Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
RUDN University

Faculty of Physics, Mathematics and Natural Sciences

educational division - faculty/institute/academy

COURSE DESCRIPTION

01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	"Foreign (Russian) language in professional activity"
Course Workload	6/216
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Practical grammar of Russian as a foreign language. Scientific style of speech	Topic 1.1. Parts of speech: definition of the part of speech to which the word refers; restoration of the original form of the word; definition of the semantic group of nouns (subject, person, process, property, relation) Topic 1.2. Sentence model: subject and its characteristics; person and his actions; object and its property; the subject and its procedural sign; the presence / absence of an object in a given place
Section 2. Scientific style: secondary ways of designating the situation and types of texts	Topic 2.1. Scientific style: secondary ways of designating a situation and types of texts
Section 3. Preparation for writing and defending the WRC in Russian.	Topic 3.1. Requirements for the structure, content and language of the WRC. Stylistic and punctuation design of the WRC. Bibliography requirements. Requirements for the preparation and presentation of a scientific presentation.

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	"Applied problems of mathematical modeling"
Course Workload	2/72
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Introduction to modern mathematical modeling in biology	Topic 1.1. Multidisciplinarity and multiphysics of modern scientific research Topic 1.2. The main types of the processes under study and the corresponding mathematical problems
Section 2. Visualization in Python	Topic 2.1. Construction of graphs of elementary functions. Setting the legend and axis labels Topic 2.2. Building a series of several curves. Construction of phase diagrams (parametric curves)
Section 3. Fundamentals of phenomenological chemical kinetics. Simple reactions of the 1st and 2nd order	Topic 3.1. Basic concepts of chemical kinetics. Reaction rate, simple reaction rate (law of mass action), reaction order. Dimensions of quantities (distance, time, concentration, speed). characteristic quantities. Kinetics of reactions of the 1st and 2nd order
Section 4. Numerical solution of kinetic equations	Topic 4.1. The concept of convergence in the integration step and convergence to the exact solution. Numerical solution of ODE (Cauchy problem) in Python. Comparison of exact and numerical solutions

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	"Functional differential equations and nonlocal boundary value problems"
Course Workload	6/216
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Introduction	Topic 1.1. Variational and boundary value problems with deviating argument. Solvability and regularity of generalized solutions. Boundary value problems for differential-difference equations in the one-dimensional case.
Section 2. Strongly Elliptic Systems of Differential Equations	Topic 2.1. Investigation of Gording's inequality for equations and systems of partial differential equations. Topic 2.2. Localization method.
Section 3. Boundary value problems for elliptic differential-difference equations	Topic 3.1. Difference operators in bounded domains of the Euclidean space. Solution of the coercivity problem (investigation of Gording-type inequality) for differential-difference operators. Topic 3.2. Boundary value problems for elliptic functional-differential equations with expansions and contractions of arguments

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	"Additional chapters of mathematical modeling"
Course Workload	4/144
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Methods for constructing mathematical models	Topic 1.1. Construction of mathematical models based on the fundamental laws of nature. Universality of mathematical models. Models of difficult-to-formalizable objects
Section 2. Examples of building mathematical models	Topic 2.1. Keynes' business cycle model and Weidlich-Haag sociodynamics. Topic 2.2. Models of interacting populations of Volterra-Lotka and Holling-Tanner. Infection patterns. Quasi-one-dimensional model of hemodynamics on graphs. Model of the legal system "power-society" Samarsky-Mikhailov. Lefebvre-Prigogine's "brusselator" model.
Section 3. Methods for constructing mathematical models	Topic 3.1. Geometric methods for ODE systems on the plane. Hopf's theorem on cycle birth bifurcation for a one-parameter system of ODEs. Cycle birth bifurcation for local semiflows. Topic 3.2. Methods of propagating waves and separation of variables in mixed problems for linear hyperbolic systems on graphs.

