. Effector mechanisms of innate immunity.

2. Classification of cells of the immune system. Hematopoiesis scheme. Dendritic cells. Human lymphatic system. The structure of the secondary lymphoid organs. Patterns of migration of myeloid cells and lymphocytes.

Classification of cells of the immune system. Hematopoiesis scheme. Dendritic cells. Human lymphatic system. The structure of the secondary lymphoid organs. Patterns of migration of myeloid cells and lymphocytes.

3. Innate immunity receptors: major families, localization, ligand recognition and signaling. Complement system.

Innate immunity receptors: major families, localization, ligand recognition and signaling. Complement system.

4. Cytokines, classification by receptor type. Chemokines. The TNF superfamily.

Cytokines, classification by receptor type. Chemokines. The TNF superfamily.

5. Development of lymphocytes in mice and humans. Receptors of lymphocytes and the formation of their diversity. Proteins involved in V (D) J recombination. Somatic hypermutation and isotype switching.

Development of lymphocytes in mice and humans. Receptors of lymphocytes and the formation of their diversity. Proteins involved in V (D) J recombination. Somatic hypermutation and isotype switching.

6. Formation of ligands for the T-cell receptor. Lymphocyte activation. Activation motifs and kinases associated with receptors. Signaling cascades and transcription factors.

Formation of ligands for the T-cell receptor. Lymphocyte activation. Activation motifs and kinases associated with receptors. Signaling cascades and transcription factors.

7. Molecular basis of costimulation. Differentiation of T-helpers and the choice of the type of immune response. Regulation of the immune response. Regulatory T cells. Immunological memory and secondary immune response.

Molecular basis of costimulation. Differentiation of T-helpers and the choice of the type of immune response. Regulation of the immune response. Regulatory T cells. Immunological memory and secondary immune response.

8. Pathological processes directly related to immunity: immunodeficiencies, autoimmune diseases, allergic reactions.

Pathological processes directly related to immunity: immunodeficiencies, autoimmune diseases, allergic reactions.

9. Oncoimmunology, concept of immunological surveillance. Antitumor immunity and approaches to its stimulation. Use of mouse models in cancer immunology.

Oncoimmunology, concept of immunological surveillance. Antitumor immunity and approaches to its stimulation. Use of mouse models in cancer immunology.

10. Mechanisms used by pathogenic viruses and bacteria to suppress host immune responses. The role of commensal microflora in maintaining immune homeostasis.

Mechanisms used by pathogenic viruses and bacteria to suppress host immune responses. The role of commensal microflora in maintaining immune homeostasis.

11. Pharmaceuticals that activate immunity and immunosuppressants. Clinical use of monoclonal antibodies, cytokines and their blockers.

Pharmaceuticals that activate immunity and immunosuppressants. Clinical use of monoclonal antibodies, cytokines and their blockers.

12. Phylogenesis of the immune system, features of antibodies in cartilaginous fish, the structure of antibodies in cyclostomes. Cas / CRISPR system in bacteria and its application in genetic engineering.

Phylogenesis of the immune system, features of antibodies in cartilaginous fish, the structure of antibodies in cyclostomes. Cas / CRISPR system in bacteria and its application in genetic engineering.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Introduction to Mathematical Analysis/Введение в математический анализ

Purpose of the course:

Formation of basic knowledge in mathematical analysis for further use in other areas of mathematical knowledge and disciplines with natural science content; the formation of a mathematical culture, research skills and the ability to apply knowledge in practice.

Tasks of the course:

- Acquisition of theoretical knowledge and practical skills by students in the field of the theory of limits, differential and integral calculus, the theory of series;

- preparing students for the study of related mathematical disciplines;

- acquisition of skills in the application of methods of mathematical analysis in physics and other natural science disciplines

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic properties of the limits of sequences and functions of a real variable, derivative, differential, indefinite integral; properties of functions that are continuous on a segment;

- basic "remarkable limits", tabular formulas for derivatives, formulas for differentiation.

be able to:

- write down statements using logical symbols;

- calculate the limits of sequences and functions of a real variable;

- calculate the derivatives of elementary functions, expand elementary functions according to the Taylor formula; calculate the limits of functions using L'Hôpital's rule.

master:

- the subject language of classical mathematical analysis, used in the construction of the theory of limits;

- the apparatus of the theory of limits, differential and integral calculus for solving various problems arising in physics, technology, economics and other applied disciplines.

Content of the course (training module), structured by topics (sections):

1. Algebraic equations and inequalities

1.1. Quadratic equations. Vieta's theorem. Graph of a quadratic function. Biquadratic equations. The main theorem of algebra. Method of intervals for solving inequalities

2. Progression

2.1. Arithmetic and geometric progressions. Sum of arithmetic and geometric progression.

3. Trigonometry

3.1. Unit circle, trigonometric functions of an arbitrary argument. Trigonometric formulas. Trigonometric function graphs. The simplest trigonometric equations and inequalities

4. Exponential and logarithmic functions

4.1. Exponential function, its properties and graph. Logarithms. Number e and natural logarithm. Exponential equations and inequalities. Logarithmic function, logarithmic equations and inequalities.

5. Method of mathematical induction

5.1. Formulation of the principle of mathematical induction. Proofs of equalities, inequalities and various statements from elementary algebra and geometry.

6. Real numbers

6.1. Real numbers. Inequality relations between real numbers. Archimedes property. The density of the set of real numbers. The theorem on the existence and uniqueness of the exact upper (lower) bound on a numerical set bounded above (below). Arithmetic operations with real numbers. Infinite decimal representation of real numbers. The countability of the set of rational numbers, the uncountability of the set of real numbers.

7. Sequence limits

7.1. Limit of a numerical sequence. Cantor's nested line segment theorem. Uniqueness of the limit. Infinitesimal sequences and their properties. Limit properties related to inequalities. Arithmetic operations with converging sequences. Weierstrass' theorem on the limit of a monotone bounded sequence. The number e. Infinitely large sequences and their properties.

7.2. Subsequences, partial limits. Upper and lower limits of a number sequence. Bolzano-Weierstrass theorem. Cauchy's criterion for the convergence of a sequence.

8. Limit and continuity of functions

8.1 Theorem on the one-sided limit of a monotone function. Weierstrass' extreme value theorem. Intermediate value theorem. Uniform continuity.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Life Safety/Безопасность жизнедеятельности

Purpose of the course:

The discipline enables the students to develop integral soft skills and acquire general professional and special undergraduate-level competencies in all the academic fields at MIPT. In addition, students will achieve competencies in the Health and Safety field, including the following:

- in human-mediated interactions with natural, anthropogenic, and socioeconomic environments, as well as protection of the human body from adverse external and internal factors;

- safe individual and collective behavior in day-to-day life (the basics of healthy living), in high risk and emergency situations;

- risk and safety theories;

- the government policy of the Russian Federation in the field of security, civil defense, and protection of the population and economy in emergency situations;

- correlation between Health and Safety requirements and effective professional activity.

Tasks of the course:

- introducing students to the theoretical foundations and practical implications of health and safety;

- gaining practical knowledge of system analysis methods to solve complex, interdisciplinary issues related to health and safety;

- acquiring basic knowledge of concepts, patterns, ideas, methods, and models in the field of health and safety;

- enabling the students to use humanitarian, social, economic and natural scientific, qualitative and quantitative approaches and methods for analysis and problem-solving in the field of health and safety, to develop these concepts and approaches;

- providing the students with the knowledge, practical skills, and abilities in the field of health and safety;

- developing students' understanding of the correlation between health and safety requirements and effective professional activity;

- developing students' understanding of the value of their outlook and attitude towards individual and collective security, including such relevant aspects as combating terrorism and corruption, promoting environmental security and sustainable development.

This education program will cover the fundamentals of risk and safety theories, including various hazards and threats that can cause vital damage to human interests and the natural environment. Knowing potential hazards and safety rules can reduce the probability or prevent emergencies caused by human factors and mitigate their adverse effects. The education program includes a brief overview of the basic rules for maintaining individual health (ensuring a healthy lifestyle), sanitary and hygiene requirements, and rules of conduct under normal and extreme conditions. The program also addresses social and economic issues related to security and sustainable development, including such important issues for Russia as combating corruption. Implementing this knowledge will enable students to ensure safety at home, in their professional activities, and maintain their work capacity and health for a long time. The program will help students improve their skills in working with information, including in a foreign language.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- natural-scientific and socioeconomic foundations of Health & Safety;
- the fundamentals of risk and safety theory, sustainable development, environmental, technological, socio-economic and health and demographic security;
- rules of conduct in normal and extreme situations and first-aid techniques for accidents, emergencies, disasters;
- basic principles of technological and social risk management, forecasting, prevention and relief of accidents, emergencies, disasters, and their consequences;
- government policy, bodies, and management system in Health and Safety, civil defense, and population and economy protection in emergencies, including legal concepts and modern terminology.

be able to:

- to analyze anthropogenic activities and their connection with environmental, economic, and Health & Safety issues;
- to find, analyze, and summarize information on specific Health and Safety issues;
- to find and analyze the connection between professional tasks and tasks related to ensuring Health & Safety;
- to apply individual Health and Safety knowledge at home, in day-to-day life, and in emergencies;
- to apply individual Health & Safety knowledge in professional settings;
- to apply basic methods of protecting operational staff, population, and economy from potential adverse effects of accidents, emergencies, disasters;

- to execute effective managerial and organizational decisions and other measures in the field of Health & Safety in strict accordance with the law.

master:

- a systematic approach to analyzing contemporary Health and Safety issues;
- basic methods of protecting operational staff, population, and economy from potential adverse effects of accidents, emergencies, disasters;
- principles and basic safety skills in day-to-day life and in professional settings, in particular, in case of accidents and emergencies;
- knowledge of physical fitness and health conditioning to promote and maintain a healthy lifestyle;
- basic legal skills of various law branches to ensure provision of Health and Safety, as well as combating corruption and terrorist threats.

Content of the course (training module), structured by topics (sections):

1. Systematic approach to the analysis of current Health & Safety related issues, including safe environmental interaction and protection from external hazards.

1.1. Introduction. Systematic approach to the analysis of current Health & Safety related issues.

Systematic approach to the analysis of the current Health & Safety issues and their various aspects:

- Health & Safety as a motivated human and social activity;
- Health & Safety, biosphere, technosphere, social sphere, anthropogenic activity, environmental protection, and ecological safety;
- Health & Safety, production and consumption, industrial and operational safety, and labor protection;
- Health & Safety, sustainable development, environmental, and socioeconomic security;
- Health & Safety as a scientific field and information security;
- Health & Safety, individual and collective behavior, security algorithms and systems, civil defense, protection of population and economy in emergencies;
- Health & Safety as an academic discipline. History, objectives, structure, and the organization of the Health & Safety program at MIPT.

Ecology, physics, economics, Health & Safety.

1.2. Natural scientific foundations of Health & Safety. Conditions for the existence of life. Anthropogenic activity. Biosphere, Technosphere, social sphere and security.

Conditions for the existence of life. Natural and artificial environments and Health & Safety. Biosphere.

Interaction of biosystems and modern industrial human societies with various components of the surrounding environment - biosphere, technosphere, and social environment. Man, nature and economy. Ecological approach to analyzing human needs. Humanity and Man as large systems. Classification and hierarchy of human needs.

Ecology, physics, economics and Health & Safety. Concepts of substance flow, free energy, information as the basis for analysis of security and sustainable existence of living systems, including socioeconomic systems.

1.3. Chemical and biological factors affecting Health and Safety.

Conditions for ensuring chemical and biological safety. Quality of air, water, soil, and food.

Chemical hazards and chemical safety. Harmful chemicals, rationing: maximum permissible concentrations and emissions (LOAEL and emission limits). Sources of chemical pollution. Control, elimination, and protection methods.

Highly toxic and carcinogenic substances, their specific side effects on human health.

Chemical and environmental hazards of modern technologies, industrial and municipal waste, standard and emergency discharges. Modern means of liquid, gas, and solid waste management. Monitoring of the chemical composition of the environment.

Occupational safety. Work area. Approximate safe levels of impact (ASLI).

Complex indicators of air and water supply quality. Environmental quality standards and environmental impact levels. Biomonitoring of environmental conditions and test objects.

Biological hazards and biological safety: infectious and invasive diseases, epizootics, epidemics. Monitoring of biological contamination of the environment. Epidemiology and medical safety.

SARS-CoV-2 pandemic.

1.4. Physical factors affecting Health & Safety.

Ionizing radiation and radioactive substances, electromagnetic radiation, sonic and mechanical impact. Examples of specific ways the human body may be physically affected: radiation (ionizing radiation fluxes), electromagnetic fields, noise, artificial lighting, etc. The human body's response to such impact.

Rationing and permissible exposure limits. Control and safety measures.

1.5. Socioeconomic and technological aspects, processes and factors affecting Health & Safety.

Social, economic, and technological safety, and security aspects, including:

- national security
- military security
- economic and financial security
- industrial and technological safety
- scientific safety
- energy and information security
- food safety
- demographic security
- epidemic security

Social and economic threats, events and processes that affect safety and security, including military threats; terrorist threats; corruption; information threats; threats to state sovereignty.

Countering social and economic threats is one of the most important factors in ensuring the socio-economic and national security of Russia and its citizens.

1.6. End-of-section offline testing assignments (or online written survey and face-to-face tutorial).

2. Health and Safety and the internal environment of the human body. Basics of a healthy lifestyle and safe individual and collective behavior in high-risk situations.

2.1. Homeostasis and nonspecific body reactions to adverse effects and stress.

Homeostasis. Dynamic condition of the human body characterized by complete psychophysical and social harmony in normal conditions.

Extreme conditions. The human body's adaptation mechanisms to variations in energy, substance, information flow and survival limits.

Nonspecific reactions of the human body to external factors. Stress. Mechanisms and stages of stress development.

2.2. Healthy living and methods to increase stress resistance.

Stress management and increasing the body's resistance to external factors. Ways to increase the body's stress resistance under short-term and chronic stresses.

The role of active lifestyle and self-preservation for maintaining Health & Safety.

Healthy living and life safety.

2.3. Express diagnostics of the human body condition. Effective stress monitoring methods.

Vital systems of the human body that ensure effective substance, energy, and information flow, as well as the body's normal functioning.

Heart rhythm variability (HRV) - a non-invasive technology that allows real-time assessment of the patient's regulatory systems and solution of numerous prognostic, diagnostic, therapeutic, and preventive tasks.

2.4. Harmful household factors and bad habits: biological, medical, and socio-economic aspects.

Harmful household factors and bad habits: biological, medical, and socio-economic aspects:

- Alcoholism
- Drug abuse
- Metabolic disorders and lack of physical activity;
- Personal and social hygiene, infections, and microbiota of the body;
- Information technologies and society, an objective worldview and information hygiene.

2.5. Individual handling of emergencies and providing first aid.

Self-preservation and handling extreme and dangerous situations.

Providing first aid to oneself and others in case of illness, accidents, emergencies, and disasters.

2.6. End-of-section offline testing assignments (or online written survey and face-to-face tutorial).

3. Foundations of risk and safety theory.

3.1. Hazards: concept, factors, origins, and classification.

Hazards are natural, anthropogenic, social, military, economic or other types of threats, which can harm one's health or cause death, as well as damage the environment.

Classification of hazards:

- by origin: natural, social, military, anthropogenic, ecological, and mixed;

- by nature of its implementation: physical, chemical, biological, and psychophysiological

(according to the official standard (Unified government standard 12.1.0.003-74));

- by a form of manifestation: natural disasters (earthquakes, mudflows, hurricanes, tornados, etc.), industrial and transport accidents, accidental poisoning, etc.

- by type: natural, fire, chemical, radiation, industrial, demographic, social, asteroid, and comet, etc.

- by a zone of occurrence: lithosphere, hydrosphere, atmosphere, and space hazard.

- by type of damage: social, technical, environmental, etc.

- by its scope and amount of damage caused.

3.2. Risk as a hazard. Classification of risks.

Risks classification and ways to determine risk levels: engineering, model, expert, sociological. Factors that determine the ranking level of a hazard (risk): controlled, uncontrolled, visible, invisible risks, selection of risk assessment systems. Voluntary and involuntary hazard, acceptable risks.

Classification of risks: by origin; by type of hazard; by risk nature and amount of risk sources; by risk recipients; by size of the affected area; by risk measurement units. Anthropogenic individual and social (group) risks. Hazard (risk) levels and their quantitative assessment.

Structure of death risks. Criteria for evaluation of hazards related to the quality of life.

Strategic risks of Russia.

3.3. Issues related to quantitative hazard analyses and disaster statistics.

Traditional approach to risk assessments and disaster statistics. Applying laws of probability to estimate the occurrence of accidents, catastrophes, and crises. Heavy-tailed distribution. The Pareto distribution and the truncated Pareto distribution.

Examples of variability and low information value of average figures illustrating the amount of damage caused by a catastrophe, examples of repeatability estimates and the scope of the greatest damage suffered.

3.4. Security and its quantitative analysis.

Security measurement, types, and conditions.

Objectives and methods of security management. Algorithms of personal security and general action plans of government security systems.

Criteria to determine security level: population and environmental approaches. Medical and demographic security: average life expectancy, health indexes, DALY, QALY, etc.

3.5. Classic and modern security concepts and tools.

- The absolute safety concept ("As low as practically achievable", ALAPA), security tools and specific features of the regulatory framework related to this concept: maximum permissible concentrations (MPC), maximum permissible impact levels (MPL), maximum permissible emissions and dumps (MPE and PDS), safety requirements for economic infrastructure assets. Advantages and limitations of the absolute safety concept.

- Cost-benefit concept in traditional monetary theory: advantages, main issues, and disadvantages. Tools and regulatory framework related to this concept.

- The acceptable risk concept ("As low as reasonably achievable," ALARA). Acceptable risk approval and its legal regulation. Optimization of life expectancy and sustainability of environmental systems.

- The concept of natural capital.

