Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Additive Combinatorics/Аддитивная комбинаторика

Purpose of the course:

mastering additive combinatorics.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of additive combinatorics;

• acquisition of theoretical knowledge and practical skills in the field of additive combinatorics;

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

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 additive combinatorics;
- modern problems of the corresponding sections of additive combinatorics;
- 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 additive combinatorics.

be able to:

- understand the task;
- use your knowledge to solve fundamental and applied problems of additive combinatorics;
- 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 the field of complex computing 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 requiring the use of mathematical approaches and methods of additive combinatorics for their solution;

 the subject language of complex calculations 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. Polynomial Growth Groups

The increase in complexity of the group.

2. Groups generated by automata

Actions on Root Trees

3. Classification of automaton groups with two states and the alphabet {0, 1}

Balog-Semeredi-Gowers Theorem. Higher energies, structural theorems.

4. Nielsen Method

Its geometric interpretation

5. Plynneke Inequality

The simplest relations between the sizes of the sums of sets.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

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Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Advanced Graph Theory/Современная теория графов

Purpose of the course:

1. Familiarity with standard proof techniques in graph theory.

2. Familiarity with classical graph invariants and standard research questions.

3. Familiarity with classical and modern results in graph theory.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in graph theory;

• acquisition of theoretical knowledge and practical skills in graph theory;

• In an open way and helping students conduct theoretical research in graph 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, graph theory;

 modern problems of the relevant sections of graph theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the graph theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of graph 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 topology orally and in writing.

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 requiring the use of mathematical approaches and methods for their solution;

 the subject language of topology 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. Recall of basic notation and facts

We recall some elementary properties of graphs, many of which were introduced in the discrete structures courser the previous semester. We also introduce some convenient notation for local graph modifications

which will be extensively used throughout the course.

2. Graph Factoring

We study classical Hall's theorem on the existence of perfect matchings in bipartite graphs. We prove this theorem using max-flow-min-cut theorem and also give a second proof using alternating chains. We then study graph coloring implications of Hall's theorem and proceed to Tutte's theorem on criterial conditions of

existence of perfect matchings in non-bipartite graphs. To finalise, we study different problems of splitting graph into complete bipartite graphs.

3. Connectivity

We introduce two notions of high connectivity, both of which generalise "standard" connectivity and prove the milestone Menger's theorem on the equivalence of these definitions, employing the max-flow-min-cut theorem. We then prove Mader's theorem on the existence of subgraph with high connectivity in a graph with high average degree. Here we illustrate graph saturation proof techniques. We then discuss properties of biconnected and triconnected graphs, recursive constructions. We also prove a beautiful result on cycles in graphs with high connectivity.

4. Coloring

We prove two classical theorems on graph coloring: Brooks' theorem on chromatic number (using Lovasz greedy coloring with special ordering of vertices) and Vizing's theorem on chromatic index. We also discuss properties of critical graphs, and in particular prove theorem on - constructible graphs. We prove some results on list coloring and connection of list chromatic number and ordinary chromatic number. In

the end we discuss a notion of perfect graphs and prove Weak perfect graph conjecture (proof due to Lovasz).

5. Embedding

We study planar graphs. We prove Kuratowski's and Wagner's planarity criteria. We also study properties of planar triangulations, in particular, prove that they are triconnected. We conclude with proving Tutte's barycentric embedding theorem and Lipton—Tarjan's theorem on planar graph separation.

6. Extremal problems

We prove the central result of extremal graph theory by Erdos, Stone and Simonovits on critical density of graphs with forbidden subgraphs.

7. Traversals

We prove several results (by Erdos, Chvatal et al.) on the existence of hamiltonian cycles in graphs.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Advanced Graph Theory/Современная теория графов

Purpose of the course:

1. Familiarity with standard proof techniques in graph theory.

2. Familiarity with classical graph invariants and standard research questions.

3. Familiarity with classical and modern results in graph theory.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in graph theory;

• acquisition of theoretical knowledge and practical skills in graph theory;

• In an open way and helping students conduct theoretical research in graph 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, graph theory;

 modern problems of the relevant sections of graph theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the graph theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of graph 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 topology orally and in writing.

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 requiring the use of mathematical approaches and methods for their solution;

 the subject language of topology 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. Recall of basic notation and facts

We recall some elementary properties of graphs, many of which were introduced in the discrete structures courser the previous semester. We also introduce some convenient notation for local graph modifications

which will be extensively used throughout the course.

2. Graph Factoring

We study classical Hall's theorem on the existence of perfect matchings in bipartite graphs. We prove this theorem using max-flow-min-cut theorem and also give a second proof using alternating chains. We then study graph coloring implications of Hall's theorem and proceed to Tutte's theorem on criterial conditions of

existence of perfect matchings in non-bipartite graphs. To finalise, we study different problems of splitting graph into complete bipartite graphs.

3. Connectivity

We introduce two notions of high connectivity, both of which generalise "standard" connectivity and prove the milestone Menger's theorem on the equivalence of these definitions, employing the max-flow-min-cut theorem. We then prove Mader's theorem on the existence of subgraph with high connectivity in a graph with high average degree. Here we illustrate graph saturation proof techniques. We then discuss properties of biconnected and triconnected graphs, recursive constructions. We also prove a beautiful result on cycles in graphs with high connectivity.