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COURSE DESCRIPTION

01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	"Mathematical models in economics"
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Introduction topic	Topic 1.1. Doing. Lyapunov stability and orbital stability. Lyapunov's methods for studying stability. structural stability. Examples
Section 2. Economic models and their dynamics	Topic 2.1. Economic models of Goodwin Topic 2.2. Rayleigh type equations. Limit cycles for equations of Rayleigh-type economic models. Hopf bifurcation of the Rayleigh equations

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Introduction to low-dimensional topology»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Fundamentals of classical differential geometry	Topic 1.1. Fundamentals of the theory of curves and regular surfaces.
Section 2. Fundamentals of the topology of smooth manifolds	Topic 2.1. Smooth manifold. Definition and examples. Embeddings and immersions of manifolds
Section 3. Fundamentals of the theory of knots and links	Topic 3.1. Concepts of knot and link. Knot and link diagrams. Polynomial invariants of knots and links Topic 3.2. Virtual knots and links. Knot and link invariants with values on graphs.

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Numerical analysis»
Course Workload	2/72
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Introduction	Topic 1.1. Practical relevance of finding numerical solutions. Problems of computational mathematics, convergence, accuracy.
Section 2. Solution of nonlinear equations	Topic 2.1. Half division method. Simple iteration method. Newton's method. The secant method. Parabola method. Topic 2.2. Methods for finding the roots of systems of nonlinear equations. Seidel iteration method. Newton's method. Aitken convergence acceleration

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COURSE DESCRIPTION

01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Elements of perturbation theory»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. The problem of blowing up solutions. Basic concepts	Topic 1.1. The problem of the absence of solutions for some classes of nonlinear equations and partial differential inequalities. Research methods: comparison method, trial function method, energy estimation method
Section 2. Semilinear inequalities in space	Topic 2.1. Sufficient conditions for the absence of solutions for semilinear elliptic inequalities of both second and higher orders in the entire space. Topic 2.2. Critical exponent of Serrin's nonlinearity, its optimality
Section 3. Quasilinear inequalities in space	Topic 3.1. Quasi-linear elliptic inequalities in the whole space. Coercive and anti-coercive cases

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Mathematical models in biology and medicine»
Course Workload	4/144
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Introduction to modern mathematical modeling in biology	Topic 1.1. Multidisciplinarity and multiphysics of modern scientific research. The main types of the processes under study and the corresponding mathematical problems
Section 2. Solving the equations of chemical kinetics in the COPASI package	Topic 2.1. The need to create software packages for the study of complex kinetic models of biology and biochemistry. Topic 2.2. Creation and analysis of simple kinetic models in the COPASI package (simple reactions of the 1st and 2nd order, reversible, sequential processes). Solution analysis
Section 3. Analysis of complex reactions. Model reduction. The bottleneck principle and the principle of quasi-stationarity	Topic 3.1. Reduction of complex models. Principles of bottleneck and quasi-stationarity. Illustration using a 2-step irreversible reaction as an example; areas of applicability of these principles. Numerical solution and its analysis

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Non-Euclidean geometries and their applications»
Course Workload	2/72
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Non-Euclidean geometry of Lobachevsky	Topic 1.1. Discovery of the non-Euclidean geometry of Lobachevsky. Lobachevsky space models. Basic of Lobachevsky planimetry. Volumes of figure in Lobachevsky space
Section 2. Spherical geometry	Topic 2.1. Basic concepts of spherical geometry. Basic formulas of spherical trigonometry Topic 2.2. Volumes of figure in spherical spaces
Section 3. Non-Euclidean geometry of Galileo	Topic 3.1. Basic definitions and concepts of Galilean geometry. The simplest examples of theorems for the Galilean plane