- Concepts of sustainable development and environmental security. Sustainable development and environmental security concepts, and concepts based on substance, energy, and information flow analysis. Understanding priorities and ways to ensure sustainable development: technocratic, resource, technological, energy, environmental and cultural paradigms.

3.6. End-of-section offline testing assignments (or online written survey and face-to-face tutorial).

4. Government policy of the Russian Federation in the field of security, civil defense, and protection of the population and economy in emergencies

4.1. Emergency situations: terms and basic concepts. Natural and anthropogenic emergencies; military emergencies and security.

Basic concepts and definitions. Classification of emergencies and components of economic infrastructure by potential hazard. Wartime emergencies and weapons of mass destruction. Natural and anthropogenic accidents and disasters: causes and consequences. Emergency situations: development phases, adverse effects of natural, anthropogenic, and military emergencies and their features. Classification of natural disasters and catastrophes. Natural and anthropogenic emergencies in Russia.

4.2. Civil defense. Warning signals. Ways to improve infrastructure security during emergencies, including wartime. Basic methods of protecting operational staff and population during peacetime and wartime.

Emergency situations and adverse effects of wartime emergencies. Types of weapons of mass destruction, their features, and the consequences of their use. Forecasting and assessing emergency situations. Civil defense. Warning signals.

Sustainability of economic infrastructure in emergency situations. Ways to improve infrastructure security in emergency situations. Individual and collective actions in emergency situations.

Basic methods of protecting operational staff and population during peacetime and wartime. Basic methods of protecting operational staff and population from adverse effects of accidents, catastrophes, natural disasters, and military emergencies. Protective structures and their classification. Evacuation of people and personnel from emergency zones. Medical safety measures. Personal protective equipment and its use.

Basics of rescue and other emergency operations in emergency situations.

4.3. Government policy and management system for protection of the population. Government system for relief of emergencies and their consequences.

Basic principles of government policy aimed to ensure the protection of the population.

Legislative and organizational framework of ensuring Health & Safety of the population.

Ensuring technological safety and labor protection. Ways in which government and businesses can prevent, reduce, and eliminate the adverse effects of emergencies, and ensure technological safety and labor protection.

Government bodies and programs in the field of security and socio-economic development of Russia.

Unified system of prevention and elimination of emergency situations in Russia.

4.4. Combating corruption as a key socioeconomic security task for Russia. Building up a mindset against corruption.

Combating corruption as a key socioeconomic national security task for Russia. Building up a mindset against corruption. Corruption as a social and economic phenomenon that implies that officials and managers at various levels abuse their rights and powers related to their official position, opportunities, authority, and existing connections for personal benefit. The systematic nature of corruption in Russia and the causes and conditions under which corruption occurs and

develops in federal and local government bodies. Forms of corruption. Social, economic, and political consequences of corruption.

Legal aspects of combating corruption. The concept of corruption in Russian legislation. Federal Law dated 25.12.2008 No. 273-FZ “On Combating Corruption.” Federal Law dated 17.07.2009 No. 172-FZ “On Anti-corruption Assessment of Legislation and Draft Legislation.” Defining the essence and traits of corruption as a social, economic, and legal phenomenon. Anti-corruption system in the Russian Federation. Presidential Decree dated 13.04.2010 No. 460 “On National Anti-Corruption Strategy and the National Anti-Corruption Plan for 2010-2011," Presidential Decree dated 21.07.2010 No. 925 “On Implementation of Certain Provisions of the Federal Law On Combating Corruption.” The current vectors of the government anti-corruption policy of the Russian Federation. The essence and implementation of the National Anti-Corruption Strategy. Practical aspects of anti-corruption policy in the Russian Federation.

Public policy of other countries and international cooperation in the fight against corruption. International experience of leading foreign countries in preventing and combating corruption. Participation of the Russian Federation in international cooperation on preventing and combating corruption.

4.5. Terrorist threats and combating terrorism as one of the key objectives facing the world today in the sphere of security.

Terrorism as a political, social, and economic phenomenon, as a tool to achieve political goals, and as a specific type of crime. Factors for the emergence of terrorism including economic inequality, limitation of political and religious freedoms, constraints for development, and ostracism of certain segments of the population (groups, classes, nationalities, religious confessions, and entire states) from participation in government, social and economic life on a national, regional, or global level. Financial, organizational, and other types of terrorism support provided by certain political forces and countries used for achieving their political and economic goals. Historical, ideological, and organizational aspects of the emergence of terrorism as the gravest threat to modern civilization; concepts of extremism and terrorism.

The Russian Federation's government policy in the field of combating terrorism and extremism, rules of conduct, and course of action for civilians in case of a terrorist threat. Social, economic, political, and ideological traits of modern terrorism. Measures to counteract terrorism.

Legal aspects and measures to counter terrorism and extremism in the Russian Federation. Concept of terrorism and extremism in Russian legislation, terrorism as a political phenomenon, and a specific type of crime. The Russian Federation's legal framework in the field of combating terrorism and extremism: Presidential Decree No. 116 dated 15.02.2006 "On Measures to Counteract Terrorism," Federal law No. 115-FZ dated 07.08.2001 "On Combating Money Laundering and Financing of Terrorism" (in part concerning the basic concepts used in this Federal Law; expanding the legal scope of recognizing persons or entities as participants of extremist activity; determining the legal grounds for including certain foreign and international organizations into the list of entities, transactions with which are subject to mandatory government control in case they are recognized as terrorist organizations by Russian courts). Federal law No. 114-FZ dated 25.07.2002 "On Combating Extremist Activity," Federal law No. 153-FZ dated 27.07.2006 "On Amendments to Specific Laws of Russian Federation related to the Enactment of Federal law "On Ratification of the European Convention on the Suppression of Terrorism" and Federal law "On Combating Terrorism" (the purpose of which is the continuous improvement of

the government system of combating terrorism and offer far and wide complex solutions to prevent terrorism threats). The government system of combating terrorism and extremism: government bodies and programs to counteract terrorism and extremism on international, federal, and regional levels (economic, political, organizational, etc.). Preventive measures to counteract terrorism: the experience of the Soviet Union and the Russian Federation.

Public policy of other countries and international cooperation in the field of combating terrorism and extremism. International experience of leading foreign countries in preventing and combating terrorism and extremism. International cooperation and international agreements related to combating terrorism and Russia's participation in this area.

Rules of conduct and course of action for civilians in case of a terrorist threat.

4.6. End-of-section offline testing assignments (or online written survey and face-to-face tutorial).

5. Current Health & Safety issues in professional settings (elective, depending on the chosen specialization), includes a course project (term paper)

Term paper requirements

1. The term paper topic shall be proposed by the lecturer to each student individually or to a small team of two or three students (who will each prepare a separate part of the essay as its co-author), or suggested by the students themselves with prior approval from the lecturer.

2. The term paper shall be submitted in printed form and the electronic version shall be sent to the e-mail address specified by the lecturer (in Word format using Times New Roman size 12 font).

3. The term paper must include a title page and a list of references, including all web links with the indication of the authors and titles of used sources and their time of publication.

4. All quantitative, illustrative, and factual data in the essay shall be documented and provided with appropriate source references.

5. It is required to include recent period publications in the term paper (which were made in the last two years).

5.1. Average life expectancy and other health and demographic factors recognized as criteria for measuring the level of development and security in a society.

Health and demographic criteria for measuring the level of development and security in a society: definitions, examples, historical, country, social, economic, and cultural differences and similarities. Infant mortality. Links between demographic statistics, economic conditions, and socio-cultural traditions and concepts – historical and country patterns and specific features.

5.2. Population reproduction. Demographic and national security, its correlation with death and birth rates.

Reproduction of population and demographic security as critical components of national security. Demographic transition. Targeted attempts at birth rate control. Global demographic security issues.

5.3 Demographic security of Russia.

History and issues of demographic development in Russia. Russian population decline; birth rate and demographic security programs in Russia.

5.4. Biology of the human lifespan.

Mortality rates, hypothetical causes, and dependencies: genetic, ecological, sociocultural, and adaptive determinants. Age as a mortality rate factor, its quantitative and parametric descriptions: the Gompertz function, the Gomperz-Makeham law of mortality, etc. Mortality rates and its variations by species, gender, geographic location, and sociocultural factors. Historical changes in age mortality and life expectancy in human society. Relationship of mortality rates and age structure with the crude figures for mortality rate and life expectancy. Relationship between mortality and specific biological traits, economic, social, political conditions, cultural and health care levels.

5.5. Factors and models of population reproduction.

The birth rate in biological populations and human society. Relationship of birth and mortality rates with other demographic, social, economic, and environmental factors. Demographic models and population change scenarios. Birth rate and its link to economic, cultural, social, political, and environmental conditions. Birth rate, age structure, and its historical evolution. Fertility and demographic transition. Economic and demographic models of population reproduction.

5.6 Prospects for extending active lifespan.

Social and biological aspects of life expectancy. "Immortality" and age-dependent mortality rates.

Social, economic, ecological, and biological determinants of age-dependent mortality rates and life expectancy. Programmed lifespan, mortal deterioration of metabolic processes resulting from the body's continual growth and development ("biological clock" hypothesis), or failure of the body's functions due to various defects accumulated in the process of life activity. Mortality rate models. Modern medicine and life extension prospects. Protection of motherhood and childhood and average life expectancy increase. Healthy living as a genuinely effective way to increase life expectancy. Issues related to the monitoring of the human body condition.

5.7. System analysis of Health & Safety and human development. Sustainable development and environmental security.

Ensuring environmental security and development, international affairs, documents, conventions, and treaties in this area. International cooperation and joint analysis of development and security

problems. The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992: the agenda and the members' stance on the discussed issues. Outcomes and documents. Sustainable development - two views on the same problem. Protecting the interests of developed countries or the need to shift to noosphere thinking? Public policies of different countries and international cooperation on sustainable development and environmental security after the Rio de Janeiro summit (UNCED).

5.8. Physical approach for describing developing systems, their sustainable development and safety.

Free energy as a feature of the system's development capabilities. Free energy analysis and empirical generalizations of developing systems. Optimization criteria for their evolution. Developing ecological systems and biosphere. Concepts of ecological costs and their types - biospheric costs, their properties. The concept of biospheric (ecological) costs as a modification of the sustainable development and security concept, which implies a physical approach to analyzing ecological and socioeconomic systems' evolution. Relationship between the biospheric (ecological) cost concept with other security concepts and socioeconomic development criteria. Empirical, physical, and economic approaches to modeling the future.

5.9. Mathematical modeling in the field of Health & Safety.

5.10. Topics mentioned in section 5 and other topics depending on the specialization and the students’ interest.

6. Test preparation

Topics for mandatory independent study

Topic 1

Ensuring individual safety: rules of conduct in dangerous, extreme, and emergency situations, first aid rules and techniques, including self-care.

Topic 2

Radiation safety standards, methods, and techniques.

Topic 3

Chemical and biological hazards. Highly toxic substances. Normalization of environmental conditions. Monitoring and ensuring chemical and biological safety.

Topic 4

Government security management policy, bodies, systems, and methods.

Topic 5

Civil defense and emergency situations. Warning signals. Ways to improve the protection of population and economic infrastructure in emergency situations.

Topic 6

Issues related to Health and Safety and sustainable development in Russia.

Topic 7

Countering corruption and building up a mindset against corruption.

Topic 8

Terrorism as a socioeconomic phenomenon and combating terrorism.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Linear Algebra/Линейная алгебра

Purpose of the course:

familiarization of students with the basics of linear algebra and preparation for the study of other mathematical courses – differential equations, the theory of functions of complex variables, equations of mathematical physics, functional analysis, analytical mechanics, theoretical physics, methods of optimal control, etc.

Tasks of the course:

- students acquire theoretical knowledge and practical skills in the field of matrix algebra, the theory of linear spaces;

- preparing students for the study of related mathematical disciplines;

- acquisition of skills in the application of analytical methods in physics and other natural sciences.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- operations with matrices, systems of linear algebraic equations matrices and determinants;

- theorems on systems of linear Kronecker-Capelli and Fredholm equations, Kramer rule, General solution of a system of linear equations;

- basic definitions and theorems on linear spaces and subspaces, on linear maps of linear spaces;

- definitions and basic properties of eigenvectors, eigenvalues, characteristic polynomial;

- reduction of the quadratic form to the canonical form, the law of inertia, the Sylvester criterion;

- coordinate recording of the scalar product, the basic properties of self-adjoint transformations;

- fundamentals of the theory of linear spaces in the volume that provides the study of analytical mechanics, theoretical physics and optimal control methods.

be able to:

- to produce a matrix, finding inverse of a matrix, to compute determinants;

- find a numerical solution to a system of linear equations. find eigenvalues and eigenvectors of linear transformations, bring the quadratic form to the canonical form, find the orthonormal basis of the eigenvectors of the self-adjoint transformation;

- operate with elements and concepts of linear space, including the main types of dependencies: linear operators, bilinear and quadratic forms.

master:

- general concepts and definitions related to matrix algebra;

- geometric interpretation of systems of linear equations and their solutions;

- concepts of linear space, matrix notation of subspaces and maps;

- conduct about the use of spectral problems;

- applications of quadratic shapes in geometry and analysis;

- concepts of conjugate and orthogonal transformation;

- applications of Euclidean metrics in geometry and analysis problems, various applications of the symmetric spectral problem;

- the ability to use the necessary literature to solve problems of increased difficulty (in the variable part of the course).

Content of the course (training module), structured by topics (sections):

1. Matrices and systems of linear equations

1.1. Solving systems of linear equations by the Kramer method. The rank of a matrix. Basic minor theorem. Theorem on the rank of the matrix.

1.2. Linear equation system. Kronecker-Capelli Theorem. Fundamental system of solutions and General solution of a homogeneous system of linear equations. The General solution of the inhomogeneous system. Gauss method. The Theorem OfFredholm.

2. Linear space

2.1. The axioms of a linear space. Linear dependence and linear independence of element systems in linear space. Dimension and basis. Subspaces and linear shells in linear space. Sum and intersection of subspaces. Direct sum. The formula for the dimension of the sum of subspaces. Derivation of the dimension formula of the sum of subspaces. Hyperplanes.

2.2. The expansion of the basis in a linear space. Coordinate representation of linear space elements and operations with them. Theorem on isomorphism. The coordinate form of the necessary and sufficient condition of the linear dependence of the elements.

2.3. Change of coordinates when changing the basis in linear space. Transition matrix and its properties. The coordinate form of the task subspaces and hyperplanes.

3. Linear dependences in linear spaces

3.1. Linear mappings and linear transformations of linear space. Operations on linear transformations. Inverse transformation. Linear space of linear maps. Algebra of linear transformations.

3.2. Linear mapping and linear transformation matrices for finite dimensional spaces. Operations on linear transformations in coordinate form. The change of the matrix of the linear display when changing bases. Isomorphism of the space of linear maps and the space of matrices.

3.3. Invariant subspaces of linear transformations. Eigenvectors and eigenvalues. Own subspaces. Linear independence of eigenvectors belonging to different eigenvectors.

3.4. Finding eigenvalues and eigenvectors of linear transformation of finite-dimensional linear space. Characteristic equation. Evaluation of the dimension of the private subspace. Diagonalizability conditions of the linear transformation matrix. Reduction of the matrix of linear transformation to a triangular form.

3.5. Linear form. Conjugate (dual) space. Biorthogonal basis. Secondary conjugate space.

4. Nonlinear dependences in linear spaces

4.1. Bilinear and quadratic forms. Their coordinate representation in a finite-dimensional linear space. Changing the matrices of bilinear and quadratic forms when changing the basis.

4.2. Reduction of the quadratic form to the canonical form by the Lagrange method. Inertia theorem for quadratic forms. Sign-definite quadratic forms. Sylvester's Test. Reduction of the quadratic form to the diagonal form by elementary transformations. FormulationofJordan'stheorem.

5. Eucledean space

5.1. Axiomatics of Euclidean space. The Cauchy-Schwarz Inequality. Triangle inequality. Gram matrix and its properties.

5.2. Finite-dimensional Euclidean space. Orthogonalization of the basis. Transition from one orthonormal basis to another. The orthogonal complement of the subspace.

5.3. Linear transformations of Euclidean space. Orthogonal projection on the subspace. Conjugate transformations, their properties. The coordinate form of the conjugation of the finite-dimensional Euclidean space transformation.

5.4. Self-conjugate transformations. Properties of their eigenvectors and eigenvalues. Existence of a basis from eigenvectors of a self-adjoint transformation.

5.5. Orthogonal transformations. Their properties are a Coordinate sign of orthogonality. Properties of orthogonal matrices. Polar decomposition of linear transformations of Euclidean space. Canonical form of the orthogonal transformation matrix. Singular decomposition.

5.6. Construction of an orthonormal basis in which the quadratic form has a diagonal form. Simultaneous reduction to the diagonal form of a pair of quadratic forms, one of which is sign-definite.

6. Unitary space

6.1. Unitary space and its axiomatics. Unitary and Hermitian matrices. Unitary and Hermitian transformations. Hermitian form. Properties of unitary and Hermitian transformations. Properties of Hermitian forms.

6.2. The concept of tensors. Basic tensor operations. Tensors in Euclidean space. Tensors in orthonormal basis.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Machine Learning I/Машинное обучение I

Purpose of the course:

To learn data analysis concepts and methods

Tasks of the course:

Learn mathematical basics of data analysis

Learn programming tools for data processing and analysis

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

Mathematical foundations of data analysis

be able to:

To prepare source data

To find key features

To choose proper method to process

master:

Data processing methods and tools

Data analysis methods and tools

Content of the course (training module), structured by topics (sections):

1. Natural language processing techniques

Presentation of texts in vector form. Classic and deep learning approaches. Word2vec, GloVe. Latent (hidden) representation of sequences using recurrent neural networks.

The vanishing gradient problem. Exploding gradient problem. Convolutional networks in text analysis.

