**PHYSICS AND ENGINEERING DEPARTMENT**

**INFORMATION PACKAGE**

Physics and Engineering Department was founded in November 2015 when Physics and Mathematics Department and Physics and Pedagogical Department were unified.

There is a wide range of bachelor and master’s degree programs as well as PhD programs. Teaching staff is highly qualified. Training is practice-oriented. Innovative techniques and rating knowledge check system have been successfully introduced.

There are research schools at Physics and Engineering Department guided by highly reputable scientists who usually participate in the State scientific and technical programs, they carry out joint international research and academic projects.

The following programs are available for studies in 2020 for foreign students:

**1-02 05 01 «Mathematics and Informatics» (Qualification: «Teacher»);**

**1-31 04 08 «Computerized Physics with specialization: «Computer modelling of physical processes» (Qualification: «Physicist. Software engineer»).**

Form of studies: full-time.

Period of studies: 4 years.

**1-02 05 01 «Mathematics and Informatics»**

**Academic plan**

**Pedagogics (11 credit points)**

Pedagogics as a science, its subjects and research methods. Scientific approaches to the study of pedagogical phenomena. Pedagogical process, its characteristics. Education in a holistic educational process. Forms, methods, teaching aids. Essence, patterns and principles of education and self-education. Technologization of training and education. Conceptual foundations for the design of pedagogical systems and technologies. History of the development of education and world pedagogical thought. Educational system of the Republic of Belarus, its modernization at the beginning of the XXI century.

**Psychology (7 credit points)**

Subject and methods of Psychology. Development of Psychology. Consciousness. Activity. Cognitive processes. Speech. Emotions and feelings. Will. Individually typological properties. Socio-psychological characteristics of the group. Communication. Interpersonal relationships. Conflicts. Personality and its structure. Basic theories of the development of Psychology in Ontogenesis. Mental development of a person in pre-school and school age. Psychological characteristics of teaching and learning. Psychology of education and self-education. Psychology of pedagogical activity and personality of a teacher. Communication and interaction of the subjects of the educational system.

**Information technologies in Education (3 credit points)**

Informatization and computerization of education. Information technologies, types and classification. Modern studies of information technology in education. Educational information resources. Electronic learning tools. Didactic capabilities of computer tools for processing graphic, textual and numerical information, databases. Tools and methods for the preparation of teaching materials. Design of electronic learning tools. Computer diagnostics of knowledge. Multimedia and telecommunication technologies in education. Educational resources of the Internet, means of their development and use. Distance learning. Information technology in the teaching of disciplines in a chosen specialty.

**Physics (4 credit points)**

 Kinematics and dynamics of material points. Forces in Mechanics. Work and Mechanical energy. Solid Mechanics. Fluid mechanics. Mechanical vibrations and waves. The main provisions of the molecular-kinetic theory of gases. Basics of thermodynamics. Electrostatics. Dielectrics and conductors in the electric field. DC electric current. Conductivity of electrolytes. Electric current in gases and vacuum. Electromagnetism. Electromagnetic induction. Magnetic properties of substances. Electromagnetic vibrations and waves. Interference and diffraction of light. Polarization and dispersion of light. Quantum nature of radiation. Elements of atomic Physics, quantum mechanics and solid state Physics. Elements of Physics of atomic nucleus and nuclear Physics.

**Mathematical Logic and Discrete Mathematics (2 credit points)**

Statements, operations and their main alliances. Expressive formulas, tautologies. Logical consequence. Predicates, operations and their properties. Predicate formulas. Application to the synthesis of discrete devices. Concept of Boolean function. Elementary functions. Formulas, basic equivalence. Principle of duality. Sets, task of sets. Subsets and their properties. Operations on sets and basic equalities. Coverings and partitions of sets. Placements with and without repetitions. Combinations without repetitions and combinations with repetitions. Counts, ways to set them. Degrees of peaks. Handshake lemma. Isomorphism and homeomorphism of graphs. Routes, chains, cycles. Connectivity. Trees. Prufer code tree. Spanning tree of minimum weight. Countdowns in graphs. Euler and Hamiltonian graphs. Euler criterion. Flat and planar graphs. Euler formula for flat graphs. Criterion of planarity. Coloring graphs, chromatic number of graphs, problem of four colors. Oriented graphs and networks.

**Analytic Geometry and Flat Transformations (13 credit points)**

Vectors and operations. Basis and dimension. Vector coordinates. Scalar product of vectors. Formula of a scalar product in an orthonormal basis. Affine and Cartesian coordinate systems on the plane. Simple ratio of three points. Formulas of transformation for coordinates of vectors and points of a plane. Polar coordinate system. Equations of a line on a plane. Lines of the second order. Ellipse, parabola, hyperbola and their canonical equations. Focal properties of an ellipse and hyperbola. Tangent to ellipse, parabola and hyperbole. Classification of lines of the second order. Affine and Cartesian coordinate systems in space. Right and left coordinate systems. Vector and mixed products of vectors and their formulas in the Cartesian coordinate system. Equations of the plane. Direct in space. Second order surfaces. Section method. Surface rotation. Cylindrical surfaces. Ellipsoid, cone, hyperboloids, paraboloids and their canonical equations. Building geometric shapes with a compass and a ruler. Method of geometric places. Method of transforming the plane. Criteria for solvability of a construction problem. Transformation group. Group of movements of the plane. Classification of the movements of the plane. Similarity Transformations. Homothety. A group of plane similarities. Decomposition of similarity into a product of Homothety and movement. Affine transformations of a plane. A group of affine transformations of a plane. Affine geometry of a plane.