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COURSE DESCRIPTION

01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Nonlinear evolution equations»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Bochner measurability, Bochner integral	Topic 1.1. Definition of measurability and Bochner integrability of a function with values in a Banach space, comprehensive properties. Criteria for measurability and integrability in the sense of Bochner. Limit of a sequence of functions measurable in the sense of Bochner. Action of a linear operator on the Bochner integral
Section 2. Spaces of integrable functions	Topic 2.1. Definition of spaces of integrable functions with values in a Banach space. Completeness and separability of such spaces, dual spaces, Hölder's inequality Topic 2.2. Lebesgue points of integrable functions. Relationship between measurability and integrability according to Bochner and Lebesgue
Section 3. Strong and weak differentiability	Topic 3.1. Definition and properties of differentiable and weakly differentiable functions with values in a Banach space. Complete systems of functions in spaces of differentiable functions. Density of spaces of differentiable functions in spaces of integrable functions

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	«Introduction to Neural Networks, Big Data Analysis and Machine Learning»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Basics of artificial neural networks	Topic 1.1. Biological prototypes, artificial neurons, single-layer and multi-layer artificial neural networks. Topic 1.2. Training artificial neural networks. Learning algorithms
Section 2. Perceptrons	Topic 2.1. Perceptron architecture. The range of tasks for which the perceptron is used. Education. Back propagation procedure.
Section 3. Stochastic methods for training neural networks	Topic 3.1. Overview of the main stochastic methods used for training neural networks
Section 4. Algorithms for training neural networks	Topic 4.1. Study of various methods for training neural networks. Systematization of what has been learned.

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

field of studies / speciality code and title

Course Title	«Computational methods of continuum mechanics»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Nonlinear models of natural science	Topic 1.1. Mathematical modeling of one-dimensional unsteady gas movement with finite disturbances: a model approach to studying the processes of gas, water, oil extraction from natural formations Topic 1.2. Mathematical model of propagation of unloading waves in a plastic medium
Section 2. About solutions (research) of nonlinear models	Topic 2.1. Numerical methods: a) modified method of characteristics b) cellular-layer method. Computational algorithms and programs that implement them on computers.

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	«Computer technologies in science and education»
Course Workload	10/360
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. MS Excel	Topic 1.1. Scientific calculations in MS Excel Topic 1.2. Data analysis in MS Excel Topic 1.3. Programming in MS Excel
Section 2. Registration of educational and scientific works in the LaTeX system	Topic 2.1. Typing in LaTeX. A set of mathematical formulas in LaTeX. Matrix set. Tags and links
Section 3. VBA programming in MS Access	Topic 3.1. Development environment. Program structure. subroutines. Built-in functions. Working with MS Access objects

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	«History and methodology of mathematics»
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Main stages and milestones in the development of mathematics	Topic 1.1. General overview of the historical development of mathematics Topic 1.2. The history of the discovery of non-Euclidean geometry Topic 1.3. History of solving an algebraic equation of the 5th degree Topic 1.4. History of the foundations of mathematics

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	«Interdisciplinary coursework»
Course Workload	2/72
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. The Cauchy problem and initial-boundary value problems for the equation of string vibrations	Topic 1.1. Construction of solutions to the Cauchy problem and initial-boundary value problems for the equation of string vibrations by the method of propagating waves
Section 2. The Cauchy problem for the heat equation	Topic 2.1. Construction of solutions to the Cauchy problem for the heat equation using the Poisson formula
Section 3. Variable separation method	Topic 3.1. Construction of solutions to boundary value problems for various classes of partial differential equations by separation of variables
Section 4. Quasi-linear equations of the 1st order	Topic 4.1. Construction of classical solutions of the Cauchy problem by the method of characteristics. Construction of solutions to the Riemann problem on discontinuity decay