Machine translate. Historical excursion. Statistical machine translation. Translation quality assessment. Neural networks in machine translation. The concept of encoder and decoder. Ray search

Attention mechanism in artificial neural networks. Attention mechanism in machine translation.

Transformer architecture (everything you need). Self-attention mechanism.

Pretrained views (attachments). Architectures and methods used in ELMo, GPT (1, 2, 3), BERT, RoBERTa.

2. Introduction to Reinforcement Learning

Historical excursion. Basic concepts of reinforcement learning. Strategy. Agent. Wednesday. Cross entropy method. Genetic algorithm.

Bellman's equations. Value iteration, policy iteration. Value function, q function.

Learning without an environment model. Q-learning. Autocorrelation problem. Double Q-learning. Experience replay. Review of the achievements of recent years.

Estimation of the gradient for in cases where it is not possible to find the gradient analytically. Log-derivative trick. Policy gradient. REINFORCE algorithm.

Getting more robust estimates for the gradient. Baselines. Advantage Actor Critic (A2C) method.

Reinforcement learning methods in applied problems. Self-critical Sequence Training (in a text generation task).

3. Deep Learning in Computer Vision

Historical excursion. Methods widely used before the popularization of neural networks. Pretrained models. Additional training of models for a specific task.

The task of recognizing and detecting objects in the image. Object detection. An overview of the approaches used on the example of architectures: R-CNN, Fast R-CNN, Faster R-CNN, YOLO (1, 2, 3, 4).

Image segmentation. An overview of the approaches used on the example of U-Net, Mask R-CNN architectures.

Transferring styles between images using neural networks.

Generative networks. Variational Autoencoder (VAE). Generative adversarial networks (GANs). Generator and discriminator concepts. Multiobjective optimization.

An overview of the relevant tasks of computer vision: biometrics, tracking objects in the frame, behavior analysis, assessment of the traffic situation in autopilots, increasing resolution (super-resolution imaging), etc.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Mathematical Analysis – Functions of One Variable/Математический анализ – функции одной переменной

Purpose of the course:

Formation of basic knowledge in mathematical analysis for further use in other areas of mathematical knowledge and disciplines with natural science content; the formation of a mathematical culture, research skills and the ability to apply knowledge in practice.

Tasks of the course:

- Acquisition of theoretical knowledge and practical skills by students in the field of the theory of limits, differential and integral calculus, the theory of series;

- preparing students for the study of related mathematical disciplines;

- the acquisition of skills in the application of methods of mathematical analysis in physics and other natural science disciplines.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic properties of the limits of sequences and functions of a real variable, derivative, differential, indefinite integral; properties of functions that are continuous on a segment;

- basic "remarkable limits", tabular formulas for derivatives and indefinite integrals, differentiation formulas, basic expansions of elementary functions according to Taylor's formula;

- basic formulas of differential geometry;

- definition and properties of definite and indefinite integrals, their relationship;

- convergence criteria for improper integrals with power, logarithmic and exponential singularities.

be able to:

- write down statements using logical symbols;

- calculate the limits of sequences and functions of a real variable;

- calculate the derivatives of elementary functions, expand elementary functions according to the Taylor formula; calculate the limits of functions using the Taylor formula and L'Hôpital's rule;

- build graphs of functions using the first and second derivatives; explore functions for local extremum, as well as find their largest and smallest values at intervals;

- calculate the curvature of plane and spatial curves;

- calculate the indefinite and definite integral;

- use a certain integral to solve applied problems.

master:

- the subject language of classical mathematical analysis, used in the construction of the theory of limits;

- the apparatus of the theory of limits, differential and integral calculus for solving various problems arising in physics, technology, economics and other applied disciplines.

Content of the course (training module), structured by topics (sections):

1. Taylor's formula

1.1. Basic rules for differentiation. Fermat's theorem (a necessary condition for a local extremum). Rolle, Lagrange, Cauchy mean theorems.

1.2. Derivative of an inverse and complex function.

1.3. Higher order derivatives. Leibniz's formula for the n-th derivative of the product. Differential of the second order. The lack of invariance of its form with respect to the change of variable. Higher-order differentials.

2. Application of the derivative to the study of functions

2.1. Taylor's formula with remainder in the Peano and Lagrange forms.

2.2. L'Hôpital's rule for disclosing species uncertainties.

3. Differential geometry elements

3.1. Sufficient conditions for monotonicity, sufficient conditions for a local extremum in terms of the first and second derivatives. Convexity, inflection points. Sufficient conditions for a local extremum in terms of higher derivatives.

3.2. Plotting functions - asymptotes, studying the intervals of monotonicity and points of local extremum, intervals of convexity and points of inflection. Study for convexity and concavity. Plotting functions.

4. Indefinite integral

4.1. Curves on the plane and in space. Smooth curves tangent to a smooth curve.

4.2. Lagrange's theorem for vector functions, arc length of a curve.

4.3. Derivative of variable arc length. Natural parameter. Curvature of a curve, formulas for its calculation. Accompanying trihedron of the space curve.

5. Definite integral

5.1. Antiderivative and indefinite integral. Linearity of the indefinite integral, integration by substitution and by parts. Integration of rational functions.

5.2. Basic techniques for integrating irrational and transcendental functions.

6. Improper integral

6.1. The definite Riemann integral. Riemann sums, Darboux sums, integrability criterion.

6.2. Integrability of a continuous function, integrability of a monotone function, integrability of a bounded function with a finite number of discontinuity points.

6.3. Properties of integrable functions: additivity of an integral over segments, linearity of an integral, integrability of a product, integrability of the modulus of an integrable function, integration of inequalities, mean value theorem.

6.4. Integral properties with variable upper limit - continuity, differentiability. Newton-Leibniz formula. Integration by substitution and by parts in a definite integral.

6.5. Geometric applications of a definite integral - area of a curved trapezoid, volume of a body of revolution, length of a curve, surface area of revolution.

7. Derivatives of functions

7.1. Improper integral (the case of an unbounded function and the case of an infinite limit of integration). Cauchy's criterion for the convergence of an integral.

7.2. Integrals of functions of constant sign, criteria for comparing convergence. Integrals of alternating functions; absolute and conditional convergence. Dirichlet and Abel signs.

8. Number series

8.1. Number series. Cauchy's criterion for convergence of a series. Sign-constant series: criteria for comparing convergence, d'Alembert and Cauchy criteria, integral criterion. Alternating series: absolute and conditional convergence. Dirichlet and Abel signs.

8.2. The independence of the sum of an absolutely convergent series on the order of the terms. Riemann's theorem on the permutation of the terms of a conditionally convergent series. The product of absolutely converging series.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Mathematical Analysis – Sequences and Series of Functions, Functions of Several Variables/Математический анализ – функциональные последовательности и

Purpose of the course:

further familiarization of students with the methods of mathematical analysis, the formation of their evidence-based and logical thinking.

Tasks of the course:

• formation of students' theoretical knowledge and practical skills in the problems of searching for unconditional and conditional extrema of a function of many variables, measure and integral theory, field theory;

• preparing students for the study of related mathematical disciplines;

• acquisition of skills in the application of methods of mathematical analysis in physics and other natural science disciplines.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- the implicit function theorem;

- determination of the extremum of a function of many variables and the conditional extremum of a function of many variables in the presence of connections, necessary and sufficient conditions in the problems of finding an unconditional, as well as a conditional extremum in the presence of connections;

- signs of convergence of functional sequences and series.

be able to:

- to investigate functions of many variables for extremum;

- to solve problems on conditional extremum by the method of Lagrange multipliers;

- to investigate functional sequences and series for convergence;

- find the region of convergence of the power series;

- expand regular functions into power series.

master:

Logical thinking, methods of proving mathematical statements.

The skills of calculating integrals and the skills of applying field theory theorems in mathematical and physical applications.

Ability to use the necessary literature to solve problems.

Content of the course (training module), structured by topics (sections):

1. Metric space and topology

1.1. Point n-dimensional Euclidean space. Distance between points, its properties. Limit of a sequence of points in n-dimensional Euclidean space. Bolzano-Weierstrass theorem and Cauchy's criterion for convergence of a sequence. Internal, limit, isolated points of the set; points of contact. Open and closed sets, their properties. Interior, closure and boundary of a set.

2. Limit and continuity of a function of several variables

2.1. Limit of a numeric function of several variables. Definitions according to Heine and Cauchy, their equivalence. Repeated limits and directional limits. Investigation of the limit of a function of two variables using the transition to polar coordinates. Limit of a function over a set.

2.2. Continuity of a function of several variables at a point and over a set. Continuity of a complex function. The properties of functions that are continuous on a compactum are boundedness, achieving exact upper and lower bounds, uniform continuity. A theorem on intermediate values of a function that is continuous in a domain.

3. Differential calculus of functions of several variables

3.1. Partial derivatives of functions of several variables. Differentiability of a function of several variables at a point, differential. Necessary conditions for differentiability, sufficient conditions for differentiability. Differentiability of a complex function. Invariance of the form of the differential under a change of variables. Gradient, its independence from the choice of a rectangular coordinate system. Directional derivative.

3.2. Partial derivatives of higher orders. Independence of the mixed partial derivative from the order of differentiation. Differentials of higher orders, lack of invariance of their form under a change of variables. Taylor's formula for functions of several variables with a remainder in Lagrange and Peano forms.

4. Implicit functions

4.1. System of implicit functions.

4.2. Differentiable mappings.

5. Extrema of functions of several variables

5.1. Local extremum.

5.2. Conditional local extremum.

6. Number series

6.1. Number series. Cauchy's criterion for convergence of a series. Sign-constant series: criteria for comparing convergence, d'Alembert and Cauchy criteria, integral criterion. Alternating series: absolute and conditional convergence. Dirichlet and Abel signs. The independence of the sum of an absolutely convergent series on the order of the terms. Riemann's theorem on the permutation of the terms of a conditionally convergent series. The product of absolutely converging series.

7. Functional sequences and ranks

7.1. Uniform convergence of functional sequences and series. Cauchy's criterion for uniform convergence. Continuity of the sum of a uniformly converging series of their continuous functions. Term-by-term integration and differentiation of functional series. Weierstrass test for uniform convergence of functional series. Dirichlet and Abel signs.

8. Power series

8.1. Power series with complex members. Abel's first theorem. Circle and radius of convergence. The nature of the convergence of a power series in the circle of convergence. Cauchy-Hadamard formula for the radius of convergence. Abel's second theorem. Continuity of the sum of a complex power series.

8.2. Power series with full members. Preservation of the radius of convergence in term-by-term integration and differentiation of a power series. Infinite differentiability of the sum of a power series in the circle of convergence. Uniqueness of the expansion of a function in a power series; Taylor series. Taylor's formula with remainder in integral form. An example of an infinitely differentiable function that does not expand in a power series. Taylor series expansion of basic elementary functions. Power series expansion of a complex function.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Microbiology/Микробиология

Purpose of the course:

Mastering the principles of the work of prokaryotic cells in the framework of summer biological practice.

Tasks of the course:

Gaining knowledge about the principles of work of prokaryotic cells.

Mastering the methods of direct and indirect observation on the example of the issued object.

Obtaining the skills of working with a given object in nature and in experiment.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

How prokaryotic cells work.

Basic methods of working with primary cell cultures.

be able to:

Carry out sampling.

Isolate primary cell cultures.

Carries out the simplest manipulations and solving primary problems associated with primary cell cultures.

master:

Methods for the isolation of primary cultures of prokaryotic cells.

Methods for working with cultures of prokaryotic cells.

Methods of preparation of cell cultures of prokaryotic cells.

Content of the course (training module), structured by topics (sections):

1. The structure of the prokaryotic cell

An overview of the forms characteristic of prokaryotic cells. Determination mechanisms of the prokaryotic cell shape. The structure and synthesis of peptidoglycan. Growth of the peptidoglycan layer in length and thickness?

2. Nucleoid structure

Bacterial chromosomes. DNA-binding proteins.

3. Inclusions

Types and forms. Structure and function.

4. Flagella and drank

Structure. Functions. Education.

5. Protein secretion systems

Transfer from the cytoplasm to the outer membrane of proteins, lipopolysaccharides, lipoproteins. Withdrawal of plasmids from the cytoplasm into the external environment.

6. Ribosomes - structure and function

Ribosome composition. Translation mechanism. History of ribosome research.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Molecular Biology/Молекулярная биология

Purpose of the course:

to introduce students to the basic concepts of molecular biology.

Tasks of the course:

- mastering by students of basic terms and concepts of molecular biology;

- the acquisition by students of the ability to apply the acquired knowledge;

- providing advice and assistance to students in the course of mastering the material.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- fundamental concepts and principles of molecular biology;

- structure and function of proteins and nucleic acids;

- mechanisms of DNA replication, repair and recombination, transcription and translation, as well as control of gene expression;

- mechanisms of membrane transport of small molecules, sorting of proteins and intracellular membrane transport;

- mechanisms of energy conversion by mitochondria and chloroplasts, signal transmission in the cell, cell cycle and cell death;

- functions of stem cells and mechanisms of tissue renewal.

be able to:

- to apply the acquired fundamental knowledge about molecular biology for planning scientific experiments;

- to apply the acquired fundamental knowledge about molecular biology to solve practical problems, including in biotechnology and medicine.

master:

- skills of mastering a large amount of information;

- skills of independent work;

- terminology, including sufficient technical terms.

Content of the course (training module), structured by topics (sections):

1. Cells and Genomes. Biochemistry and Bioenergy

Universal features of cells on Earth. Diversity of genomes and the tree of life. Genetic information in eukaryotes. Chemical components of the cell. Catalysis and energy use by cells. How cells get energy from food.

2. Proteins. DNA, chromosomes and genomes

Chemical components of the cell. Catalysis and energy use by cells. How cells get energy from food. DNA structure and function. Chromosomal DNA and its packaging in chromatin fiber. Chromatin structure and function. The global structure of chromosomes. How genomes evolve.

3. Replication, repair and recombination of DNA. How cells read the genome

Maintaining DNA sequences. DNA replication mechanisms. Initiation and completion of DNA replication in chromosomes. DNA repair. Homologous recombination. Transposition and Conservative Site-Specific Recombination. From DNA to Protein. From DNA to RNA. From RNA to Protein. The world of RNA and the origins of life.

4. Control of gene expression

Gene control overview. Control of transcription using sequence-specific DNA-binding proteins. Transcriptional regulators turn genes on and off. Molecular genetic mechanisms that create and maintain specialized cell types. Mechanisms that enhance cellular memory in plants and animals. Post-transcriptional control. Regulation of gene expression by non-coding RNA.

5. Membrane structure. Membrane transport of small molecules and electrical properties of membranes

Lipid bilayer. Membrane proteins. The principles of membrane transport. Conveyors and active membrane transport. Channels and electrical properties of membranes.

6. Intracellular compartments and protein sorting. Intracellular membrane transport

Cell compartmentalization. Transport of molecules between the nucleus and the cytosol. Transport of proteins to mitochondria and chloroplasts. Peroxisomes. Endoplasmic reticulum. Molecular mechanisms of membrane transport and maintenance of compartment diversity. Transport from the ER through the Golgi apparatus. Transport from the trans-Golgi network to lysosomes. Transport into the cell from the plasma membrane: endocytosis. Transport from the trans-Golgi network to the extracellular space: exocytosis.

7. Cytoskeleton. Intercellular junctions and extracellular matrix

Function and origin of the cytoskeleton. Actin and actin-binding proteins. Myosin and actin. Microtubules. Intermediate fibers and septins. Cell polarization and migration. Intercellular connections. Extracellular matrix of animals. Cell-matrix compounds. Plant cell wall.

8. Energy conversion: mitochondria and chloroplasts. Signaling in a cell

Mitochondria. Proton pumps of the electron transport chain. ATP production in mitochondria. Chloroplasts and photosynthesis. Genetic systems of mitochondria and chloroplasts. Principles of cell signaling. Signaling through g-protein coupled receptors. Signaling through enzymatic receptors. Alternative signaling pathways in gene regulation. Transmission of signals in plants.

9. The cell cycle. Cell death

Cell cycle overview. Cell cycle control system. S phase. Mitosis. Cytokinesis. Meiosis. Control of cell division and cell growth.

10. Stem cells and tissue renewal

Stem cells and epithelial tissue renewal. Fibroblasts and their transformations: a family of connective tissue cells. Genesis and regeneration of skeletal muscles. Blood vessels, lymph vessels, and endothelial cells. The hierarchical system of stem cells: the formation of blood cells. Regeneration and repair. Cell reprogramming and pluripotent stem cells.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Multiple Integrals and Field Theory/Кратные интегралы и теория поля

Purpose of the course:

further familiarization of students with the methods of mathematical analysis, the formation of their evidence-based and logical thinking.

Tasks of the course:

• formation of students' theoretical knowledge and practical skills in the problems of searching for unconditional and conditional extrema of a function of many variables, measure and integral theory, field theory;

• preparing students for the study of related mathematical disciplines;

• acquisition of skills in the application of methods of mathematical analysis in physics and other natural science disciplines.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- definition of a multiple Riemann integral, a criterion for the integrability of a function, a sufficient condition for the integrability of a function, properties of integrable functions, a theorem on the reduction of a multiple integral to a repeated one, physical applications of the integral;

- basic facts and formulas of field theory (formulas of Green, Ostrogradsky-Gauss, Stokes), physical meaning of formulas of field theory.

be able to:

- calculate the integral of a function of many variables over a set;

- be able to solve applied physical problems: calculate body mass, moments of inertia, volumes, etc.

- apply field theory formulas for solving mathematical problems: calculating integrals, finding areas and volumes of bodies, areas of surfaces;

- to apply the formulas of field theory for solving physical problems: checking the potentiality and solenoidality of the field, finding the work of the field when a material point moves, etc .;

- be able to carry out calculations with the nabla operator.

master:

Logical thinking, methods of proving mathematical statements.

The skills of calculating integrals and the skills of applying field theory theorems in mathematical and physical applications.

Ability to use the necessary literature to solve problems.