**Methods for depicting shapes and Geometry bases (4 credit points)**

Central and parallel design of a figure on a plane. Image of plane figures in parallel projection. Image of spatial figures in parallel projection. Polke-Schwartz theorem. Axonometric design method. Positional tasks. Full and incomplete images. Metric tasks. Metrically defined images. The “beginning” of Euclid. Axiomatic method in Geometry. Problem of the fifth postulate of Euclid. Creation of non-Euclid’s Geometry. Hilbert axioms system of Euclid’s Geometry. Axiomatics of Euclid’s space according to Weyl. Concepts of consistency, independence and completeness of the system of axioms. Arithmetic model of this system of axioms. Consistency and completeness of Weyl axiom system. Absolute geometry. Statements equivalent to the fifth postulate. Axiom of parallelism and its negation. Axiom of Lobachevsky. Lobachevsky’s Geometry. Parallelism of lines according to Lobachevsky. Super parallel lines. Angle of parallelism. Formula of Lobachevsky. Consistency of Lobachevsky’s Geometry.

**Algebra (16 credit points)**

Arithmetic of integers. Algebra and trigonometry forms of a complex number. Raising and extracting the root. Basic algebraic structures: groups, rings, fields. A group of roots from one. Cyclic groups and their subgroups. Permutation group. Adjacent classes by subgroup. Lagrange theorem. The ideals of commutative rings. The rings of the main ideals. Matrices and operations on them. Determinant. Inverse matrix. Systems of linear equations: Gauss method, Cramer's formula.

Linear spaces, basis and dimension, vector coordinates. Kronecker-Capelli theorem. Homogeneous systems of linear equations. Fundamental decision system. Linear operators and their matrices. Similar matrices. Eigenvectors and eigenvalues of linear operators. Diagonalizable matrices. Euclidean spaces. Cauchy-Bunyakovsky inequality. Orthogonal vectors. The process of orthogonalization. Quadratic forms and their reduction to canonical form. The law of inertia of quadratic forms. Ring of polynomials in one variable. The greatest common divisor of polynomials and its linear representation. Bezout theorem. Horner's scheme. Theorems on the rational roots of polynomials with integer coefficients. Irreducible polynomials over number fields. Ring of polynomials in several variables. The main theorem on symmetric polynomials and its application to elementary algebra. Field extensions. Extent of expansion, final expansions. Algebraic and transcendental numbers. Simple algebraic field extensions. The theorem on getting rid of irrationality in the denominator of the fraction. The primitive element theorem. Field of algebraic numbers. Solvability of construction problems using a compass and a ruler. Constructing regular n-gons using a compass and a ruler.

**Theory of numbers (4,5 credit points)**

Integer separability properties of integers. The largest common divider and the smallest common multiple. Mutually simple numbers. Final chain fractions. Representation of a rational number in the form of a final chain fraction. Suitable fractions. Simple numbers. Eratosthenes sieve. Decomposition into simple multipliers. Basic theorem of arithmetic. Ring of integer Gaussian numbers, dividers of a unit, theorem about division. Simple whole Gaussian numbers. Representation of integer Gaussian numbers in the form of the product of simple integers Gaussian numbers. Linear diophantos equations. Some nonlinear diophantos equations and methods of their solution. Farm equation. Numerical functions. Whole part of the number. Number and sum of natural dividers. Multiplicative numeric functions. Comparisons and their main properties. Complete and given deduction system. Euler's function and its multiplicity. Formula for calculating the Euler function. Theorems of Euler and Ferm. Signs of separability of natural numbers. First-degree comparisons: solvability criterion and number of solutions. Chinese theorem about residuals. The order of the number by this module. Periodic fractions. Conversion of ordinary fractions into periodic fractions. Primary roots on a simple module. Indices for a simple module. Two-membered comparisons. Quadratic deductions. Symbol of Legendra and its properties.

**Mathematical Analysis (18 credit points)**

Elements of a set theory. A set of real numbers. Sequences and their limits. The concept of function. Properties of continuous functions. Elementary functions.

Derived and differential function of one variable. Applications of differentiated functions. Undefined and defined integrals. Applications of a certain integral. Numerical and functional series. Decomposition of functions into power series. Metric spaces. Full spaces. Differentiable functions of many variables. Multiple and curvilinear integrals and their applications.

**Differential equations (4 credit points)**

Basic concepts of the theory of differential equations. Theorems of existence and uniqueness of Cauchy problem solution. Differential equations of the first order (total differential equations, equations with separating variables, linear equations) and methods of their solution. The simplest differential equations of higher orders. Linear differential equations with continuous coefficients. Linear second-order differential equations with constant coefficients and their applications to vibration theory. Construction of the theory of elementary functions sin x, cos x, ex. Systems of differential equations.

**Mathematics teaching methodology (14 credit points)**

Subject, goals, objectives and methods of Mathematics teaching methodology. Mathematics as a science and as a subject at school. Aims and content of Mathematics teaching. Teaching methods of mathematics and their classification. Methods of scientific knowledge in Mathematics teaching. Methods of studying mathematical concepts and sentences. Tasks in a school course of Mathematics. Differentiation in the teaching of mathematics.

Methods of studying numerical sets in a school Mathematics course. Methodology for studying identical transformations of expressions, generalization of the concept of degree in the school Mathematics course. Features of the method of studying functions in the school course of mathematics. Methods of teaching students how to solve equations, inequalities and their systems. Teaching students to solve text problems by the method of compiling equations, inequalities, their systems. Features of the methodology of studying the derivative.