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	"Mathematical models and databases"
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Work of subqueries, nested queries	Topic 1.1. Statements that allow you to work with subqueries, nested SELECT statements
Section 2. Correlated subqueries	Topic 2.1. Subqueries that allow you to work with candidate shirts for checking the predicate
Section 3. Conditions of the first order in the classical problem of the calculus of variations	Topic 3.1. Action of EXISTS operators with correlated subqueries
Section 4. Special operator ANY (or SOME)	Topic 4.1. Alternative operators to the EXIST operator, more convenient for subqueries
Section 5 Special operator ALL	Topic 5.1. An alternative operator that checks information in all rows
Section 6. Combining multiple queries into one	Topic 6.1. Queries with the same structure in the SELECT clause can be combined into one and executed as a single entity
Section 7. EXEPT and INTERSECT statements	Topic 7.1. Operators that use the minus and intersection operation, according to the operations of set theory
Section 8. Introduction to representation	Topic 8.1. Creation of virtual tables that are used to work with data in order to hide it from the user

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	"Nonlinear analysis and optimization"
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. General concepts	Topic 1.1. Classification of extremal problems. Statement of classical problems of calculus of variations and optimal control. Elements of functional analysis
Section 2. Differentiable functionals	Topic 2.1. Differentiable Functionals. Derivative in direction, Lagrange, Gateau and Fréchet. Extremum of differentiable functionals Topic 2.2. Uniqueness of the Fréchet derivative. Fermat's principle and related statements
Section 3. First order conditions in the classical problem of the calculus of variations	Topic 3.1. Statement of the simplest problem of the calculus of variations. Basic Lemmas of the Calculus of Variations Topic 3.2. Extremal smoothness. Derivation of the Euler equation for the classical problem of the calculus of variations. Special cases of the Euler equation
Section 4. The Euler equation in the multidimensional case	Topic 4.1. Formulation of the problem. Derivation of the Euler equation using the main lemmas of the calculus of variations

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	"Functional spaces"
Course Workload	3/108
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Morrey spaces	Topic 1.1. Definition and basic properties of Morrey spaces. Examples of functions from Morrey spaces. Completeness. Comparison with Nikolsky spaces Topic 1.2. Definition and basic properties of local Morrey spaces. Examples of functions from Morrey spaces Topic 1.3. Definition and basic properties of general local and global spaces of Morrey type. Conditions for non-triviality
Section 2. Maximum operator	Topic 2.1. Definition and basic properties of the maximum Hardy-Littlewood operator Topic 2.2. Necessary and sufficient conditions for a maximal operator to be bounded in general local spaces of Morrey type
Section 3. Fractional maximum operator	Topic 3.1. Definition and basic properties of the fractional maximal operator. Necessary and sufficient conditions for boundedness of a fractional maximal operator in general local spaces of Morrey type

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01.04.01 Mathematics / Functional methods in differential equations and interdisciplinary research

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Course Title	"Modern problems of mathematics"
Course Workload	6/216
Course contents	
Course Module Title	**Brief Description of the Module Content**
Section 1. Fourier transforms	Topic 1.1. Fourier transforms of basic and generalized functions Topic 1.2. Fourier transform of functions from L_2 Topic 1.3. Fourier transform of functions from L_2. Plancherel's theory. Topic 1.4. Fourier transform of functions from L_2
Section 2. Definition and basic properties of Fourier multipliers	Topic 2.1. The Fourier space of multipliers in L_2. Sufficient conditions for Fourier multipliers in L_2. Statement and proof of the main theorem on the multipliers of the Fourier integral
Section 3. Subspace of functions with bounded spectrum	Topic 3.1. Integral representation of a function with limited spectrum. Bernstein's inequality for a function with bounded spectrum. Inequality of different Nikolsky metrics for a function with bounded spectrum.
Section 4. Sobolev spaces	Topic 4.1. Averaging of functions according to Sobolev, its connection with generalized differentiation Topic 4.2. Embedding theorems for Sobolev spaces

Program manager:

V.I. Burenkov

signature name and surname

HEAD
OF EDUCATIONAL DEPARTMENT

A.B. Muravnik

signature name and surname