Content of the course (training module), structured by topics (sections):

1. Curvilinear integrals. Green's formula

1.1. Definition of multiple integral and integrability criterion. Multiple integral properties.

1.2. Reduction of a multiple integral to a repeated one.

1.3. The geometric meaning of the modulus of the Jacobian of a mapping. Change of variables in multiple integrals.

1.1. Definition of multiple integral and integrability criterion. Multiple integral properties.

1.2. Reduction of a multiple integral to a repeated one.

1.3. The geometric meaning of the modulus of the Jacobian of a mapping. Change of variables in multiple integrals.

2. Surfaces. Surface integrals

Green's formula. Potential vector fields on the plane. Condition of independence of a curvilinear integral of the second kind from the path of integration.

3. Field theory: Ostrogradsky-Gauss and Stokes formulas

3.1. Plain smooth surface. Surface integral of the first kind. Independence of the expression of the integral through the parametrization of the surface from the admissible parameter change Surface area.

3.2. Orientation of a simple smooth surface. Surface integral of the second kind, expression in terms of surface parametrization. Piecewise smooth surfaces, their orientation and integrals over them.

4. Multiple integrals

4.1. Gauss-Ostrogradsky formula. Divergence of a vector field, its independence from the choice of a rectangular coordinate system and geometric meaning. Solenoidal vector fields. Connection of solenoidality with turning the field divergence into the rudder. The concept of vector potential.

4.2. Stokes formula. The rotor of a vector field, its independence from the choice of a rectangular coordinate system and its geometric meaning. Potential vector fields. Conditions for the independence of the curvilinear integral from the path of integration. Connection of potentiality with the vanishing of the rotor of the field.

4.3. Vector "nabla" and actions with it. Basic relations containing the nabla vector. Laplacian and vector gradient for scalar and vector fields.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Neurotechnologies&Artificial Intellegence/Нейротехнологии и искусственный интеллект

Purpose of the course:

studying the possibilities of using artificial intelligence algorithms for solving problems in the healthcare industry.

Tasks of the course:

to give an understanding of the existing problems in the healthcare industry and approaches to their solution using machine learning and artificial intelligence.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- decoding of marking of samples of medical devices;

- the main characteristics of the structural levels of a biological object (physical and biological aspects), their relationship with each other; time (frequency) characteristics and biorhythms: their origin, physical and physiological components;

- the system as a philosophical category, its composition and properties; the inevitability of research at the nuclear, atomic and molecular levels; combination of technical and biological parts of the biotechnical system; ideal measuring system, expected integral frequency response, essence of content;

- basic information on the development of new medical devices for measuring the parameters of biological objects in a wide frequency range (from extremely low to extremely high frequencies); priority directions of development of medical science;

- problems of assessing the safety, efficiency and quality of medical devices operating in the extremely low and extremely high frequency ranges;

- monitoring of medical devices.

be able to:

- apply the acquired knowledge in the study of the basic principles of drug development and medical applications.

master:

- statistical skills in processing the results of clinical trials;

- the skills of examination, research and testing of safety, efficacy and quality of medical devices.

Content of the course (training module), structured by topics (sections):

1. Artificial intelligence in medicine: goals, objectives and directions of use

Story. The concept of artificial intelligence, goals, objectives and directions of use. Areas of application in medicine. Examples.

2. The history of medical informatics in the human dimension

The concept of medical information History of the development of medical informatics.

3. AI for Risk Analysis in Cardiology

The use of artificial intelligence in cardiology. An overview of already implemented projects for the use of artificial intelligence in cardiology, which exist at the moment in the development of information technology. The main problems related to artificial intelligence in cardiology are highlighted, and ways of solving these problems are proposed.

4. Routine practice data (Real World Data)

Routine practice data (Real World Data). Research planning. Data analysis.

5. NLP in Medicine and Healthcare

NLP in medicine and healthcare. The problem of natural language processing (NLP) today is the most important trend in the development of artificial intelligence in all areas of human activity.

6. SaMD and data in medicine

SaMD and data in medicine. New criteria for classifying software as medical devices.

7. AI in medical imaging. A case of two-dimensional images (X-ray, histology).

Artificial intelligence in medical imaging. A case of two-dimensional images (X-ray, histology).

8. 3D image processing (CT, MRI). Review of models.

3D image processing (CT, MRI). Review of models. Applications and benefits of 3D printed anatomical models.

9. Exploiting data features to reduce computational complexity

Information technology in the design, manufacture and operation of heat exchangers. Computer-aided design. Design as an information process.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Ordinary Differential Equations/Дифференциальные уравнения

Purpose of the course:

familiarization of students with the basics of differential equations and preparation for the study of other mathematical courses – the theory of functions of complex variables, equations of mathematical physics, optimization and optimal control, functional analysis, etc.

Tasks of the course:

- the acquisition by students of theoretical knowledge and practical skills in the field of solutions of elementary differential equations, linear differential equations and systems, problems in calculus of variations, the study of Cauchy problems, the study of special solutions for the construction and study of phase trajectories of Autonomous systems, finding the first integrals and solutions with their help and nonlinear systems of equations, solving linear equations and systems with variable coefficients;

- preparation of students for the study of related mathematical disciplines;

- acquisition of skills in the application of methods of differential equations in physics and other natural Sciences.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

The simplest types of differential equations, methods of lowering the order of differential equations.

Basic formulas of General and particular solutions of linear systems and equations with constant coefficients, definition and properties of the matrix exponent.

Conditions of existence and uniqueness of the solution of the Cauchy problem for normal systems of differential equations and for the n-th order equation in the normal form, the nature of the dependence of the solutions on the initial conditions. The concept of a special solution.

Formulation of problems of variational calculus.

Basic concepts and properties of phase trajectories of Autonomous systems, classification of equilibrium positions of linear Autonomous systems of the second order.

The concept of the first integral of nonlinear systems of differential equations, their application to the solutions of partial differential equations of the first order, the conditions of existence and uniqueness of the solution of the Cauchy problem for the equation in the first order partial products.

Structure of the General solution of linear systems with variable coefficients, properties of the Vronsky determinant, Liouville-Ostrogradsky formula. Properties of zeros of solutions of differential equations of the second order (Sturm's theorem).

be able to:

To solve the simplest differential equations, to apply methods of order reduction.

Solve linear equations and systems with constant coefficients, apply the matrix exponent to the solution of systems of linear equations with constant coefficients.

Investigate the Cauchy problem. Find special solutions of the equation of the first order, not resolved with respect to the derivative.

To investigate various problems of variational calculus.

Find the equilibrium position, to build the linearized system in a neighborhood of an equilibrium, to determine the type of equilibrium and to construct the phase trajectories of linear systems of second order.

Find the first integrals of systems of differential equations, apply them to solve simple nonlinear systems. Solve first order linear partial differential equations.

Apply the Liouville-Ostrogradsky formula and the method of variation of constants to solve second-order equations with variable coefficients. To investigate the properties of solutions of differential equations of the second order using the theorem of Sturm.

master:

Logical thinking, methods of proof of mathematical statements.

Skills in solving and researching differential equations and systems in mathematical and physical applications.

The ability to use the necessary literature.

Content of the course (training module), structured by topics (sections):

1. The simplest types of differential equations

Basic concept. The simplest types of equations of the first order: equations with separating variables, homogeneous, linear, equations in complete differentials. Integrating factor. A method for introducing a parameter for a first-order equation that is unsolved with respect to a derivative. Methods of decreasing the order of differential equations. Using one-parameter transformation groups to lower the order of differential equations.

2. Linear differential equations and systems with constant coefficients

The formula for the General solution of a linear homogeneous equation of the n-th order. Finding solutions of linear inhomogeneous in the case when the right-hand side of the equation is a quasi multinomial. Euler equation. Study of boundary value problems for the second-order linear equation (in particular, in the presence of a small parameter for the highest derivative). The formula for the General solution of a linear homogeneous system of equations in the case of simple eigenvalues of the coefficient matrix of the system. Theorem on reduction of the matrix of linear transformation to Jordan form (without proof). The formula for the General solution of a linear homogeneous system in the case of multiple eigenvalues of the matrix of coefficients of the system. Finding a solution to a linear inhomogeneous system in the case where the free terms of the equations are vector-quasi-polynomials. Matrix exponent and its use to obtain the General solution formula and solution of the Cauchy problem for linear homogeneous and inhomogeneous systems. Laplace transform and its application to solving linear differential equations with constant coefficients.

3. Elements of variational calculus

Basic concept. The simplest problem of variational calculus. A problem with free ends; a problem for functionals depending on several unknown functions, and a problem for functionals containing higher order derivatives. Isoperimetric problem. Lagrange's Task.

4. The study of the Cauchy problem

Theorem of existence and uniqueness of the solution of the Cauchy problem for normal systems of differential equations and for the n-th order equation in the normal form. Theorem on continuation of solutions of normal systems. The nature of the dependence of the Cauchy problem solution on the parameters and initial data: continuity, differentiability. The Cauchy problem for the first order equation unsolved with respect to the derivative. Special solution.

5. Autonomous systems of differential equations

Basic concepts and properties of phase trajectories. Classification of equilibrium positions of linear Autonomous systems of equations of the second order. The behavior of phase trajectories in the vicinity of the equilibrium position of Autonomous nonlinear systems of second-order equations. Stability and asymptotic stability of the equilibrium position of an Autonomous system. Sufficient conditions for asymptotic stability.

6. First integrals and linear homogeneous partial differential equations of the first order

Basic concepts and properties of phase trajectories. Classification of equilibrium positions of linear Autonomous systems of equations of the second order. The behavior of phase trajectories in the vicinity of the equilibrium position of Autonomous nonlinear systems of second-order equations. Stability and asymptotic stability of the equilibrium position of an Autonomous system. Sufficient conditions for asymptotic stability.

7. Linear differential equations and linear systems of differential equations with variable coefficients

The existence and uniqueness theorem of the Cauchy problem solution for normal linear systems of equations and for the n-th order equation in the normal form. Fundamental system and fundamental matrix of solutions of linear homogeneous system of equations. The structure of the General solution of a linear homogeneous and inhomogeneous system of equations. Vronsky's Determinant. Liouville-Ostrogradsky Formula. The method of variation of constants for a linear

inhomogeneous system of equations. Consequences for linear equations of n-th order. Theorem of Assault and its consequences.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Organic Chemistry/Органическая химия

Purpose of the course:

The course of organic chemistry is designed to form students studying in the direction of "Biotenology" the ideas about the basic concepts and laws of chemistry, chemical reactions and properties of organic substances. The course is the basics of chemical literacy, shows the place of chemistry in modern natural sciences, especially the chemical approach to the study of the world, gives an idea of the methodology and approaches of chemistry to the study of chemical properties of matter, makes it clear that chemistry, being closely related to physics and biology, is an independent science.

The peculiarity of this course is that it is taught in the forth semester and is based only on the knowledge that students have received in the previous semester of the course of General chemistry. The course consists of lectures, seminars and laboratory work. This makes it possible to fully develop the curriculum and the active use of knowledge for the development of further training in such disciplines as chemical physics, biochemistry and biophysics.

Theoretical and practical exploration of fundamental topics of organic chemistry in light of modern trends of development of chemical science that is necessary for a deeper understanding of the possible chemical approach to the study of the world, general regularities of structure of matter and its transformations in nature.

Tasks of the course:

- familiarity with the internal logic of organic chemistry as a science; formation of ideas about the mechanisms of organic reactions;

- study of the main classes of organic compounds; formation of ideas about the relationship of the reactivity of organic molecules with their structure;

- study of laws of interaction of various organic substances with objects of environment, their physiological and pharmacological action, biological role, application in practical activity of the person; formation of representations about the ecological problems connected with use of organic substances.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic concepts of organic chemistry;

- basic properties of the most important classes of organic compounds and their application;

- basic mechanisms of organic reactions;

- basic methods of chemical and spectral identification of organic substances;

- basic methods of work in the laboratory of organic chemistry.

be able to:

- depict the structure of typical representatives of the classes of organic compounds by name and call them by structural formulas based on knowledge of the principles of nomenclature and isomerism;

- to isolate the reaction centers in the molecule, to predict the behavior of the organic compound under specific conditions, based on its structure and knowledge of the typical reactivity of functional groups;

- to carry out a simple chemical experiment for the synthesis, isolation, purification and chemical identification of the substance;

- draw up reports of laboratory work.

master:

- methods for determining the possibility of chemical transformations of the main classes of organic compounds in different conditions;

- methods of safe handling of combustible and toxic substances and laboratory equipment;

- methods of preparation of solutions of the set concentration.

Content of the course (training module), structured by topics (sections):

1. General ideas about the structure and reactivity of organic compounds.

Subject and tasks of organic chemistry. Carbon and organic matter in nature. A brief excursion into the structure of the electron shells of the atom, the example of the carbon atom. Types of chemical bonds and methods of their graphical representation. The concept of hybridization. Methods of imaging molecules of organic compounds (structural formulas, abbreviated structural formulas, Lewis formulas, resonance structures). Mapping a graphical model to a real structure (dashes and arrows). The concept of a functional group, the relationship with chemical properties, the main classes of organic compounds (relationship with functional groups, basic functional groups). Interconversion of connections with different functional groups. Principles of construction of names of organic compounds, systematic and trivial. Homology. Isomerism (skeletal, position). Spatial isomerism. Configuration, unlike conformation. Asymmetric carbon atom, optical activity. Enantiomers and diastereomers. Racemates. Chirality. Different types of chirality. The principle of R, S-nomenclature. Compounds with two asymmetric carbon atoms. Construction of Fisher projections.

2. Saturated hydrocarbons. Homology. Isomers, types of isomerism

Saturated hydrocarbons – alkanes. Structure concept of conformations and conformers of alkanes. Obstructed, hindered, beveled conformation. Newman projection formulas. Conformations of ethane, butane, their energy diagrams. Chemical properties of alkanes: galogenirovannami (chloration, bromation) with the formation of halogenoalkanes. Energy of chain free radical halogenation reactions. Nitration. Relative stability of various alkyl radicals. Thermal cracking of alkanes.

Classification of mechanisms of chemical reactions in organic chemistry. Concepts nucleophile, electrophile. Classification of chemical reactions by result: addition, cleavage, substitution, rearrangement, classification by the nature of the reagent and the type of bond break: heterolytic (nucleophilic, electrophilic), homolytic: (radical), molecular.. The energy profile of the reaction.

3. Unsaturated hydrocarbons (Alkenes and alkynes). Geometric isomerism (concepts CIS -, TRANS-and Z -, E-nomenclature)

The nature of the double bond in alkenes. Geometric isomerism-definitions and concepts of CIS-, TRANS - and Z-, E - nomenclature.

Catalytic hydrogenation of alkenes. Thermodynamic stability of alkenes based on hydrogenation heats.

Electrophilic double bond connection (Ade). Reaction mechanism, π-and σ-complexes, reaction energy profile, bromonium ions. Markovnikov's Rule. Halogenation, hydro-halogenation. Hydration. Conjugate connection. Oxidation of alkenes to diols and oxiranes. Ozonolysis of alkenes, oxidative and reductive cleavage of ozonides. Radical reactions of alkenes: HBr joining in Karasu. Carbenes. Reactions of addition of carbenes to alkenes.

Electronic structure of triple bond in alkynes. Electrophilic addition to alkynes. Reactivity of alkynes. Halogenation, hydrohalogenation, hydration (Kucherov). Reduction of alkynes to CIS - and TRANS-alkenes. C-H acidity of acetylene. Sodium, magnesium and copper acetylenides, their preparation and use in organic synthesis.

4. Functional derivatives with a simple C-Hal bond.

Halogenoalkane, alkenylamine and arivalagan the most important examples. Features of the electronic structure of C-Hal bond. Inductive effect. (Graphical representations of electron density transfer). Common methods of obtaining halogenoalkanes, -alkenes, -alkynes.

Nucleophilic substitution in saturated carbon atom. The concept of nucleophilicity, nucleophiles. Classification of mechanisms of nucleophilic substitution reactions. Main characteristics of SN1 and SN2 reactions. SN2-type reactions. Energy profile of reactions. Kinetics, stereochemistry, Walden circulation. Influence of the nature of the substituent and the outgoing group, the nature of the nucleophilic agent and solvent on the rate of SN2 reactions. SN1-type reactions, dependence on the nature of the radical, the outgoing group, the solvent. Carbocations, their stability. Elimination reactions, α-and β-elimination. Classification of elimination mechanisms: E1, E2. Zaitsev's Rule. Sin - and anti-elimination. The influence of the nature of the base and the outgoing group on the direction of elimination. Competition of E2 and SN2, E1 and SN1 processes. Halogen derivatives of alkenes.

5. Functional derivatives with more than one multiple bond. Alkadiene. Mesomeric effect

1,2 -, 1,3-diene. Butadiene-1,3, structural features, conjugation of double bonds. Galogenirovannami and hydrohalogenation 1,3-dienes. 1,2 - and 1,4-joining.

Diene synthesis as an example of pericyclic reaction. Diels-Alder Reaction. Influence of diene and dienophile structure on regio-and stereo-selectivity of the process. The use of diene synthesis for synthetic purposes. Thermal and photochemical reactions of cycle closure and opening in dienes and polyenes.

6. Cycloalkane. Strain energy. Conformations of cyclohexane

Classification of alicycles. Energy tension. Structure of cyclopropane, cyclobutane, cyclopentane, cyclohexane. Conformations of cyclohexane. Axial and Equatorial bonds in the chair conformation of cyclohexane. Conformations of mono-and disubstituted cyclohexane derivatives and conformational transition barriers. Features of chemical properties of compounds with three-membered cycle.

7. Aromatic hydrocarbon. Aromaticity. Substitution reactions in the aromatic series.

Structure of benzene. Kekule Formula. Molecular orbitals of benzene. Frost Circle. The concept of aromaticity, resonance energy. Hückel's Rule. Aromatic cations and anions. Condensed aromatic hydrocarbons: naphthalene, phenanthrene, anthracene, azulene and other Heterocyclic aromatic compounds.