Methods of studying the school planning course. Study of relations between the elements of the triangle. Methods of studying quadrilaterals and their properties. Methods of studying the values in the school Mathematics course. Features of the technique of studying the similarity of figures. Formation of students' skills in solving problems of planning. Methodological features of studying the first sections of the course of Stereometry. Methods of studying the mutual arrangement of straight lines and planes. Methods of teaching students to find angles and distances in space. Study of polyhedrons, bodies of rotation and their properties. Methodology for studying surfaces and volumes of polyhedrons and bodies of rotation. Training schoolchildren to solve problems on a combination of polyhedrons and bodies of rotation.

**Teaching techniques and algorithmic method (8,5 credit points)**

Structurally-modular programming. Fundamentals of programming technology. Languages and programming systems. Basic elements of Pascal programming language. Basic structures of algorithms. Algorithms of integer arithmetic. Graphic possibilities of Pascal language. Structured data types. Mechanisms of structuring programs. Algorithms of work with external and internal memory of the computer.

Object-oriented programming. Event-based programming in Pascal environment. Visual object-oriented programming. Realization of algorithms in Delphi environment. String data types in Delphi. Creation of Windows applications.

Development of programming technologies. Platform .Net Framework. MS Visual Studio .Net system. Programming language C. Creation of applications with graphical interface. Prospects of programming technologies development.

**Computer graphics and multimedia (4 credit points)**

Computer graphics. Types of computer graphics. Basics of digital images formation. Typical tasks of graphic information processing. Two-dimensional (raster and vector) graphics. Digital models. Graphic formats. Graphics conversion. Software for working with two-dimensional graphics. Drawing and collage technologies. Curves. Layers. Masks, channels. Color and tone correction. Filters, effects. Basics of graphic design.

Fundamentals of business and engineering graphics. Charts. Schemes and drawings.

Multimedia. Hardware and software of multimedia. Types and methods of animation. Processing of audio and video information. Technologies of creation of a multimedia content. Flash-technologies.

Three-dimensional graphics. Basics of three-dimensional modeling. Software for working with three-dimensional graphics. Creation of three-dimensional images. Virtual reality.

**Information systems and nets (6 credit points)**

Automation of work in office applications. Office programming. Presentation of data and knowledge. Classification of data models. Relational databases. Database management systems. SQL database design stages. Information and reference systems. Local and global computer networks. Fundamentals of Internet functioning. Internet services. Tools and methods for developing web pages. Visual means of creating web pages. HTML. CSS. Graphics and multimedia in the Internet. Web design basics. Information model of the site. Navigation. Usability. Development of interactive and dynamic web pages. Fundamentals of JavaScript. Processing of CGI forms. Fundamentals of PHP. Database access technologies. MySQL. Client and server applications. Development of web applications.

**Informatics teaching methodology (5 credit points)**

Subject, Objectives and Objectives of the Methodology of Teaching Informatics. Structure and content of the Informatics Teaching Methodology course. Typical professional and methodological tasks of a computer science. History of school Informatics formation. Aims and objectives of the school Informatics course. Educational and methodical support of Informatics courses. Teaching aids on Informatics. School software course. Peculiarities of preparation of means of training for conducting lessons of computer science. Lessons of Informatics, types of lessons. Target-setting for the lesson. Methods and forms of work in computer science lessons. Peculiarities of computer science homework for students. Forms and methods of monitoring students' learning achievements in computer science. Norms of students’ knowledge and skills assessment. Lesson analysis.

Methodology of studying basic concepts of Informatics. Methodological aspects of studying the topics of the school informatics course.

Forms of additional training in informatics. Optional classes, circles, student scientific conferences. Organization of Academic contests, independent creative work of students. Work with underachieving students. Computer science for younger schoolchildren. Extra-curricular work on Informatics. Types and methods of organization of extra-curricular activities in Informatics. Forms of extracurricular work in Informatics. Game-playing technologies in Informatics education.

**Introduction to Informatics (3,5 credit points)**

Lots of natural numbers. Induction and deduction as methods of thinking. Method of Mathematical induction. Application of the method of Mathematical induction in various sections of mathematics. Sequences. Arithmetic and geometric progression. Whole, rational and irrational numbers and their properties. Separability of numbers. Degree root n. Arithmetic root. Expressions with variables. Polynomials and their properties. Degree of polynomial. Reduced multiplication formulas. Decomposition of polynomials by multipliers. Numerical inequalities and their properties. Basic methods of proving inequalities. Equation. Equation roots. Inequalities with variables. Methods of solving rational inequalities. Irrational equations and inequalities and methods of their solution. Systems and sets of equations and inequalities and methods of their solution.

**Project Geometry (3 credit points)**

Perspective display of a straight line in a beam. Extended straight line and its perspective display on the beam of lines. Projective line and its models. Projective coordinates of the straight beam. Projective coordinates of the line points. Projective repertoire of the straight line. Complex ratio of four line points. Harmonic fours. Projective and perspective representations of lines and beams. Perspective mapping of the plane in the bundle. Special plane and special straight bonds. Extended plane and its perspective mapping to the bundle. Basic properties of non-extended plane elements. Projective plane and its models. Projective coordinates of points of the plane. Projective repertoire of the plane. Transformation of projective coordinates. Condition of collinearity of three points of the projective plane. Straight line equations in projective repetitions. Coordinates. Principle of duality. Desargue Theorems. Perspective display of the plane on the plane and its basic properties. Projective transformation of the plane. Specifying the projective transformation by two four points of general position. A group of projective plane transformations. Full four-tip and its harmonic properties. Dissimilar and homogeneous coordinates of plane points and the connections between them. Homogeneous coordinates of discrete points. Second order curves in homogeneous coordinates and their non-native points.