Substitution reactions in the aromatic series. Classification of aromatic electrophilic substitution reactions. Ideas about the mechanism of reactions, π-and σ-complexes. Resonance structure.The energy profile of the reaction. Arenonium ions in electrophilic substitution reactions. Influence of the substituent on the rate and direction of electrophilic substitution, connection with the electron density distribution. Orientate the first and second kind. Nitration of benzene, reaction mechanism. Getting polynitroalkanes. Halogenation, reaction mechanism of halogenation of arenes, catalysis by Lewis acids. Sulfonation, reaction mechanism, kinetic and thermodynamic control in sulfonation reaction on the example of naphthalene. The concept of ipso attack and ipso substitution. Friedel-Crafts alkylation of arenes, polyalkylation, side processes - isomerization of alkylating agent and final products. Friedel-Crafts acylation of arenes. Acylating agents. Reaction mechanism. regioselectivity of acylation. Gutterman-Koch formylation and related reactions.

Nucleophilic aromatic substitution. General ideas about the mechanism of nucleophilic substitution. The mechanism of cleavage-addition on the example of conversion of halobenzenes into phenols and aromatic amines. The mechanism of joining-splitting. Meisenheimer Complex.

Reactions with the destruction of the aromatic system. Catalytic hydrogenation of arenes, restoration of arenes by Birch.

Reactions not affecting the aromatic system. Oxidation of alkylbenzenes to carboxylic acids, aldehydes and ketones. Oxidation of condensed aromatic hydrocarbons. Substitution of hydrogen in the side chain of alkylbenzenes by halogen. Benzyl radical.Allyl radical. Allyl halogenation. π-Orbitals of the allylic system.

8. Methods of analysis of organic compounds.

Ideas about physical and chemical methods of analysis of organic compounds. Electron absorption spectra of organic compounds in the UV region. Ground and electron-excited States of molecules. Allowed and forbidden transitions. Chromophores and auxochromes. Relation of the position of absorption maxima and intensities with the structure of organic compounds.

Fundamentals of IR spectroscopy - vibrational spectroscopy in the IR region. Origin of vibrational spectra. Selection rules in IR spectroscopy. The intensity of the absorption signals. Characteristic frequencies of functional groups in organic molecules. Detection of compounds with different functional groups and structural analysis of organic compounds using IR spectroscopy.

Concepts of NMR spectroscopy, fundamentals of the method and applications, application for the analysis of organic compounds. General principles of modern pulse NMR spectrometers. Conditions of observation of high-resolution NMR spectra in liquids and gases and rules of sample preparation for measurements. Chemical shifts and spin-spin interaction constants in the 1H-NMR and 13C-NMR spectra of organic compounds. Connection of these parameters with the structure of molecules. Determination of the structure of organic compounds by NMR.

9. Carbon-metal compounds (organometallic compounds)

Lithium-and magnesium-organic compounds, the electronic structure of the carbon-metal bond. Receiving by means of the interaction of the metal with alkyl halides, transmetalation. Structure of Grignard reagents in solution. Schlenk's Equilibrium. Reactions with hydrocarbons (C-h acids). The use of lithium-and magnesium-organic compounds in the synthesis of hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids. Dialkylamide, their synthetic use.

10. Functional derivatives with a simple C-O bond. Alcohols and esters

Monatomic alcohols, thiols. Properties of alcohols, hydrogen bond. Substitution of hydroxyl group in alcohols for halogen (under the action of halides, phosphorus halides, thionyl chloride). Dehydration of alcohols. Oxidation of primary alcohols to aldehydes and carboxylic acids, secondary alcohols to ketones. Oxidation reagents based on chromium anhydride and manganese dioxide. Diatomic alcohols. Ethylene glycol and glycerin. Pinacolada regrouping. Ether. Properties of esters: formation of oxonium salts, cleavage by acids, formation of hydroperoxides. Oxiranes. Disclosure of the oxirane ring under the action of electrophilic and nucleophilic agents. Cyclic ethers, crown ethers. Phenols. Phenols as OH-acids, the effect of substituents on the acidity of phenols. Cumene process. Electrophilic substitution reactions in the aromatic phenols nucleus: halogenation (mechanism), sulfonation, nitration, nitrosation and alkylation. Carboxylation of alkali metal phenolates by Kolbe. Formation of phenols by Reimer-the Timan, and Vilsmaier. Vries regrouping. The rearrangement of allyl ethers of phenols (Claisen). Oxidation of phenols. The concept of hydroxyl radicals.

11. Functional derivatives with one multiple bond C=O. Aldehydes and ketones.

Electronic structure of the carbonyl group, its polarity and polarizability. The most important aldehydes and ketones. Formaldehyde, acetaldehyde, acetone, aromatic aldehydes and ketones. Concepts of the mechanism of nucleophilic addition on carbonyl group. Acid and basic catalysis. Accession of water, alcohols, thiols. Acetals and semiacetale, dioxolane. Getting bisulfite derivatives and cianhydrines. Interaction of aldehydes and ketones with phosphorus ilides (Wittig). Interaction of aldehydes and ketones with nitrogenous bases. Oximes, hydrazones, phenylhydrazones. Schiff bases, methenamine. The Beckmann Rearrangement. Reactions of aldehydes and ketones with organomitallic compounds. Keto-enol tautomerism. Enolization of aldehydes and ketones in halogenation reactions. The influence of structural factors and the nature of the solvent on the position of keto-enol equilibrium and its dependence on the ratio of CH - and OH-acidity of ketone and enol. Dual reactivity of enolate ions. Aldol-Croton condensation of aldehydes and ketones in acid and alkaline medium, reaction mechanism. Benzoin condensation. Aminomethylation of aldehydes and ketones, Mannich reaction.

Reduction reactions of carbonyl compounds. Reduction of aldehydes and ketones to alcohols, reduction reagents; reduction of carbonyl group to CH2-group; Kizhner-wolf and Clemensen reactions. Reductive dimerization of aldehydes and ketones. Oxidation of aldehydes, oxidation reagents. Reductive amination of carbonyl compounds. The interaction of aldehydes and ketones with ammonium formate (Lacerta reaction). Disproportionation of aldehydes by Cannizaro.

12. Functional compounds with carboxyl group. Carboxylic acid. Derivatives of carboxylic acids, halides, esters

Features of the electronic structure of the carboxyl group. Effect of substituents in an organic radical on the acidity of carboxylic acids. Halogenation of acids by Hello-Folgard-Zelinsky. Pyrolytic ketonization, Kolbe reaction, Borodin-Hunsdiecker reaction.

Derivatives of the carboxylic acids. Halides. Properties: interaction with nucleophilic reagents (water, alcohols, ammonia, amines, hydrazine, organometallic compounds). Reduction by Rosenmund and complex metal hydrides. Interaction of diazomethane with halides of carboxylic acids (reaction Arndt-Eistert). Anhydrides. Reactions of anhydrides of acids. The ketene, properties. Esters, esterification reaction. Reactions of esters: hydrolysis (mechanism of acid and basic catalysis), ammonolysis, transesterification. Ester condensation (Claisen), the interaction with magnesium - and organolithium compounds, the recovery of esters to alcohols and aldehydes with complex metal hydrides, the restoration of Buvo-Blanc, acyloin condensation. Reaction of esters with diazomethane. Esters of polyatomic alcohols. Fats, lipids, triglycerides, phospholipids. Amides. Hydrolysis, reduction to amines, dehydration of amides. The concept of sextet rearrangements. Rearrangements Of Hoffmann, Curtius. Nitriles. Hydrolysis, ammonolysis, reduction by complex metal hydrides to amines, interaction with magnesium - and lithium-organic compounds. Dibasic acids. Oxalic, malonic, succinic acid. Diethyloxalate in ester condensation. Syntheses and malonic ether, the Michael reaction, condensation with aldehydes and ketones (Knoevenagel condensation).

13. Nitrogen-containing compounds. Nitroalkanes, amines, diazo compounds

Nitroalkanes. Electronic structure of NO2-group. Acidity and tautomerism of nitroalkanes. Condensation with carbonyl compounds. Restoration of nitro compounds to amines.

Amines. Amines as bases. Alkylation and acylation of amines. Protecting the amino group. Decomposition of tetraalkylammonium hydroxides (Hoffmann elimination).

Aromatic amines. Reduction of aromatic nitro compounds in acid and alkaline medium. Benzidine rearrangement. Comparison of the basic properties of aliphatic and aromatic amines. Effect of substituents amines in the aromatic nucleus on the basicity. Electrophilic substitution reactions in the benzene core of aromatic amines. Oxidation and halogenation of amines.

Diazo compounds. Aromatic diazocompounds. The reaction of diazotization of primary aromatic amines. Mechanism, nature of nitrosing agent. Structure and stability of diazonium salts. Reactions of diazo compounds with nitrogen release: replacement of diazogroup with hydroxyl-, halogen-, cyano -, nitrogroup and hydrogen. Reactions of diazo compounds without nitrogen release: reduction to arylhydrazines, azo combination. The azo coupling reaction electrophilic substitution. Azo - and datastudio, conditions for the combination of amines and phenols. Azo dyes, chromaticity of azo dyes. Aliphatic diazo compounds. The electronic structure of diazomethane, its reaction with carboxylic acids, diazomethane as a source of carbene.

14. Heterocyclic compound. Five-membered and six-membered aromatic heterocycles with one heteroatom

Electronic structure of heterocyclic five-and six-membered aromatic compounds (pyrrole, furan, thiophene, indole, azoles, pyridine, quinoline).

Five-membered aromatic heterocycles with one heteroatom(heterocyclisation). Furan, thiophene, pyrrole.(Electron excess). Acidophobicity of furan and pyrrole. Electrophilic substitution reactions in five-membered aromatic heterocycles (analogy with the reactivity of benzene): nitration, sulfonation, halogenation, formylation, acylation. Orientation of electrophilic substitution. Indole. Electrophilic substitution reactions in the indole pyrrole ring.

Six-membered aromatic heterocycles with one heteroatom. Pyridine and quinoline, electronic structure, comparison with heterocyclization. The basicity of pyridine. Pyridine reactions with alkyl halides. Oxidation and reduction of pyridine. Electrophilic substitution reactions in pyridine and quinoline: nitration, sulfonation, halogenation. N-Oxides of pyridine and quinoline and their use in the nitration reaction. Nucleophilic substitution of hydrogen atoms in pyridine in reactions with sodium amide (the Chichibabin) and phenyllithium.

15. Multifunctional, including natural (biologically important) compounds.

Hydroxo- and oxo- acids, the most important examples, α-β-nomenclature. Acetoacetic ether and its use in synthesis. Keto-enol tautomerism of β-ketoacids esters, ambident character of enolate ion. Dieckmann condensation as a variant of the condensation of Clausen. Acylic condensation of dicarboxylic acid esters in the synthesis of medium and macrocycles. α-β-Unsaturated acids. Fumaric and maleic acids, their esters, maleic anhydride, use in organic synthesis.

Amino acid. Structure and properties of amino acids. α-amino acids, β-amino acids (β-alanine, asparagine). Essential amino acids, stereochemistry of amino acids, D-L-nomenclature. Synthesis of amino acids by Gabriel, Strecker. Separation of racemic amino acid mixtures. Peptides and proteins. Peptide bond. Examples of di - and tri-peptides. Synthesis of peptides. Structure of proteins.

Carbohydrates. Classification and nomenclature of carbohydrates. Monosaccharides and polysaccharides. Types of monosaccharides: trioses, tetroses, pentoses, hexoses (aldoses and ketoses). Spatial structure of monosaccharides, an example of glycerol aldehyde. L - and D-carbohydrates. The formula of Fischer and Hawara. Glucopyranose and glucofuranose. Ring-chain tautomerism of monosaccharides. Conversion of aldose to 2-ketose (mutarotation). The most important reactions of monosaccharides. Synthesis of monosaccharide esters and complex esters. Oxidation of aldose to aldonic acids. Oxidative cleavage. Lengthening and shortening of the carbohydrate chain. Disaccharides (BIOS): maltose, cellobiose, lactose, sucrose. α - and β-disaccharides. Structural features of natural polysaccharides on the example of cellulose and starch.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Partial Differential Equations/Уравнения математической физики

Purpose of the course:

The ultimate goal of the discipline "Equations of Mathematical Physics" is the formation of basic competencies together with the underlying knowledge, skills and abilities of using a standard mathematical apparatus designed to describe physical processes that depend on two or more variables. Typically, such processes are described by partial differential equations. And although in the most interesting cases the equations turn out to be nonlinear, the simplest way to construct a theory of even nonlinear partial differential equations of the second and higher order begins with the linearization of such equations. Due to the fact that the introduction to the theory of quasilinear partial differential equations of the first order was included in the previous course of ordinary differential equations, the general goal of the introductory course in the basic mathematical apparatus for describing multidimensional physical processes is traditionally reduced to the study of methods for solving correctly posed problems of mathematical physics, formulated as problems with initial, boundary and initial-boundary conditions for linear second-order partial differential equations. In this case, equations of order higher than the second, as a rule, remain outside the standard introductory course, despite their importance, for example, for mechanics of continuous media and the theory of elasticity. The main goal of this introductory course is to master the basic classical approaches to solving correctly posed problems, using both analytical methods of solution, supplemented with elements of modern methods, and qualitative methods of analyzing the sought solutions, applicable even when the analytical form of the solutions themselves is not known. Concrete classical problems solved in the course by classical methods should not be perceived purely utilitarian, as solutions of certain problems that can be applied to something, but cannot be applied directly to something. The fundamental motivation for this course should be considered an introduction to classical approaches to classical problems of mathematical physics, which should be perceived rather as the simplest and most understandable samples and examples that can and should be guided by a researcher who poses and solves urgent problems of modern mathematical physics.

Tasks of the course:

To master all stages of solving the problem of mathematical physics according to the complete scheme:

“Classification of the problem - analysis of the correctness of the formulation - the choice of a suitable analytical method for the solution - solution of the problem - analysis of the found solution”. Also master all the stages of the analysis of a problem of mathematical physics of a general type according to an incomplete scheme:

"Classification of the problem - analysis of the correctness of the statement - qualitative analysis of the properties of the desired solution" in the case when the problem does not lend itself to an analytical solution in an explicit form, which for partial differential equations is more a general rule than an exception. In practice, such an analysis makes it possible to quickly determine the correct direction of the search for any other means of solving the problem, in addition to analytical ones, such as, for example, approximate and numerical methods, although based on the MFM course, but going beyond its traditional framework.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- the main types of partial differential equations;

- determination of the characteristic surface;

- basic boundary value problems for equations of hyperbolic type, parabolic type, elliptic type;

- d'Alembert, Poisson, Kirchhoff formulas for the solution of the Cauchy problem for the wave equation;

- maximum principles for parabolic and elliptic equations;

- Fourier method for constructing classical solutions of initial-boundary value problems for the heat equation and the wave equation;

- basic properties of harmonic functions;

- Poisson's formula for the solution of the Dirichlet problem for the Laplace equation in a ball;

- Poisson's formula for the solution of the Neumann problem for the Laplace equation in a ball.

be able to:

- determine the type of partial differential equations; reduce second order equations with variable coefficients to the canonical form;

- to solve by the method of characteristics of the Cauchy and Goursat problem for the hyperbolic equation on the plane;

- to solve mixed problems on the semiaxis for a one-dimensional wave equation;

- solve the Cauchy problem for the wave equation;

- solve the Cauchy problem for the heat equation;

- to apply the Fourier method when solving mixed problems for the wave equation and the heat equation;

- to solve boundary value problems for the Poisson equation in circular and spherical regions.

master:

- determine the type of partial differential equations; reduce second order equations with variable coefficients to the canonical form;

- to solve by the method of characteristics of the Cauchy and Goursat problem for the hyperbolic equation on the plane;

- to solve mixed problems on the semiaxis for a one-dimensional wave equation;

- solve the Cauchy problem for the wave equation;

- solve the Cauchy problem for the heat equation;

- to apply the Fourier method when solving mixed problems for the wave equation and the heat equation;

- to solve boundary value problems for the Poisson equation in circular and spherical regions.

Content of the course (training module), structured by topics (sections):

1. Harmonic functions and their properties.

Harmonic functions. Fundamental solution to the Laplace equation. Potentials of single and double layers. Volume (Newtons) potential. Infinite differentiability of harmonic functions. Average theorems. Singularity elimination theorem. Maximum principle. Liouville's theorem.

2. Cauchy problem for the wave equation.

Wave equation in the case of two and three spatial variables. Flat characteristics of the wave equation, light cone. Statement of the Cauchy problem. Cauchy problem for the wave equation. Necessary conditions for the existence of a solution. Energy conservation law and uniqueness of the solution to the Cauchy problem. Existence of a solution to the Cauchy problem in the cases of three spatial variables (Kirchhoff's formula). Existence of a solution to the Cauchy problem in the case of two spatial variables (Poisson's formula, descent method). Continuous dependence of the solution on the initial functions.

Wave propagation in the case of two and three spatial variables. Diffusion of waves in the case of two spatial variables.

3. Cauchy problem for the heat equation.

The Cauchy problem for the heat equation. Necessary conditions for the existence of a solution. Fundamental solution of the heat conduction equation. Uniqueness of the solution limited in each characteristic strip. Tikhonov's uniqueness class. Solution of the Cauchy problem for the homogeneous heat equation-Poisson's formula. Infinite differentiability of the solution. Maximum principle. Continuous dependence of the solution on the initial function. The absence of a continuous dependence of the solution of the Cauchy problem for the equation of "inverse heat conduction" (example of Hadamard).

4. Classification of equations. Characteristics.

Partial differential equations. Linear differential equations. Classification of second-order equations.

Characteristics of second-order linear equations. Ordinary differential equation for characteristics in the two-dimensional case. Characteristics of the wave equation.

Wave equation in the case of one spatial variable. Statement of the Cauchy problem (in particular, the localized problem), d'Alembert formula. Dependence domain of the solution to the Cauchy problem. Continuous dependence of the solution on the initial functions. An example of the absence of a continuous dependence in the case of the Laplace equation (Hadamard's example).

5. The Fourier method for solving mixed problems for the wave equation and the heat equation.

Mixed problem for a one-dimensional heat equation on a finite segment. Necessary conditions for the solvability of the problem (smoothness conditions for the right-hand side of the equation and the initial and boundary functions and the conditions for their agreement). The maximum principle and the uniqueness theorem. A theorem on the continuous dependence of the solution on the initial and boundary functions.

Fourier's method of proving the theorem on the existence of a solution.

Mixed problem for a one-dimensional wave equation on a finite segment. Necessary conditions for the solvability of the problem (smoothness conditions for the right-hand side of the equation and the initial and boundary functions and the conditions for their agreement). The uniqueness theorem and the theorem on the continuous dependence of the solution on the initial functions (energy conservation law).

Fourier's method of proving the theorem on the existence of a solution.

6. Areas of the outer type. Boundary value problems for the Laplace equation in domains of external type.

Uniqueness of the solution to the external Dirichlet problem. Uniqueness of the solution to the external Neumann problem.

7. Solution of the Dirichlet problem and the Neumann problem for the Laplace equation in a circle and in a ball.

The Dirichlet problem for the Poisson equation in a bounded domain. Necessary conditions for its solvability. Uniqueness of the solution; continuous dependence of the solution on the boundary function. Solution of the Dirichlet problem for the Laplace equation in the ball-Poisson formula.

Neumann's problem for the Poisson equation in a bounded domain. Necessary conditions for solvability. Theorem on the general form of the solution to the problem. Solution of the Neumann problem for the Laplace equation in a ball.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Pathophysiology/Патофизиология

Purpose of the course:

- formation of basic knowledge of cellular and molecular biology and understanding of fundamental physicochemical and biological processes occurring in a living cell, for their subsequent use in a more detailed study of other biological and biochemical disciplines;

- the formation of biological culture and the ability to apply biological knowledge in practice.

Tasks of the course:

- to form basic knowledge of cellular and molecular biology;

- to form an understanding of the fundamental physicochemical and biological processes occurring in a living cell, an understanding of the interaction of cells, the results of this interaction, as well as possible dysfunctions of both individual cellular processes and their totality;

- to form a biological culture: to instill knowledge of the basic concepts of cell biology, the principles of the structure and composition of the cell; to acquaint with the methods of studying cells and their macromolecules, teach to correctly pose and formulate questions in the study of biological disciplines, both theoretical and practical;

- to form skills and contribute to the development of skills to apply the knowledge gained in independent, including research, work, solving problems, as well as analyzing the results.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic concepts and definitions;

- types of cells, their similarities, features and differences;

- the main cellular organelles, their structure and functions, pathologies associated with organelle dysfunctions;

- cell transport, cell transport systems, molecular mechanisms of the process;

- systems of cell reception and signaling;

- interaction of cells on the example of immunity and carcinogenesis.

be able to:

- work with scientific literature on biological topics, including scientific articles and reviews,

- competently formulate an experimental problem, propose ideas for its solution, as well as assume possible results and analyze the actual results.

master:

- knowledge about the theoretical foundations of experimental techniques and manipulations with cells, as well as basic cell macromolecules (proteins, nucleic acids).

Content of the course (training module), structured by topics (sections):

1. Introduction

Causes and mechanisms of functional and biochemical disorders underlying the disease. Mechanisms of adaptation and restoration of functions impaired in disease

(mechanisms of recovery).

2. Cell pathophysiology

Types of damage and cell death. The universal response of a cell to damage. Mechanisms of damage to cell membrane structures.

3. General reactions of the body to damage

General adaptation syndrome. Acute phase reactions. Shock. Coma.

4. Allergy. Autoimmune Disorders

Allergy. Pseudo-allergic reactions. Autoimmune disorders.

5. Inflammation

Basic theories of inflammation. Inflammation etiology. Experimental reproduction of inflammation. The pathogenesis of inflammation. Chronic inflammation. General manifestations of inflammation. The role of reactivity in inflammation. Types of inflammation. The course of inflammation. Inflammation outcomes. The importance of inflammation for the body.

6. Fever

Ontogenesis of fever. Etiology and pathogenesis of fever. Fever stages. Fever types. Fever metabolism. The work of organs and systems with fever. The biological significance of fever. Feverlike conditions. The difference between fever and overheating. The principles of antipyretic therapy.

7. Pathophysiology of internal organs

Pathological changes in the blood system are detected in morphological and functional disorders in organs participating in the processes of hematopoiesis and blood destruction, as well as in

disorders of their regulation as a result of the direct action of various damaging factors, in a number of infectious diseases and in the actual diseases of the blood system.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Philosophy/Философия

Purpose of the course:

ntroduce students to the highest achievements of world philosophical thought, give a clear understanding of the specifics of philosophy, introduce them to the main stag-es and directions of its development, the peculiarities of modern philosophy and its role in culture, instill general theoretical and philosophical thinking skills, contribute to the formation and improvement of independent analyt-ical thinking in the field of humanitarian knowledge, mastery of the principles of a rational philosophical ap-proach to information processes and trends in modern so-ciety

Tasks of the course:

The tasks of the course are:

- formation of a holistic worldview system with natu-ral science, logical-mathematical, philosophical and socio-humanitarian components
- mastering the skills of rational discussion, rational reflection and critical analysis of a theoretical text
- the study of various styles of philosophical think-ing, basic philosophical categories and concepts.
- study of general scientific and philosophical re-search methods

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

The main sections and directions, categories and con-cepts of the history of philosophy and philosophical analysis of social, scientific and general cultural prob-lems to the extent necessary for professional activities and the formation of a citizen's worldview.

be able to:

Organize a system of their activities aimed at solving practical and theoretical problems, taking into account the historical, cultural and philosophical context of their occurrence.

Remove in their practical activities the barriers of nar-row specialization, think interdisciplinarily, identify the epistemological sources of problems and put them in the value context of human culture.

master:

Skills of demonstrative presentation of one's own point of view; skills in public speaking, argumentation, discussion and debate; logical methods of text analysis and reasoning; abilities of critical assessment of infor-mation.

Content of the course (training module), structured by topics (sections):

1. Philosophy, its subject and significance

The historical diversity of the definitions of philosophy. Sections of philosophy. "Being" as a philosophical con-cept and ontology as a doctrine of being. Epistemology. Ethics. Aesthetics. Philosophical Anthropology. The question of man as a philosophical problem. Man / indi-vidual / individuality / personality. Man and society. The nature of man and his essence. Man and his freedom. The problem of the meaning of life. Social philosophy. Man as a social being. Man in society and society in man. So-cium as a system of extra- and supra-individual forms, connections and relations

Man, society and the state. The philosophy of history: the subject of history and its driving forces. Personality – so-ciety – history. The focus of history and its meaning.

The emergence of philosophy and pre-philosophy. Phi-losophy and mythology. The specifics of the philosophy of Ancient China and Ancient India.

The Ancient World and the Genesis of Ancient Greek Philosophy: Social and Epistemological Prerequisites

2. History of ancient philosophy, its role for the development of the world philosophical thought

Periodization of ancient philosophy. The value of ancient philosophical tradition for the development of world philosophical thought.

The period of the pre-Socratics. Antique cosmocentrism, the arche problem, the natural philosophy of the pre-Socratics. Miletus school. Pythagoras and Pythagorean-ism. The philosophical teachings of Heraclitus and the Elean school. Teaching Parmenides about being. The thesis of the identity of being and thinking. Ancient Greek atomism.

Sophists and features of their philosophical position. Socrates, his place and role in the history of European philosophy. A new orientation of philosophy in Socrates. Mayevtica of Socrates.

Plato, his works, the basic principles of philosophical doctrine. Ontology of Plato: being as a hierarchy of ei-dos, the world of being and the world of becoming, the doctrine of matter. Anthropology and social philosophy of Plato. Academy. The meaning of platonism.

Encyclopedic system of Aristotle. Aristotle's doctrine of being: a categorical analysis of existence. Threefold defi-nition of metaphysics as a science of the first principles, of the existing as such and of the divine. Criticism of the Platonic theory of ideas. Essence as a subject of philoso-phy. The problem of the ratio of unit and total. The con-cepts of form and matter, actual and potential. The doc-trine of the Mind as a form of form. Eudaimonic ethics of Aristotle. Man as a social being. Likey. The peripatetic school.

Philosophical teachings of the Hellenistic era, their ethi-cal orientation. Cynics, skeptics, stoics. Epicurus Ploti-nus and the Neoplatonic synthesis of the basic ideas and intuitions of ancient philosophy

.

3. Medieval and Renaissance philosophy

The philosophy of the Middle Ages, its periodization and specificity. Theocentrism and creationism. Philosophy and theology. Relation to the ancient philosophical herit-age. Christian apologetics.

Medieval ontology: God as an absolute being. The main topics of medieval philosophy: faith and reason, anthro-pological ideas, the question of free will, the debate about universals. Greek and latin patristics. Christian an-thropology: man is the image and likeness of God. The concept of "inner man." The concept of "sacred history" in Christianity, eschatologism.

Scholasticism as a philosophy of schools and universi-ties. Platonic orientation of the early scholasticism: real-ism. Arabic philosophy, medieval Aristotelianism, Latin Averroism. Thomas Aquinas and its significance. Nomi-nalism. The tradition of voluntarism in the teachings of Duns Scotus and Occam. Late scholasticism. East Chris-tian theological thought. Doctrine of sv. Gregory Pala-mas about energies. Hesychasm. Philosophical knowledge in Ancient Russia.

Anthropocentrism and Renaissance humanism. The spec-ificity of the philosophy of the Renaissance. The individ-ualistic interpretation of man in the Renaissance. Meta-physics of Nicholas of Cusa. Florence Academy. Panthe-istic ideas D. Bruno.

The Reformation and its influence on the philosophical process of the New Time.

4. Philosophy of the Modern Times

New European philosophy. Criticism of the previous tra-dition, the problems of “experience” and “method”, justi-fication of the project of modern science, innovations in the formulation of epistemological problems. Empiri-cism: F. Bacon, sensationalism of T. Hobbes, D. Locke, D. Berkeley, skepticism of D. Hume. The tradition of ra-tionalism: the main ideas of R. Descartes, B. Spinoza, G. Leibniz and others. The place of ontology in the philoso-phy of the New Time. The idea of substance. The mecha-nistic anthropology of the New Time: man is the “body” and man is the “machine”. Pascal: man is a “thinking reed”.

Social philosophy of the New time. Basic concepts: the idea of "natural law", the theory of social contract, the principle of separation of powers. The mechanistic inter-pretation of society in T. Hobbes's “Leviathan” (the con-cept of “natural state”).

The Age of Enlightenment and the cult of the mind. So-cio-political doctrines of the Enlightenment. Enlighten-ment Ideas in Germany: G. Lessing, I. Herder and others. Features of the reception of educational ideas in Russian philosophical culture of the eighteenth century.

Kant as the founder of German classical philosophy and the creator of transcendental idealism. Key Points Critics of Pure Reason. The doctrine of the antinomies of the mind. Ethical doctrine of I. Kant. The concepts of auton-omous and heterogeneous ethics. Categorical imperative. The concept of debt. The definition of personality and its difference from a thing. The concept of freedom in Kant's philosophy. Post-Kant German idealism: I. Fichte, F. Schelling, romance. The absolute idealism of G. Hegel.

The main directions of 19th-century European philoso-phy: positivism, neo-Kantianism, and others. The Marx-ist theory of class society.

Russian philosophy of the XIX century. Socio-political ideals of the Slavophiles and Westerners. Vl. Soloviev, K. Leontyev and others.

5. Problematic and main trends in the XX century philosophy and of the contemporary philosophical thought

UGHT.

New directions in European philosophy at the beginning of the XX century. Existentialism and its varieties. The fundamental ontology of M. Heidegger: the history of European philosophy as a “history of oblivion of being." Return to ontology: Russian metaphysics, neo-Thomism, etc. Russian philosophical thought in the XX century. Social philosophy of I.A. Ilyin. Anthropological issues in Western European and Russian personalism.

Berdyaev on social inequality, aristocracy, revolution, democracy and anarchy. Phenomenology. Analytical philosophy. Structuralism. Socio-philosophical topics in the philosophical thought of the XX century. Modern discussions in the philosophy of consciousness. Postmodernism and its critics. Contemporary philosophical issues. The problems of the meaning of history, the “end of history” and posthistory, multiculturalism and the “clash of civilizations” in contemporary philosophical discussions.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Physical Chemistry/Физическая химия

Purpose of the course:

- familiarization of students with the basics of physical chemistry (chemical thermodynamics and kinetics, colloidal chemistry and electrochemistry) in the field of high-tech technologies and their practical preparation for further independent work in the field of biochemistry, physics of living systems, biotechnology, nanomaterial technology, materials sciences.

Tasks of the course:

- familiarization of students with the subject, principles, methods and models of physical chemistry;

- acquisition by students of theoretical knowledge, practical skills and skills in the field of research of chemical and electrochemical processes;

- advising, assisting students in conducting their own theoretical and experimental research.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- fundamental concepts, laws and theories of physical chemistry;

- the numerical values of the constants and orders of magnitude of physical quantities, is used in physical chemistry;

- principles of calculating the equilibrium composition of multicomponent systems and constructing phase diagrams;

- conditions of thermodynamic equilibrium, including phase, chemical, electrochemical, interfacial;

- basic methods of physical and chemical analysis, calorimetry and measurement of thermodynamic properties;

- fundamentals of thermodynamics of heterogeneous electrochemical systems;

- types, structure and properties of the main electrodes in potentiometry;

- principles of the device of electrochemical cells for potentiometric, conductometric and electrocapillary measurements;

- general reasons for the formation and stability of dispersed systems;

- basic models for describing the double electric layer at the interface;

- patterns of adsorption at interphase boundaries, electrocapillary phenomena;

- basic regularities of electrokinetic phenomena;

- fundamentals of the theory of electrolyte coagulation;

- regularities of micelle formation in surfactant solutions;

- laws of acting masses and acting surfaces;

- laws on homogeneous catalysis, enzymatic kinetics, interphase catalysis;

- basic laws of the kinetics of electrode processes;

- the theory of active collisions, the activated complex;

- concepts of chain, radical, and polymerization reactions.

be able to:

- identify significant factors in the analysis of physical and chemical processes;

- draw conclusions from comparisons of the results of theory and experiment;

- make numerical estimates;

- make qualitative conclusions in the tasks and problems under consideration;

- to see the physical essence of chemical processes and phenomena in dispersed systems;

- formulate physical and mathematical models of certain chemical phenomena;

- use the reference literature to search for the necessary physical and chemical data and concepts;

- plan the experiment;

- evaluate the error and the degree of reliability of the measured values and the results obtained during their processing;

- find out the sources of errors of the performed measurements.

master:

- skills of independent work in the laboratory on modern experimental equipment;

- skills of mastering large amounts of information;

- skills in setting and analyzing physical and chemical problems;

- methods of experimental research of physical and chemical systems;

- methods of composing and solving kinetic equations for chemical systems;

- skills in processing the results of the experiment and comparing them with theoretical values and reference data.

Content of the course (training module), structured by topics (sections):

1. Thermochemistry. Temperature dependence of thermodynamic functions.

Basic concepts of thermodynamics. The beginnings of thermodynamics. Thermodynamic parameters, functions, and potentials; integral and differential identities between them. Maxwell's reciprocity relations. The Gibbs–Helmholtz equations.

Thermochemistry. Changes in thermodynamic functions as a result of the reaction. The thermal effect of the reaction. Hess' law. Standard conditions and potentials. The Born-Haber cycle. The energy of the chemical bond.

The temperature dependence of the thermodynamic functions. The laws of Kirchhoff. The heat capacity of gases, liquids, and solids, and their relationship to the number of degrees of freedom. The theorem on the equidistribution of energy by degrees of freedom.

2. Phase and chemical equilibria. Fundamentals of thermodynamics of solutions. Activity. Colligative properties of solutions. Phase diagrams.

Chemical potential, its relation to the Gibbs potential. The Gibbs–Dugem equation. The chemical potential of an ideal gas and an ideal solution.

Thermodynamic and kinetic conditions of equilibrium. Mechanical, thermal, and chemical equilibrium. The change in the Gibbs energy during a chemical reaction, the Van't-Hoff isotherm. Determination of the direction of the spontaneous flow of a chemical reaction.

The equilibrium constant and its relation to thermodynamic potentials. The Van't-Hoff equation for the temperature dependence of the equilibrium constant.

Phase equilibria of single-component systems. The Clapeyron–Clausius equation. Phase diagrams. Triple and critical points. The Gibbs phase rule.

Phase equilibria of two-component systems. Abulia and cryoscopy. Osmosis, Van't Hoff's law. Raoul's law. Solubility of gases and solids. Henry's law. Extraction, distribution coefficient.

Phase diagrams of two-component systems. The lever rule. Azeotrope. The eutectic.

3. Electrolyte solutions: description of solubility and ionic composition. Acid-base equilibria. Buffer solutions. The Debye-Hückel theory.

Dissociation and chemical equilibrium in electrolyte solutions. Dissociation constant, ionic product, solubility product. Ostwald's dilution law. pH. Buffer solutions, buffer capacity. The Henderson-Hasselbach equation. Acid-base titration.

Ideal and real solutions. Activity and activity coefficient. The dependence of the chemical potentials of the ideal and real solution on their concentration. Solutions of electrolytes. The Debye-Hückel theory. Ionic atmosphere, ionic strength, Debye radius. The influence of the ionic force on the equilibrium position, the salt effect.

4. Formal kinetics. Approximate methods of chemical kinetics. Catalysis. Homogeneous catalysis. Enzymatic catalysis. Heterogeneous catalysis.