**Differential Geometry (2,5 credit points)**

Vector function of one scalar argument, its derivative and differential. The concept of a line. Smooth line of class Cc. Tangent to the line. The length of the arc of the line. Natural parameterization of the curve. Formula Frene. Accompanying curve turret. Vector function of two scalar arguments. The concept of the surface in E3. Smooth surfaces of class Cc. Tangent plane and normal to the surface at its point. Line on the surface. Curvilinear coordinates of the surface point. The first square shape of the surface. Arc length, angle between lines, surface area. The second quadratic form of the surface. Full and average curvature of the surface. Gauss theorem. Geodetic curvature of the line on the surface. Geodetic lines. Internal surface geometry. Isometric surfaces.

**Numeral system (2 зач.ед.)**

Natural numbers. Arithmetic operations in a set of natural numbers. Principle and method of mathematical induction. Definition of an integer number. Arithmetic operations in a set of integers. Integer ring. Integer ring properties. Definition of a rational number. Arithmetic operations in a set of rational numbers. Field of rational numbers. Enclosing the ring of integers in the field of rational numbers. Rational numbers and finite and infinite periodic fractions. Infinite decimal fractions. Determination of actual numbers. Final decimal fractions. Suitable numbers. Decimal approximations of actual numbers. Actual number field. Properties of the valid number field. Enclosure of the field of rational numbers in the field of real numbers. Definition, properties and algebraic operations with complex numbers. Algebraic and trigonometric forms of recording complex numbers. Actions over complex numbers in algebraic and trigonometric forms. Attachment of the field of real numbers in the field of complex numbers. Quaternions. Definition of quaternions. Algebraic operations on quaternions.

**Elementary mathematics and problem solving practicum (14,5 credit points)**

Methods of solving rational equations. Methods of solving rational inequalities. Irrational equations and inequalities. Systems and sets of equations and inequalities. Methods of research of function by elementary means. Transformation of function plots. Similar transformations of expressive expressions. Exponential equations and inequalities. Similar transformations of logarithmic expressions. Logarithmic equations and inequalities. Text problems. Functional approach to solving equations, inequalities and their systems. Equations with parameters. Inequalities with parameters. Trigonometric functions. Inverse trigonometric functions and their graphs. Transformations of trigonometric expressions. Conversions of inverse trigonometric expressions. Solutions of the simplest trigonometric equations and inequalities. Solutions of the simplest inverse trigonometric equations and inequalities. Solution of trigonometric equations and inequalities. Overview of basic theorems and formulas of Planimetry. Methods of solving planimetric problems. Basic relations between elements of triangles. Equality, similarity of triangles. Wonderful points and lines of the triangle. Circle. Polygons. Methods of geometric transformations. Properties of parallel designing. Image of flat shapes. The image of polyhedrons and bodies of rotation. Calculation of angles and distances in space. Polyhedrons. Construction of sections of polyhedrons. Bodies of rotation. Vector and coordinate methods of solving geometry problems. Problem solving on the combination of geometric bodies. The largest and smallest values of values in geometry. Evidence and plausible reasoning. Functional approach to finding solutions to non-standard problems. Heuristic methods for solving non-standard problems. Olympiad problems. Derikhle principle. Logical and combinatorial tasks.

**Law of probability and Mathematical statistics (2 credit points)**

Subject of probability theory. Application of probability theory and mathematical statistics in other fields of knowledge. Classification of events, their probabilities. Operations on events, relations between events. Definition of conditional probability. Probability multiplication theorem and its use for introduction of elementary events probabilities. Total probability formula and Bayes formula. Determination of the independence of two or more events. The concept of a random variable and its distribution. System of random variables. Conditional distribution laws, dependent and independent random variables. Basic laws of distribution of random variables. Law of big numbers. Limit theorems. General population. Sample set (sampling). Methods of organizing samples. The concept of measurement scales. Statistical tables. Ranking methods. Variation and cumulative series. Indicators of the center of distribution and variation. Point and interval estimates of distribution indicators. Parametric and nonparametric statistical methods. Parametric and nonparametric methods of interval estimation of the arithmetic mean. Statistical testing of hypotheses and criteria of agreement.

**Mathematical tasks solution (3 credit points)**

Games, tournaments, strategies and algorithms. The simplest combinatorial tasks. Logical tasks. Separability of polynomials. Roots of polynomials. Bezu Theorem. Vieta Theorem for polynomials of arbitrary degrees. Basic theorem of polynomial arithmetic. Basic algebra theorem. Polynomials with valid, integer, rational coefficients. Unidirectional polynomials. Polynomials of several variables. Method of mathematical induction, varieties. Simple numbers. Euclidean algorithm. Basic theorem of arithmetic. Pythagoras of the triplets. Comparison theory elements. Farm's small theorem, Euler's theorem, Wilson's theorem. Chinese theorem about residuals. Multiplicative functions of number theory. Quadratic deductions. Diophantos equations. Equations of the Catalan type. Discrete nature of integers. Classical theorems about triangles. Geometry of inscribed and described quadrilaterals. Analytical methods in geometry. Equations with integer and fractional parts. Basic combinatorial principles. The formula of the sum and the formula of product. Bin Newton. Classical inequalities about the average. Koshi-Bunyakovskiy's inequality. Geometric inequalities. Inequalities of Bernoulli, Jensen, Gölder. The inequality of Chebyshev. The concept of the Count. The simplest tasks on the graphs. The language of the theory of graphs. The simplest numerical characteristics and types of graphs. Classic theorems of graph theory. Different properties of functions, their applications. Functional equations.

**Information processing languages at the lessons of Informatics at school**

**(2 credit points)**

Basic concepts of programming language. Linear algorithms.

Comments. Assignment operator. I/O procedures. Operator calling the procedure. Data output formats. Building linear programs.

Extending algorithms. Condition Operator (IF). Composite operator. Selection operator (CASE). Programming with branching.

Cyclic algorithms. Preconditioned Cycle Operator (WHILE). Cycle operator with postcondition (REPEAT). Cycle operator with the parameter (FOR). Compilation of cyclic programs.

Procedures and functions of the user. Description order, formal and actual, global and local parameters.

Symbolic and string types. Character and string operations, standard procedures and functions for handling characters and strings.

Structured data types. Arrays (one-dimensional and two-dimensional), sets, records. Methods of processing structured data types.

**Fundamentals of office programming (2 credit points)**

Description of the VBA programming language. Basics of programming in Office. Office application packages. Creation of VBA-program. Project Explorer window and VBA project structure. Execution of VBA-programs. Help VBA-application. Syntax and VBA program constructions. Data types and variables. Constants. Main VBA operators. Procedures and functions. Forms and controls. Programming in office applications. Application object, properties and methods of the object. Organization of input-output. Collection Workbooks and object Workbook, collection Sheets and object Worksheet, their properties and methods. Object Range. Collection QueryTables and object QueryTable. VBA-programming in Word. Creation of macros in Word. Use of custom forms. Templates in Word. Specificity of VBA application in Word. Access to Word documents via VBA. Working with document sections, window areas. Working with Word VBA text. Text formatting. Search and replace text with VBA in Word. Hierarchy of objects. Working with a Document object. Selection, Range and Bookmark objects. Database programming. Distinctive features of creating Access applications. Working with Access forms from VBA (Form object). Properties, methods and events of forms. Working with reports (object Report). Other Access objects. VBA-programming in PowerPoint. Creation of macros in PowerPoint. Specifics of VBA application in PowerPoint. Working with PowerPoint from VBA, automating presentation creation, PowerPoint.Application objects, PowerPoint.Presentation, PowerPoint.Slide, PowerPoint.Shape.

**Architecture and Software of computer-based systems (2,5 credit points)**

Computer architecture. Physical fundamentals of computer functioning. Basics of Boolean algebra and logical elements. Logical integrated circuits. Structure of modern computer. Case and power supply unit. Processor. Electronic memory. Peripheral devices. I/O devices. Video adapters. Monitors. External memory. Audio devices. Printers. Connecting and configuring expansion cards and accessories. Assembler. Processor architecture. Memory organization. Assembler language basics. Development of the program in assembler language. Computer networks. Organization of computer network. Communication equipment. Organization of access to the network. Computer systems and network software. Characteristics of software. System software. Network operating systems. Installation of software. Network security. Administration of the school network. Trends in development of hardware and software of computer systems.

**Computer methods and computer modelling (4.5 credit points)**

Computational methods and their role in the modern world. Methods of assessment of computational error of problem solving. Numerical algorithms for solving equations and their systems, numerical integration and differentiation, Solution of ordinary differential equations and their systems. Modeling of processes and phenomena. Optimization problems.

**1-31 04 08 Computerized Physics**

**Academic plan**

**Module «Mechanics» (9 credit points)**

Physical properties of space and time, Galileo transformation. Material point and point system kinematics and dynamics, conservation laws, inertial reference systems, kinematics and dynamics of the absolute solid body, oscillatory motion, deformations and stresses in solids, fluid and gas mechanics, waves in a solid environment and acoustic elements.

**Module «Higher Mathematics -1»**

**Mathematical analysis (9 credit points)**

Limit theory. Differential Calculation and its applications. Primary and integrals, basic methods and rules of integration. Functions of several variables and geometric applications. Row theory. Non-own integrals and integrals depending on the parameter. Fundamentals of differential geometry. Multiple, curvilinear and surface integrals. Main characteristics of scalar and vector fields. Green, Ostrogradsky, Stokes formulas. Second order differential operations in curvilinear coordinates. Potential and solenoidal fields.

**Analytic geometry and Linear algebra (6 credit points)**

Vector algebra. Straight lines and planes. Second order curves. Linear spaces. Matrixes and determinants. Systems of linear equations. Quadratic forms and surfaces of the second order. Linear representations. Geometry of Euclidean spaces. Linear operators on Euclidean spaces. Polylinear forms and tensors. Main operations with tensors.

**Basics of vector and tensor analysis (3 credit points)**

Vector functions of scalar argument, limit and continuity, derivative and differential, derivative of complex function, Taylor formula, integrals. Vector functions of many variables. Curves in three-dimensional space, their parameterization. Surfaces in three-dimensional space, parametric and implicit equations. The first quadratic form of the surface. The concept of the second quadratic form of the surface. Scalar field, level surfaces, limit, continuity, differentiability. Gradient derived from the direction of the scalar field. Vector field, vector lines, limit, continuity, differentiability. Divergence, rotor and derivative in the direction of the vector field. Differential operations of the second order. Curvilinear orthogonal coordinate systems. Curvilinear integrals of the 1st and 2nd order, properties, calculation methods and applications. Surface integrals of the 1st and 2nd order, properties, calculation methods and applications. Application of curvilinear and surface integrals for solving geometric and physical problems. Potential vector fields. Potentiality criterion of the vector field and finding the potential. Conjugate linear spaces. Mutual bases. General definition of the tensor. Algebraic operations on tensors.

**Module «Software engineering»**

**Software engineering (6 credit points)**

Modern programming languages and technologies. Algorithms. C++ programming: basic language constructions and their software implementation. Compilation of programs.