Direct and inverse problems of chemical kinetics. Basic concepts and problems of formal kinetics. Classification of reactions. The law of active masses. The speed constant. Partial and general orders of the reaction and their relation to the molecular nature of the reaction. Half-rotation time and characteristic time, relaxation time. The Van't-Hoff temperature rule and the Arrhenius equation. True and effective activation energy.

Features of the kinetic description of unilateral and reversible reactions.

The rate-limiting step. The Bodenstein method. Quasi-stationary and quasi-equilibrium approximations.

Homogeneous catalysis and enzymatic kinetics. The Michaelis-Menten kinetic scheme. Straightening coordinates, their advantages and disadvantages. Effects of effectors: inhibition and activation.

Heterogeneous reactions. The law of acting surfaces. Heterogeneous (interfacial) catalysis. Isotherms of associative and dissociative, competitive and non-competitive adsorption.

5. Electrochemistry. The Born theory. Electrical conductivity of electrolyte solutions. The Nernst equation. The structure of the double electric layer.

Electrochemistry of heterogeneous systems. Volta-and galvani-potentials. A galvanic cell and an electrolytic cell. Electrode potential and potentials of redox reactions. Recording of a galvanic circuit, calculating its EMF. The anode and cathode in galvanic and the electrolytic cells.

Thermodynamics of galvanic cells. The Nernst equation. Luther's rule. Standard electrode potential. Standard hydrogen electrode. Electrodes of the I and II kind. Reference electrodes. Glass electrode and pH-meter.

The Born model for calculating the heat of hydration.

Nonequilibrium phenomena in electrolyte solutions. Ion diffusion and migration. Specific and equivalent electrical conductivity. The Kohlrausch rule. Walden-Pisarzhevsky rule for the effect of viscosity on electrical conductivity. Relay mechanism of electrical conductivity of H+ and OH-ions.

6. Interphase phenomena and fundamentals of colloidal chemistry. Effect of adsorption on surface tension, Gibbs isotherm. Micelle formation in surfactant solutions.

Thermodynamics of surface phenomena. Physical and chemical adsorption. Isotherms of the Henry, Langmuir adsorption.

Surface tension. Surface-active and inactive substances. Classification of surfactants and principles of their action. The Duclos-Traube rule. Effect of adsorption on surface tension, Gibbs isotherm equation. Dependence of the surface tension on the surfactant concentration (Shishkovsky equation). The Duclos-Traube rule and its physical meaning.

Wettability and its dependence on the properties of the liquid, the type and structure of the surface. Influence on the surface tension of the length and polarity of the solvent molecules. Hydrophobicity and hydrophilicity, amfifil-ness and ambivalent (omnitest). The boundary angle, the Young-Dupree equation.

Lyophilic dispersed systems, their thermodynamic stability.

Surfactant micelles and their structure in aqueous solutions and nonpolar solvents. Bilayer structure of the membrane and foam. Relationship of the molecular structure of organic surfactants and their properties. Critical concentration of micelle formation and methods for its determination. Influence of temperature, ionic strength, structure, and size of the hydrocarbon radical on the CMC. The temperature limit of micelle formation, the Crafting point, and the opacity point. Solubilization in solutions of micelle-forming surfactants. Hydrophilic-but-lipophilic balance.

The structure of the double electric layer at the surface of the lyophobic sol particle. The electrokinetic ζ-potential, its determination, typical values for stable sols, and the dependence on the electrolyte concentration. Electrokinetic phenomena. The Helmholtz-Smoluchowski equation for the electrophoretic transfer rate. Electrophoresis. Electrophoretic mobility. Gel electrophoresis.

Transport processes in porous membranes. Electro-osmosis, the speed of the current in the electro-osmosis.

7. Preparation and properties of lyophilic and lyophilic colloidal systems. Factors affecting the stability of lyophobic colloidal systems. Electrolyte coagulation

Lyophobic dispersed systems and methods of their preparation: peptization and condensation. Aggregation and sedimentation stability of lyophobic colloids, factors of their stabilization and spontaneous processes leading to their destruction. The Tyndall effect. Opalescence. Wedging pressure.

Fundamentals of the theory of coagulation of sols by electrolytes (DLMO theory). Structure of the mycelium of lyophobic sols. Mechanisms of concentration and neutralization coagulation, dependence on the ion charge. The Schulze-Hardy rule for the coagulability of ions. Recharge of colloidal particles under the action of electrolytes. Zones of stability and coagulation of sols according to the concentration of the electrolyte. The rules of Deryagin–Landau, Eilers–Korf, Faience–Panet–Gan. Hoffmeister series and their relation to coagulation and peptization. Kinetics of coagulation, the Smoluchowski equation.

8. Chemical equilibria in electrolyte solutions: conductometry and potentiometry. pH measurement. Titration.

Dissociation and chemical equilibrium in electrolyte solutions. Dissociation constant, ionic product, solubility product. Ostwald dilution law and limits of its applicability. pH. Buffer solutions, buffer capacity. The Henderson-Hasselbach equation and the limits of its applicability. Acid-base titration.

Membrane potential. Glass electrode and pH-meter. The Nikolsky equation.

Diffusion potential: the mechanism of its occurrence and methods for minimizing its contribution in measurement schemes.

9. Surface phenomena. Isotherms of surface tension and adsorption. Surfactants. Formation of micelles in surfactant solutions.

Поверхностная активность. Поверхностно-активные и поверхностно-инактивные вещества. Правило Дюкло–Траубе и его физический смысл.

Лиофильные дисперсные системы. Условия их образования при диспергировании макрофаз и термодинамическая устойчивость.

Мицеллы ПАВ и их структура в водных растворах и неполярных растворителях. Бислойные структуры: мембраны и пены. Связь молекулярного строения органических ПАВ и их свойств. Критическая концентрация мицеллообразования и методы её определения. Влияние на ККМ температуры, ионной силы, структуры и размера углеводородного радикала. Температурный предел мицеллообразования, точка Крафта и точка помутнения. Солюбилизация в растворах мицеллообразующих ПАВ Гидрофильно-липофильный баланс.

10. Kinetics of chemical reactions in solutions. Influence of the ionic strength of the solution on the rate of chemical reactions

Теория переходного состояния (активированного комплекса) Эйринга–Поляни. Поверхность потенциальной энергии. Понятие о статистическом описании скорости химической реакции.

Влияние среды на скорость химических реакций. Солевые эффекты в кинетике химических реакций. Формула Бренстеда-Бьеррума.

Формула Дебая–Смолуховского.

Спектрометрические методы изучения кинетики химических реакций. Закон Бугера-Ламберта-Бера. Оптическая плотность. Коэффициенты поглощения и экстинкции.

Особенности кинетического описания односторонних и обратимых реакций.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Physiology/Физиология

Purpose of the course:

The course is divided into two modules:

• physiology of the visceral systems

• physiology of the nervous system

The purpose of the first module is the mastering by students of basic knowledge related to the physiology of the visceral systems. Familiarization of students with the mechanisms of normal functioning of the body, the principles of regulation of various systems of the body and with the consequences of deviations in the work of regulation systems (elements of pathological physiology). Determination of the range of the most urgent modern physiological issues and problems, in the solution of which specialists with fundamental education in the field of physics and mathematics can take an active part.

The purpose of the second module is the mastering by students of basic knowledge in the field of creating the physiology of the nervous system, basic fundamental concepts, laws and theories of modern neurophysiology.

Tasks of the course:

The objectives of the first module are:

• Familiarization of students with the main mechanisms of functioning of the most important internal systems of the body - blood circulation, respiration, excretion, digestion.

• Familiarization of students with medical terminology, which should enable them to effectively collaborate with doctors and work in medical research laboratories.

• A detailed analysis of the mechanisms of regulation of the activity of the internal systems of the body.

• Analysis of mathematical models of physiological processes.

• Familiarization of students with the basic methods of physiological research and the equipment used for this.

• Development of students' ability to navigate in the assessment of quantitative relationships and patterns of body functioning in normal conditions and in the most common types of pathology.

• Critical analysis of a number of existing physiological and clinical concepts of the mechanisms of occurrence of pathological conditions.

The objectives of the second module are:

• Teaching students the basics of modern concepts in the field of laws, theories and models that underlie modern physiology of the nervous system.

• Mastering neurophysiological terminology.

• Mastering the skills of independent work and mastering new sections of physiology.

• Familiarization of students with the basic methods of neurophysiological research and the equipment used for this.

• Developing the ability to navigate in classical and modern formulations of fundamental and applied problems in the field of neurophysiology; evaluate the correctness of the problem setting and the reliability of the conclusions.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- basic fundamental concepts, laws and theories of modern neurophysiology;

- general principles of the structure of the nervous system of vertebrates and invertebrates;

- the history of the development of ideas about human physiology;

- modern ideas about the principles of functioning of the systems that form the human body;

- basic fundamental concepts, laws and theories of modern physiology, general principles of regulation of functions in the human body.

be able to:

- to distinguish the normal physiological functions of organs and individual functional systems from pathological;

- use various research methods: the nervous system, the cardiovascular system, the digestive system, the respiratory system, the excretory system, etc., and, in particular, the functions of the brain, heart, lungs, kidneys, etc.

master:

- neurophysiological terminology;

- skills of independent work and mastering new sections of physiology;

- the foundations of modern concepts in the field of laws, theories and models that underlie the modern physiology of the nervous system;

- the culture of formulating, analyzing and solving fundamental and applied problems, the skills of competently describing the solution of problems and presenting the results obtained;

- physiological and medical terminology;

- skills of independent work and mastering new sections of physiology;

- the culture of setting, analyzing and solving fundamental and applied physiological problems.

Content of the course (training module), structured by topics (sections):

1. Physiology is the science of life of the organism

General principles of the functioning of the whole organism. Physiology of excitable tissues. The structure and function of membranes of cells of excitable tissues. Excitability and arousal. Bioelectric processes in excitable cells. Mechanisms of transport of substances through the membrane. Characterization of membrane ion channels. Resting potential and action potential. Change in membrane excitability during a single excitation cycle.

2. Physiological properties of striated and smooth muscles

The mechanism of muscle contraction. Physiology of nerves and nerve fibers. The laws of the conduction of excitation along the nerves. The mechanism of the propagation of excitation along myelinic and nonmyelinated fibers. Physiology of synapses: properties of synapses, the mechanism of transmission of excitation in synapses.

3. Physiological bases of humoral-hormonal regulation

Nervous regulation of physiological functions. Structural and functional organization of the nervous system. Research methods of the central nervous system. Brain functions. Neuron. Systemic organization of nerve centers and their properties. Inhibition in the central nervous system. Types and mechanisms of braking. Integrative activity of the central nervous system.

4. Motor functions of the body

Maintaining muscle tone, posture formation and voluntary movement. The autonomic nervous system. Structural and functional features. Mediators and receptors. The sympathoadrenal system. Vegetative reflexes and vegetative tone.

5. Physiology of the heart

Cardiac cycle. Properties of the heart muscle. Regulation of the heart. Hemodynamics of the systemic and pulmonary circulation. Basic hemodynamic parameters. The mechanism of transcapillary exchange. Features of regional blood circulation. A functional system that determines the optimal blood pressure level for metabolism. Clinical and physiological methods for studying the cardiovascular system in humans.

6. The internal environment of the body, its physiological significance

Composition of blood, its functions, basic blood parameters. Functional systems that maintain blood pH and osmotic pressure at an optimal level for metabolism. Coagulation and anticoagulant blood systems. Blood groups. Physiological bases of blood transfusion.

7. Breath. Physiological mechanisms of external respiration

Physiological mechanisms of external respiration. Gas exchange between alveolar air and blood. Transport of gases by blood. Oxyhemoglobin dissociation curve. Breathing at altered atmospheric pressure. Nervous and humoral regulation of respiration. A functional system that provides an optimal blood gas composition for metabolism.

8. Digestion

Digestive tract functions, mechanisms of their regulation. Features of digestion in various parts of the digestive tract. Liver function. A functional system that maintains the level of nutrients in the blood at an optimal level for metabolism. The mechanism of hunger and satiety.

9. Energy exchange

Basic and general exchange. Methods for assessing human energy metabolism. Principles of drawing up food rations. Thermoregulation. Body temperature scheme. Physiological fluctuations in human body temperature. A functional system that maintains body temperature at an optimal level for metabolism. Heat production and heat transfer paths. Physiological bases of hypothermia.

10. Highlighting

Excretory organs, their participation in maintaining the most important parameters of homeostasis. Kidney, its functions. Nephron as a structural and functional unit of the kidney. Processes of urine formation, their regulation. A functional system that maintains the constancy of the osmotic pressure of the blood.

11. Physiology of sensory systems

Physiology of analyzers. Characteristics of the individual links of the analyzer. Private physiology of analyzers. Physiology of pain. The role of analyzers in the operation of functional systems.

12. Behavior. Reflex theory

Congenital and acquired forms of behavior. An unconditioned reflex, an instinct. Conditioned reflexes. Classification, development rules. Dynamic stereotype. Types and inhibition in higher nervous activity.

13. Central architecture of the behavioral act from the perspective of the theory of functional systems P.K. Anokhin

Nodal stages of the central architecture of the behavioral act. Vegetative and endocrine support of the behavioral act.

14. Psychophysiology

Systemic organization of emotional reactions. The biological role of emotions. Theories of emotions. Emotional stress, resistance and predisposition to it. Prevention of emotional stress.

15. Sleep

The biological significance and structure of sleep. Modern concepts of sleep mechanisms.

16. Mental activity of the brain: consciousness, emotions, feelings

Systemic organization of sexual functions. Mechanisms of regulation of sexual functions. The ratio of social and biological factors in the implementation of sexual functions.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Probability Theory/Теория вероятностей

Purpose of the course:

mastering the basic modern methods of probability theory.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in probability theory;

• acquisition of theoretical knowledge and practical skills in probability theory;

• providing advice and assistance to students in conducting their own theoretical research in probability theory.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

 fundamental concepts, laws of probability theory;

 modern problems of the corresponding sections of probability theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of probability theory.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem statements;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and conduct their analysis;

 independently see the consequences of the results;

 accurately represent mathematical knowledge in probability theory in oral and written form.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 the culture of the formulation, analysis and solution of mathematical and applied problems that require the use of mathematical approaches and methods for their solution;

 the subject language of probability theory and the skills of competent description of problem solving and presentation of the results.

Content of the course (training module), structured by topics (sections):

1. Discrete probability spaces.

Discrete probability spaces. The classic definition of probability. Examples.

2. Independence of an arbitrary set of random variables.

Independence of an arbitrary set of random variables. Independence criterion, a theorem on the independence of Borel functions from disjoint sets of independent random variables.

3. Random variables in discrete probability spaces.

Random variables in discrete probability spaces. Independence of random variables. The mathematical expectation of a random variable, its basic properties. Dispersion, covariance and their properties.

4. Bernoulli test design

Mathematical model, limit theorems: Poisson and Muavre-Laplace

5. Random elements, random variables and vectors.

Random elements, random variables and vectors. A sufficient condition for the measurability of a mapping, a corollary for random variables and vectors. Actions on random variables.

6. Systems of sets (semirings, rings, algebras, sigma-algebras)

Minimal ring containing a half ring. The concept of the smallest ring, algebra, sigma-algebra containing a system of sets. Measures on half rings. The classical Lebesgue measure on the half ring of spaces and its sigma additivity.

7. Carathéodory’s theorem on the continuation of a probability measure (proof of uniqueness).

Carathéodory’s theorem on the continuation of a probability measure (proof of uniqueness). Lebesgue theorem on distribution function

8. Completeness and continuity of measures

Theorems on the relation between continuity and sigma additivity. Borel measure. Lebesgue-Stieltjes measures on the line and their sigma additivity.

9. Immeasurable sets.

Theorem on the structure of measurable sets. Measurable functions. Their properties. Measurable functions and passage to the limit.

10. Convergence. Cauchy Convergence Criterion

Convergence in measure and almost everywhere. Their properties (Cauchy criterion for convergence in measure, arithmetic, connection of convergence, Riesz theorem). Theorems of Egorov and Luzin.

11. Conditional probabilities.

Conditional probabilities. The formula for total probability. Bayes formula. Examples

12. Lebesgue integral

The Lebesgue integral and its properties. Definition of the Lebesgue integral in the general case. The main properties of the Lebesgue integral.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Python Programming/Программирование на языке Python

Purpose of the course:

Teaching students to program in Python at a level sufficient for use in scientific research and in professional activities.

Tasks of the course:

 provide students with a clear understanding of the basics of computer science, including some areas of mathematics (number systems, logic, discrete mathematics);

 to teach students the basic algorithms for processing of numeric and text information;

 to form students ' skills of using Python 3 programming language for solving specific application problems.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

 fundamentals of the Python programming language;

 software development techniques;

be able to:

 to choose optimal algorithm for the particular problem;

 to develop complete complete Python programs using modern tools for writing and debugging programs;

 to use math packages of Python language to automate the solution of applied and fundamental problems;

master:

 skill of research of theoretical and applied problems;

 skill of coding of algorithmic problem's solution on Python programming language;

 ways of presenting the results;

 skills of independent work and use of information from knowledge bases in the Internet;

Content of the course (training module), structured by topics (sections):

1. Basics of Python syntax

Variables. Expressions. Functions. Conditional statements and loops.

2. Working with collections

Collection methods. Search collections. Conditional expressions and collections. Compare collections.

3. Work with files

Open and close methods. Construction with as. Read and write data in different encodings.

4. Functions and working with them

The default values of the function arguments. Mandatory and non-mandatory arguments. Positional and named arguments.

5. Modules and packages

Connect modules with the import instruction. Various import syntaxes.

Executing the module as a script. Search path. dir()

"Compilation" of modules.

Packages. Import inside the module.

6. Single-pass algorithms

The problem of finding the largest element of the sequence.

7. Sorting algorithm

Sort. The concept of recursion and its application to simple problems.