**Hardware-software interfaces of information systems (3 credit points)**

Characteristics of information systems interfaces. Interface organization principles. Classification and purpose of interfaces. Internal and external interfaces. Interfaces of peripheral devices. Human-machine (user) interface. Development of user interface.

**Introduction to Interpretable Languages (3 credit points)**

History, development and current state of the interpreted languages. Introduction to Java programming. .NET platform. Main features and programming in C#. Programming elements in Python language. Overview of PHP language features.

**Module «Higher mathematics-2»**

**Theory of complex variable functions (6 credit points)**

Complex numbers and corresponding actions. Geometric representation of complex numbers. Functions of complex argument. Limit, continuity and uniform continuity. Derived from the function of a complex variable. Differentibility conditions. The concept of analytical function. Harmonic functions. Entire functions. Geometric meaning of the module and derivative argument. Linear and fractional linear functions. Steppe function and radical. Showing and logarithmic functions. Degree with an arbitrary index. Trigonometric functions. Zhukovsky's function. Euler's theorem. Euler formulas. Integral from the function of the complex argument. Properties and calculation of the integral. Koshi theorem. Primordial for the function of complex variable and undefined integral. Nyoton-Leibnitz formula. Integral representation of the logarithmic function. Complex numerical and functional series. Converging sequences and series of complex numbers. Absolute convergence. Multiplication of absolutely convergent rows. Stepped rows. Abel's Theorem. Circle and radius of convergence. Properties of the sum of the steppe rows. Weyerstrasse Theorem. Regular functions. The concept of analytical continuation of the analytical function. Theorem of analytical function uniqueness. Deductions. Calculation of integrals by means of deductions. Application of subtractions to calculate non-proprietary integrals.

**Differential equations (6 credit points)**

Basic concepts of the theory of differential equations. Theorems of existence and uniqueness of Cauchy problem solution. Differential equations of the first order (total differential equations, equations with separating variables, linear equations) and methods of their solution. The simplest differential equations of higher orders. Linear differential equations with continuous coefficients. Linear second-order differential equations with constant coefficients and their applications to vibration theory. Construction of the theory of elementary functions sin х, cos х, ех. Systems of differential equations.

**Probability theory and mathematical statistics (3 credit points)**

Space of elementary events. Distributions for discrete and continuous random variables. Conditional probability, Bayesian formulas and total probability. Binomial distribution, Poisson and Gauss distributions. Limit theorems. Moments of a random variable, matrix of covariance. Laws of large numbers. Central limit theorem and its applications. Markov chains, ergonomics. Random processes. Sampling, selective distributions. Point and interval estimations of parameters. The method of maximum plausibility.

**Equations of Mathematical Physics (6 credit points)**

Classification of equations in partial derivatives of the second order. Setting of boundary value problems for mathematical physics equations. Main methods of solving boundary value problems of hyperbolic, parabolic and elliptical equations. Application of special functions in the study of physical processes. Finite difference method.

**Basics of mathematical modeling (3 credit points)**

Fundamentals of algorithm theory, algorithmic languages, C++ language. Basic data structures and work with elements of the standard C++ library. Fundamentals of modern programming technologies, object-oriented programming. Methods of solving algebraic, differential and integral equations. Modeling of physical processes.

**Module «Molecular Physics»**

**Molecular Physics (8 credit points)**

Main experimental facts about discrete structure of substance, intermolecular interactions, thermal motion. Statistical description of molecular phenomena, ideal gas, temperature concept, velocity distribution of gas molecules, Brownian motion, thermodynamic approach to description of thermodynamic systems, first and second principles of thermodynamics, cyclic processes, concept of entropy, real gases and liquids, surface phenomena in liquids, evaporation and boiling, transfer phenomena.

**Module «Electricity and Magnetism»**

**Electricity and Magnetism (9 credit points)**

Electromagnetic interaction. Constant electric field, electrostatic field in the presence of dielectrics, electrostatic field energy, direct electric current, conductivity phenomenon, stationary magnetic field, magnetics, electromagnetic induction, electromagnetic oscillations, quasi-stationary alternating currents, Maxwell equations.

**Module «Theoretical Mechanics»**

**Theoretical Mechanics (6 credit points)**

Equations of motion of the system of interacting particles in the formulations of Newton, Lagrange, Hamilton. Hamilton-Jacoby method. Variation principles. Laws of preservation. Movement of particles in fields. The problem of two bodies. Particle scattering theory. Linear oscillations. Solid state dynamics. Particle motion in inertial reference systems. Basic equations of dynamics of ideal and viscous liquids.

**Module «Optics»**

**Optics (8 credit points)**

Basics of electromagnetic light theory, interference, diffraction, light polarization, spectral analysis, elements of anisotropic media optics, interaction of radiation with matter, radiation and light generation.

**Module «Electrodynamics»**

**Electrodynamics (6 credit points)**

Electromagnetic fields of charges and currents in a vacuum. Maxwell equations. Relativity principle, Lorentz transformations and covariant form of electrodynamic equations. Energy-momentum tensor, conservation laws. Electromagnetic field potentials, calibration invariance. Lagging potentials, electromagnetic wave radiation. Electrodynamics of continuous media: Maxwell equations for macroscopic fields, electrostatics, boundary conditions, conductors and dielectrics in electromagnetic fields, magnetostatics and quasi-stationary approximation, electromagnetic waves in media.

**Module «Physics of the atom and Nucleus Physics»**

**Physics of the atom and atomic phenomena (8 credit points)**

Scale, constants, experimental data on the wave and quantum properties of radiation and matter, de Broglie waves. Hydrogen atom according to Bohr, bases of quantum mechanics, single-electron and multielectron atoms, interaction of quantum system with radiation, X-ray spectra, atom in the field of external forces, molecules, systems of many particles.

**Physics of the nucleus and elementary particles (4 credit points)**

Properties of atomic nuclei, radioactivity, nuclear reactions. Experiments in high energy physics. Inclined interactions and properties of nuclear forces, models of atomic nuclei, interaction of nuclear radiation with matter, elementary particles and interactions, electromagnetic, strong and weak interactions, discrete symmetries, union of interactions, modern astrophysical concepts.

**Module «Thermodynamics, statistical physics and quantum mechanics»**

**Thermodynamics and Statistical Physics (6 credit points)**

Basic laws and methods of thermodynamics. Quasi-static and non-static processes. Balance and stability conditions. Phase transitions. Basic concepts of statistical mechanics. Microcanonical and canonical distribution, systems with variable number of particles. Theory of ideal systems. Bose- and fermi-gases. Theory of fluctuations. Brownian motion and random processes. Basics of thermodynamics of irreversible processes. Kinetic equations in statistical physics.

**Fundamentals of Quantum Mechanics (3 credit points)**

State of the quantum system, state vector and wave function. Description of physical quantities (observed) by operators. Theory of representations. Evolution of quantum-mechanical systems with time. Schroedinger equation. Stationary states. Ratio of uncertainties. Movement integrals. The concept of a complete set of joint observables. Pure and mixed states. Harmonic oscillator. Pulse moment as a generator of infinitely small turns. Movement of a particle in a central field. Hydrogen-like atom. Approximate methods of quantum mechanics. Elastic particle scattering. Quantum transitions theory. Forced and spontaneous radiation. Basics of relativistic quantum mechanics. Dirac equation. Multipartial systems.

**Module «Integrated data processing and modelling systems»**

**Modern integrated packages for process and system analysis and modeling**

**(3 credit points)**

Basic structures of MathCAD and MATLAB system. Functions in MathCAD and MATLAB systems, basic library functions. Application of universal mathematical packages (MathCAD, MATLAB) for: solution of algebra problems and research of dynamic systems. Working with graphics in MathCAD and MATLAB systems. Basic software constructions in MathCAD and MATLAB systems. Elementary work in MATLAB system using SimuLink. Solution of problems containing differential equations in partial derivatives in MathCAD and MATLAB systems. MATLAB and MathCAD connection with MS Office. GUIDE environment. Environment with graphical interface.

**Database management systems (3 credit points)**

Classification of database management systems. Categories of database management system users. Life cycle of database systems. Database design. Essence-Link model. DBMS construction - oriented models. Basic concepts and definitions of relational model. Data definition language (DDL). Data manipulation language (DML). Request execution plan. Data modification. Views. Basic constructions and types of language data. Anonymous PL/SQL blocks. Cursors. Stored procedures and functions. Packages. Working with exceptions. Triggers. Transactions and their properties. Transaction management operators. Transaction isolation. Collisions arising from joint data processing. Blocks. Functional duties of a database administrator. Privileges and roles. Database copying and recovery.

**Module «Electronics and Quantum Electronics»**

**Introduction to electrical engineering and electronics (3 credit points)**

DC circuits. AC sinusoidal circuits. Three-phase circuits. Transformers. Three-phase asynchronous motor. Synchronous machines. DC machines. Electric drive.

Semiconductor devices. Electronic amplifiers. Logic, overallschionnye devices and triggers. Fundamentals of microprocessor and information-measuring equipment. Uncontrolled rectifiers.

**Introduction to solid-state electronics (3 credit points)**

Basic properties of semiconductors. Contact phenomena. Semiconductor diodes. Bipolar transistors. Thyristors. Field transistors. Optoelectronic devices. Integrated circuits.

**Quantum electronics and holography (3 credit points)**

Energy levels. Spontaneous, stimulated radiation, resonance light absorption. Principle of operation of amplifier and light generator. Methods of creating population inversion. Method of separation. Maser on ammonia. Three-level laser circuitry. Pumping method. Solid state lasers. Laser on ruby. Gas lasers. HeNe - laser. Gas-dynamic lasers. Semiconductor lasers, liquid lasers. Solution of problems on calculation of laser resonators. Hologram of flat and spherical waves Types of holograms. Demonstration of different types of holograms. Observation of light diffraction on holographic gratings. Interference of light in a volumetric medium and its application to the explanation of the properties of holograms. Modeling of holograms with the help of computer.

**Module «Technical software of the experiment»**

**Computer architecture (3 credit points)**

Main characteristics, areas of application of computers of different classes; functional and structural organization of the processor; organization of computer memory; main stages of command execution; organization of interruptions in the computer; organization of input-output; peripheral devices; architectural peculiarities of organization of computers of different classes; parallel systems; concept of multi-machine and multi-processor computer systems; matrix and associative computer networks; conveyor and streaming computer networks; computer networks; information computer systems.

**Experimental Physics (3 credit points)**

**Development of Java applications (3 credit points)**

Basics of development in Java. Object-oriented programming. Graphical user interface. Collections. Exceptions and errors. I/O streams. Execution flows. Network programs. JDBC, drivers, connections and queries. Servlets. Design templates.

**Software tools of the operating systems (3 credit points)**

Basic functions of operating systems. Principles of operating systems construction. Network structures. Support of operating systems. Service means of operating systems.

**Module «Programming Languages»**

**Object-oriented programming (6 credit points)**

Programming paradigms. Object-oriented programming. Classes, encapsulation, inheritance, polymorphism. Creation of object-oriented applications and their optimization.

**Module «Computational Physics -1»**

**Computational experiment in Physics (3 credit points)**

Computational experiment: role and place in scientific and technological progress. Modeling in programming systems. Simulation modeling in physics.