Annotation

Major: 19.03.01 Биотехнология

specialization: Biomedical Engineering/Биомедицинская инженерия

Russian as a Foreign Language/Русский язык как иностранный

Purpose of the course:

The Russian as a foreign language (A2+) course is aimed at the formation of intercultural professionally oriented communicative competence from the zero level to the Pre-Intermediate level (according to the European scale of foreign language proficiency levels) for solving social and communicative tasks in various areas of everyday, cultural, professional and scientific activities in the Russian language, as well as for further self-education.

Tasks of the course:

The tasks of the formation of intercultural, professionally oriented communicative competence consist of the gradual mastery by students of a set of competences, the main of which are:

– linguistic competence, i.e. the ability to adequately perceive and correctly use language units based on knowledge of phonological, grammatical, lexical, stylistic features of the studied language;

– sociolinguistic competence, i.e. the ability to adequately use realities, background knowledge, situationally conditioned forms of communication;

– sociocultural competence, i.e. the ability to consider during the communication speech and behavioral models adopted in the relevant culture;

– social competence, i.e. the ability to interact with communication partners, to make contact and maintain it, owning the necessary strategies;

– strategic competence, i.e. the ability to apply different strategies to maintain successful interaction in oral/written communication;

– discursive competence, i.e. the ability to understand and generate foreign language discourse considering cultural differences;

– general competence, including, along with knowledge about the country and the world, about the features of the language system, also the ability to expand and improve their own picture of the world, to be guided by the media sources of information;

– intercultural competence, i.e. the ability to achieve mutual understanding in intercultural contacts, using the entire set of skills to realize the communicative intention;

– compensatory competence, i.e. the ability to avoid misunderstandings, to overcome the communication barrier through the use of well-known speech and metalanguage means.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

– The main facts, realities, names, attractions, traditions of Russia;

– some achievements, discoveries, events in the field of Russian science, culture, politics, social life;

– basic phonetic, lexical-grammatical, stylistic features of the Russian language and its difference from the native language;

– the main differences in writing and speaking.

be able to:

– Generate adequate oral and written texts in a specific communication situation;

– to realize the communicative intention with the purpose of influencing the communication partner;

– adequately understand and interpret the meaning and intention of the author in the perception of oral and written authentic texts;

– identify similarities and differences in the systems of native and foreign languages;

– show tolerance, empathy, openness and friendliness when communicating with representatives of another culture.

master:

– Intercultural professionally oriented communicative competence in different types of speech activity at the level of A2+;

– socio-cultural competence for successful mutual understanding in terms of communication with representatives of another culture;

– various communication strategies;

– learning strategies for organizing your learning activities;

– strategies of reflection and self-evaluation for self-improvement of personal qualities and achievements;

– different methods of memorization and structuring digestible material;

– Internet technologies to select the optimal mode of obtaining information.

Content of the course (training module), structured by topics (sections):

1. Nice to meet you!

Communicative tasks. To get acquainted. To introduce yourself and other people. To ask for a phone number. To ask for repetition. To start conversation with a person.

Vocabulary. Common phrases for meeting people, saying goodbye etc. Occupation. Professions. Numbers 0-9. People (man, woman, etc.).

Grammar. Construction "Who is this?" Personal pronouns (subject): я, ты, он, она, мы, вы, они. Personal pronouns (object): меня, тебя, его, её, нас, вас, их.

Phonetics. Pronunciation of sounds (т, к, м, а, о, е, э, я, б, п, в, ф, ж, д, р, з, с, ш, щ, ч).

2. My World

Communicative tasks. To talk about your everyday activity. To tell the time. To make an appointment. To talk about your family. To fill the registration form.

Vocabulary. Verbs describing everyday activity. Time. Parts of the day. Numbers 10 – 100. Events. Family. Registration form.

Grammar. 1st conjugation of verbs. 1 час, 2-4 часа, 5-20 часов. Consolidate conjugation of verbs. Possessive adjectives: мой/моя, твой/твоя.

Phonetics. Pronunciation of sounds (т, ть). Pronunciation of [ц], unstressed «я», «е». Pronunciation of [ж], [ш]. Devocalization of sound «ж» at the end of words.

3. Our Lesson

Communicative tasks. To understand your teacher’s instructions in Russian. To ask people if they have something. To indicate something. To set a meeting. To talk about your plans for a week.

Vocabulary. Verbs describing activities at the lesson. Personal things. Numbers 100-1000. Days of week. Events.

Grammar. Imperative form of verbs (читайте, слушайте etc.). Construction “у меня есть”. Gender of nouns. Construction “У меня + событие”. Nouns in plural. Days of week.

Phonetics. Pronunciation of "о" in unstressed position. [ж], [ш]. Devocalization of sound «ж» at the end of words. Pronunciation of у, г.

4. In the City

Communicative tasks. To talk about your city. To ask where to go. To understand signs of a city. To buy a ticket for metro. To order in a restaurant. To refuse an offer. To say where were you yesterday.

Vocabulary. Places in town (parks, restaurants, museums etc.). Words for ordering in a café or buying a ticket for metro. Russian way to say “last/next week”.

Grammar. Endings of adjectives. Possessive pronouns. The prepositional case for locations. The past tense of the verb “to be”.

Phonetics. Devocalization “д” at the end of words and in front of voiced consonants. Practicing the phrase “к сожалению”. Words where “ч” is pronounced as [ш].

5. Countries and Nationalities

Communicative tasks. To ask a person where he he is from. To talk about countries. To talk about the weather. To talk about the season. To talk about traditions and nationalities.

Vocabulary. Countries. Months. Weather. Season. Verbs (to love, to call, to speak). Traditions and nationalities.

Grammar. Months in the prepositional case (when?). 2nd conjugation of verbs. Nationalities.

Phonetics. Pronunciation of р, рь, ю. Pronunciation of the names of nationalities.

6. My Home

Communicative tasks. To describe your house. To call for a master to fix broken things at home. To explain location of things in the house. To talk about your free time and ways to rest at home.

Vocabulary. Furniture. Rooms. Verbs (to sleep, to want, to see, to watch, to hate). Parts of a house (wall, floor etc.). Outside the house (garden, forest). Verbs describing activities at home.

Grammar. Neuter gender nouns in plural. Masculine gender nouns in plural. Exceptions. The prepositional case, exceptions. The past tense. The accusative case for objects.

Phonetics. Pronunciation of the names of the rooms. Pronunciation of words with a change of stress in the prepositional case (в лесу, на полу, etc.). Pronunciation of [х]. Being surprised by the word “ух ты!”.

7. Tasty Food

Communicative tasks. To explain what you need to buy. To talk about food preferences. To order and pay in a restaurant. To talk about recipes. To invite friends for dinner. To express admiration or criticism.

Vocabulary. Phrases for shopping. Phrases for restaurants. Phrases for inviting and accepting invitations.

Grammar. Personal pronouns with “нужно”, “надо”, “нравится”. The instrumental case after the preposition “с”. The future tense.

Phonetics. Pronunciation [ы], [и]. Devocalization of the voiced consonants at the end of words (б, д, в, з, ж, г). Intonation of admiration: “Как хорошо!”.

8. Health

Communicative tasks. To talk to a doctor. To talk about health. To give recommendations. To talk about mood (I am sad, happy etc.). To agree/disagree.

Vocabulary. Parts of body. Health. Можно/нельзя. Emotions. Mood.

Grammar. Construction “у меня был”. Personal pronouns of with age, “можно”, “нельзя”. Short forms of adjectives.

Phonetics. Intonation of the interjection "ай!" when expressing pain. Pronunciation of ь, ъ.

9. People

Communicative tasks. To talk about people’s character. To describe appearance. To compare things. To buy clothes. To agree to do something.

Vocabulary. Adjectives. Describing a person. Adjectives. Appearance. Clothes. Colours. Size.

Grammar. Endings of adjectives. The comparative and superlative degree. The genitive case in possessive constructions. Endings of adjectives.

Phonetics. Pronunciation of [ш], [щ]. Combination «дж». Intonation of admiration urprise using the word “так”. Pronunciation of “ё” after the hushing sounds.

10. Transport

Communicative tasks. To talk with a taxi driver (price, address, etc.). To order a taxi. To cancel, reschedule or confirm a meeting. To talk about your trip. To describe cities.

Vocabulary. Transport. Dates. Verbs: перенести, отменить, подтвердить, прийти/приехать, уйти/уехать. The compass. Words for travelling.

Grammar. The prepositional case for transport. Ordinal numbers. The accusative case for directions with prepositions “в”, “на”.

Phonetics. Practicing the difference of pronunciation between "е" and "ё" in the conjugation of the verbs "идти", "ехать". Words where the letter "г" is pronounced as "в" (его, сегодня). Devocalization "з" in the preposition "из".

11. My Family

Communicative tasks. To talk about family. To accept the invitation. To talk about hobbies. To refuse the invitation. To ask and tell about biography.

Vocabulary. Family. Relatives. Activities during the holidays. Verb “уметь”. Verbs: пожениться, родиться, случиться, познакомиться.

Grammar. The genitive case. Possession. Reflexive verbs (the present tense). Заниматься + the instrumental case. Reflexive verbs (the past tense).

Phonetics. Devocalization of sound “ж” at the end of words. Pronunciation of тс, тьс = [ц]. Pronunciation of и = [ы] after ш, ж, ц.

12. Holidays

Communicative tasks. To congratulate with holidays. To tell about traditions. To sign postcards. To say wishes. To suggest the idea of gifts. To express surprise.

Vocabulary. Name of the holidays. Verbs: праздновать, поздравлять, прощаться, гулять. Wishes (happiness, love, luck, etc.). Gifts.

Grammar. Поздравлять + the instrumental case. The genitive case with the verb желать. The genitive case after prepositions.

Phonetics. Words with an unpronounceable "д". Words where г = [в]. Intonation of the phrase "Да ладно?!".

13. Shopping

Communicative tasks. To understand the information on the labels of cosmetic products. To buy groceries. To communicate in the store. To buy clothes.

Vocabulary. Body parts. Cosmetic. Stores. Numbers and time. Fruits and vegetables. Clothes, shoes, accessories. In the store.

Grammar. The genitive case. Plural. The genitive case with numbers. The genitive case. Lack.

Phonetics. Devocalization of "в" at the end of words. Devocalization of paired voiced consonants before voiceless consonants. The difference in pronunciation between "большой" and "больше".

14. Vacation

Communicative tasks. To ask about vacation. To book. To change the booking dates. To offer to do something together.

Vocabulary. Nature. At the hotel. Verbs forming the perfective aspect differently.

Grammar. Aspects of verb. The past tense. The genitive case. Dates. Aspects of verbs. The future tense. Perfective aspect. The future tense. New verbs: открыть, закрыть, продать, купить, выбрать, встретить, сказать, рассказать.

Phonetics. Reduction. Unstressed "о" = [а]. The end of the ordinal numerals in the genitive case г = [в]. Pronunciation of new verbs.

15. Our House

Communicative tasks. To talk about your dream home. To expressing outrage. To talk what are different things in the house are for. To talk about the location of different things in the house.

Vocabulary. House. Tidy up. Verbs мыть, убирать, чистить, стирать. Necessary things for cleaning. Appliances. Verb пользоваться.

Grammar. The prepositional case. Location. Preposition “для” and conjunction “чтобы”. The instrumental case after prepositions “над”, “под”, “за”, “перед”, “между”, “рядом с”. The instrumental case with the verb “пользоваться”.

Phonetics. Intonation in the expression of perturbation.

16. At Work

Communicative tasks. To talk about your work. To pass an interview. To make phone calls (to order, to book, etc.). To write emails.

Vocabulary. Professions. Job interview. On the phone. The structure of a letter.

Grammar. The instrumental case with verbs “работать”, “стать”, “быть”. The instrumental case of pronouns. Prepositions “за” and “что” in constructions “спасибо за + noun”, “извините / простите за + noun”, “спасибо, что + verb”, “извините/простите, что + verb”. The dative case. Addressee. The dative case of pronouns, nouns and adjectives.

Phonetics. Names of professions.

17. Leisure

Communicative tasks. To talk about hobbies (movies, music, literature). To tell and understand the story of the film or the book, to call of the director, actors, etc. To tell about where you usually go, where you went yesterday. To chat in the park with other dog owners.

Vocabulary. Hobby, books, movie, music. Genres. Event guide.

Grammar. Verb “нравиться”. Difference between “зовут” and “называется”. The accusative case + “зовут”. The prepositional case after the preposition “о”. The prepositional case of personal pronouns. Verbs of motions ходить, ездить in the past tense.

Phonetics. Pronunciation of “о / обо”. Vowel assimilation зж = [жж], зш = [шш].

18. Cities

Communicative tasks. To tell and understand information about interesting places. To navigate the city. To explain your location. To buy a ticket. To find out the necessary information at the station / airport. To say what year.

Vocabulary. Tourist attractions. Roads. At the city. At the airport (вылет, посадка, стойка регистрации, etc.).

Grammar. Direction and location. The dative case after the prepositions “к”, “по”. Verbs “лететь / полететь / летать”. Verbs of motions with prefixes.

Phonetics. Soft consonants.

19. Routine

Communicative tasks. To talk about your day. To call the time. To learn the details before going on a tour. To express disappointment.

Vocabulary. Verbs of statics and dynamics (стоять – встать). Time designation. Verbs of everyday activity.

Grammar. Repetition (reflexive verbs, types of verb). Time (half past eight, five to five). Passive voice (reflexive verbs). Passive design + the instrumental case. Reflexive verbs (subject and object). Imperfective and perfective verbs after the phrase "я хочу".

20. Bon appetit!

Communicative tasks. To understand information on grocery packaging. To talk about diets. To explain how to cook, serve and eat different dishes. To buy the groceries. To refine the order. To explain the composition of dishes.

Vocabulary. Tastes. Product composition. Table setting. Crockery. Preparation of dishes. Kind of meat. Packaging.

Grammar. Formation of an adjective from a verb. “Приходиться/удаваться” + the dative case. The instrumental case in the expression of the instrument. The genitive case (definition). The formation of adjectives.

21. Friendship

Communicative tasks. To tell about childhood, friends, relationships. To ask and tell about interests. To know how to say, “Я буду то же самое”. To talk about feelings and reactions, to quote famous people.

Vocabulary. Relations. Interests. Hobby. Reactions and behavior (upset, happy, etc.).

Grammar. Reflexive verbs. Reciprocal action. The "I want you to do something" construction. “Одинаковый / такой же” and “разный/другой”. Quantitative numerals in the genitive case (одного, одной, двух, трех, четырех, пяти).

22. It's never too late to learn

Communicative tasks. To talk about your favorite subjects and studies. To talk about your learning experience and the education system in your country. To tell, what you learn now, what you have learned before. Sign up for courses.

Vocabulary. Verbs: учить, учиться, изучать. Disciplines. Types of subjects. The verb “поступать”. Schedule. Services of sports clubs.

Grammar. Difference between “учиться”, “учить” and “изучать”. Phrases with the verb “иметь”. Conditional mood. “If I were you” construction. The dative case. Preposition “по”. Construction of “У меня получилось”.

23. Amazing Planet

Communicative tasks. To ask and tell about the animals, the area in which they live and feed. To keep the conversation going with phrases of astonishment. To describe daily movements. To keep talking about camping and surviving in the wild. To discuss what you need to take along with you.

Vocabulary. Animals. Birds. Fishes. Phraseological units: animals. Phrases of surprise to keep the conversation going. Things you need to travel. Verb брать/взять. Type of cars.

Grammar. Verbs of motion (ходить, ездить, бегать, плавать, летать, ползать). Verbs of motion with prefixes. Transportation verbs (transitive verbs): носить, возить, водить.

24. Communication

Communicative tasks. To talk about people, describe their character. To express their opinion. To meet, ask and answer: как дела? To thank, to respond to an apology. To speak in public. To give instructions and advice.

Vocabulary. Human character. Comparisons with animals. Etiquette phrases. Dating and maintaining conversation. Words and phrases for presentations.

Grammar. Formation of nouns from adjectives. Imperative mood (2nd person). Imperative mood (1st and 3rd person). Types of verb in the imperative mood.

25. On the Internet

Communicative tasks. To discuss applications, technologies and websites. To communicate with people online. To talk about people and things without naming them. To make online purchases. To leave feedback.

Vocabulary. On the Internet. Verbs of thought processes. Informal phrases for online communication. Online store.

Grammar. Oppositions (хотя, несмотря на, иначе). Indefinite pronouns (кто-то, кто-нибудь, кое-кто) and the word "угодно". “Кто” and “что” in all cases.

26. Around the World

Communicative tasks. To talk about geography, different places, the history of their discoveries. To discuss the itinerary. To understand figurative names of countries and cities. To tell more fully about countries. To understand the regional division of the Russian Federation and the system of state car numbers.

Vocabulary. Geographical name. Periphrases of toponyms. Regions and territories.

Grammar. “Какой / какая / какое / какие” in all cases. “Это” and “то” in all cases. Reflexive pronoun “себя”.

27. Thoughts

Communicative tasks. To ask and tell about the achievements. To talk about desires and goals. To support other people. To tell about dreams, about fears and experiences. To maintain the theme of tradition and superstition. To understand Russian subjects.

Vocabulary. Goals and achievements. Verbs: стараться, пробовать, гордиться, любоваться, добиваться, являться, наслаждаться, бояться, расстраиваться. Dreams, fears, phobias. Signs, superstitions and traditions.

Grammar. Verbs + instrumental case. Reflexive possessive pronoun “свой”. "Бояться" + the genitive case. “Из-за” + the genitive case, “благодаря” + the dative case. The verb “везти” in the sense of luck.

28. Mass Media

Communicative tasks. To understand the basic information when watching the news (focus on policy). To quote, transmit requests and wishes of other people. To express emotionally disagreement. To understand the basic information when you view ads. To convince.

Vocabulary. Media, news. TV shows, television vocabulary. Purchasing, profit, price, convenient, advantage, disadvantage.

Grammar. Conjunction “который”, in all cases. The repetition of the reflexive verbs in a passive sense. Direct and reported speech. “за” + goal. Active participle in the present tense.