**Module «Computational Physics -2»**

**Computer simulation of Physical systems, processes and phenomena**

**(6 credit points)**

General concepts of modeling. Use of Matlab system for computer simulation of physical processes. Computer simulation of physical processes: movement of bodies at an angle to the horizon, body oscillations, movement of bodies in a gravitational field, movement of charged particles in electric and magnetic fields, propagation of light in different media from the point of view of geometric optics, propagation of light waves from the point of view of wave optics.

**Module «Modern information technologies»**

**Parallel programming (6 credit points)**

Parallel programming. Multiprocessor systems. Parallelization of calculations. Computer clusters. Programming in systems with shared and distributed memory. MPI and OMP technologies. Parallel algorithms of numerical integration and solution of linear algebraic equation systems.

**Operating systems and system programming (6 credit points)**

General description of the structure of Linux and Windows operating systems. Users and access rights. Creation and management of users. Description and assignment of user access rights. File systems and general principles of file space organization. Description of standard directory structure. Mounting file systems in nix-systems. Access rights to files. Service applications. Brief description of typical system services. Acquaintance with the Linux shell on the example of Bash. Main window managers of Linux: Gnome and KDE.

Programs and software. System programming. Program preparation stages. Programming in Assembler language. Assembler language suggestions. Registers. Arithmetic operations. String processing commands. Entry and execution of programs. Assembling the program. Program layout. Program execution. Cross-reference file. Algorithms of Assemblers' work.

Basics of C++ programming. Structure of the classical C-program. Preprocessor. Creation of a simple program. Data types. Description of variables. Logic operators. Operators of C++ language. Operator of transition goto. Conditional operator if ... else. Operators of the loop. Pointers. Functions. Embedded functions.

Classes. Namespace. Inheritance. Using classes as custom data types. Virtual methods and classes. Classes declared as virtual. Templates. Template function. Class template. Processing of exceptions.

Flows. Console I/O. Flags. Manipulators. Methods. Memory as a stream. File I/O. Arbitrary access to files. Access to file buffer. Stream buffer iterators.

Standard STL template library. Organization of the window interface. Windows application framework. Program research. Message processing. Pressing a key. Mouse message. Creating a window. Timer. Drawing in a window. Working with text. Dialog with the user. Message window. Menu. Interface of Windows applications. Dialog with the user. Message window. Menu. Example of interactive graphics.

Dynamic Layout Library DLL. Creation of DLLL. Using DLL. Implicit binding. General use DLLL. Explicit DLLL loading. Loading resources from the DLLL.

Processes and streams. Creation of the process. Creation of a stream. Functions of C++ to create and end a thread. Measuring the thread's runtime. Shared access to data of several processes. Data transfer via message.

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**Basics of mobile application development (3 credit points)**

Application development industry. Basic technical principles of application development. Interface Builder and Layout Editor. AutoLayout in iOS and ConstraintLayout in Android. Local data storage in the application. Push and local notifications. Multithreading in applications. Using the features of the device. Promote applications.

**Computer and engineering graphics (6 credit points)**

Types of computer graphics. Basics of digital images formation. Graphic formats. Software for working with two-dimensional graphics. Drawing and collage technologies. Curves. Layers. Masks, channels. Color and tone correction. Filters, effects. Basics of graphic design.

Fundamentals of business and engineering graphics. Charts. Registration of design documentation. Construction of drawings. Conditions and simplifications in the construction of images. Sketch details. Technical drawing. Drawing. Dimensioning of the drawing. Methods of projection. Surface, sweep of surfaces. Systems of the automated designing.

Multimedia. Hardware and multimedia software. Types and methods of animation. Processing of audio and video information. Technologies of multimedia content creation. Flash-technologies.

Three-dimensional graphics. Basics of three-dimensional modeling. Software for working with three-dimensional graphics. Creation of three-dimensional images. Virtual reality.

**Modern programming technologies (3 credit points)**

Basic constructions of algorithmic languages. Main language operators. Procedures and functions. Modules. Object-oriented programming. Technologies of WEB-programming. Programming technologies in computer mathematics systems.

**Module «Modern information technologies»**

**Physics research problems**

Introduction. Research and experimental tasks and their role in teaching physics. The problem of balloon collisions. The problem of slipping the body from the surface of a sphere. The problem of the falling oscillating body. Study of board oscillations on two rotating cylinders. Solution of the problem about liquid pendulum. The problem of a charged electrometer. Tasks on electrostatics. Solving the problem of rainbow. Problem about the number of images in the collecting lens.

**Fundamentals of information technology**

Technical and software of modern information technologies. Technology of text information processing. Technology of numerical data processing. Technology of graphic information processing. Technology of creation of web-documents. Hardware-software means of providing multimedia technologies. Development of multimedia applications. Creation of interactive multimedia presentations. Technologies of input and primary processing of text and graphic information on a personal computer. Technology of creation and use of video documents.

Physics of real crystals

Crystal lattice and its description. Types of crystal lattices. Types of bonds in crystals. Liquid crystal structures. Varieties of liquid crystals. Plastic properties of crystals. Plastic deformation: sliding and twinning. Dislocations. Types and properties of dislocations. Defects in crystals. Electroplastic deformation. Electronic wind and the power of electronic entrainment. Kinetics of plastic deformation. Crystallization. Melting.

**Basics of Optoelectronics**

Wave optics basics. Optical waves in crystals. Artificial anisotropy of crystals. Analysis of wave propagation and transformation in anisotropic media by the method of bound waves. Linear electrooptical effect. Longitudinal and transverse electrooptical effect. Amplitude and phase modulation of light.