4. Coloring

We prove two classical theorems on graph coloring: Brooks' theorem on chromatic number (using Lovasz greedy coloring with special ordering of vertices) and Vizing's theorem on chromatic index. We also discuss properties of critical graphs, and in particular prove theorem on - constructible graphs. We prove some results on list coloring and connection of list chromatic number and ordinary chromatic number. In

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7. Traversals

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Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Algorithmic Game Theory/Алгоритмическая теория игр

Purpose of the course:

To acquaint students with the basic concepts and results of non-cooperative and cooperative game theory. Central to the course is the concept of Nash equilibrium, sequential equilibrium, and the concept of the core in co-op games with side payments.

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in game theory;

• acquisition of theoretical knowledge and practical skills in game theory;

• providing advice and assistance to students in their own theoretical research in game 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, game theory;

 modern problems of the relevant sections of game theory;

 concepts, axioms, methods of proofs and proofs of the main theorems in the sections included in the basic part of the game theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of game theory.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately represent mathematical knowledge in topology both orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of 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 topology and the skills of competently describing the solution of problems and presenting the results obtained.

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

1. Brower's theorem. Sperner's lemma. Kakutani's theorem

Nash's theorem on the existence of equilibrium in mixed strategies.

2. Dominated strategies

Consistent elimination of heavily dominated strategies. Minimax and maximin. Zero-sum games. Saddle point

3. Definition of a game in normal form: strategy, player, utility

Nash equilibrium in pure

strategies. Examples. The Prisoner's Dilemma. Game "rock-paper-scissors".

4. Defining a mixed strategy

Nash Equilibrium in Mixed Strategies

5. Expanded form of the game

Equivalence with normal form. Equilibria perfect in subplay. Examples

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Applied Discrete Optimization/Прикладная дискретная оптимизация

Purpose of the course:

study of classical and modern optimization methods. Consideration of examples of their use in applied problems of physics, mathematics and computer science.

Tasks of the course:

 study of the mathematical foundations of modern combinatorics;

 acquisition of theoretical knowledge in the field of combinatorial analysis of problems arising in practice;

 mastering the analytical and algebraic apparatus of discrete mathematics and obtaining skills in working with basic discrete structures.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of a part of discrete mathematics;

 modern problems of the corresponding sections of discrete mathematics;

 concepts, axioms, methods of proofs and proofs 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 discrete mathematics.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately present mathematical knowledge in the field orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of setting, analyzing and solving mathematical and applied problems that require the use of mathematical approaches and methods for their solution;

 the subject language of discrete mathematics and the skills of competently describing the solution of problems and presenting the results obtained.

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

1. Prim and Boruvka's Algorithms for Solving the MST Problem

Reminder of basic concepts from linear programming. Problem in standard and canonical forms. Transition from inequalities to equalities and vice versa. Geometry of the problem: a simplex algorithm as a local search along the vertices of a polyhedron.

2. Duality in linear programming

Statement of the TSP problem in terms of the CLP. Miller – Tucker – Zemlin conditions (polynomial number of inequalities in the TSP). Remark “on the non-catastrophic nature of the exponential number of constraints in LP problems”.

3. Discrete linear subset problem (DLS problem)

TSP and MST problems as special cases of DLS minimization problems; transition to maximization. Hereditary systems. Bases and cycles. Rank and lower rank of a set, rank spread. Matroids: equivalent definitions, examples. Evaluation of the performance of a greedy algorithm on a hereditary system through its rank spread. Corollary on the correctness of the greedy algorithm for constructing the shortest spanning tree. Estimation of the rank spread through the limitation on the number of cycles. Submodularity of the rank function of the matroid. Enumeration of matroids. Estimation of the number of cycles for a hereditary system in terms of the number of matroids in the intersection.

4. The problem of constructing a matching of maximum cardinality in an arbitrary graph

Augmenting paths (the statement that matching is non-maximal ⇔ is an augmenting path). The problem with finding augmentation paths in the absence of dicotyledonous: flowers. Flower shrinkage statements. Edmonds algorithm.

5. Branch and bound method

Exhaustive enumeration of complex discrete objects. Reed's approach: ordered enumeration. Avis-Fukuda local search inversion method.

6. Dijkstra's Algorithm Modifications

Two algorithms: gradual minimization of the flow cost at a constant value; an increment in value due to the smallest possible increment in value.

7. Distinctive features of discrete optimization problems

An overview of the formulations of classical discrete optimization problems: set coverage, vertex coverage, shortest path, minimal spanning tree, matching problems, assignment problem, scheduling problems, packing problems (bin packing, knapsack), flow problems (largest flow, flow least cost, multi-product flows), transport problem (Hitchcock problem), traveling salesman problem.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Applied Mathematical Modeling/Прикладное математическое моделирование

Purpose of the course:

Equilibrium-based mathematical modeling is one of the main ways to study complex systems.This course examines basic equilibrium models in various fields of application, such as economics and telecommunications systems. These include equilibrium models under conditions of perfect and imperfect competition, with various types of information use, including exchange models, Arrow-Debreu, Wald, Cournot and Bertrand. The dynamic models of Leontief and von Neumann are presented. In addition, models of spatial economic equilibrium, transport equilibrium, and models of population migration processes are considered. Variational inequality is used as a basic equilibrium model in complex systems. The elements of the theory and basic methods for solving variational inequalities are considered, as well as their connection with other general problems of nonlinear analysis.

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in applied mathematical modeling;

• acquisition of theoretical knowledge and practical skills in applied mathematical modeling;

• providing advice and assistance to students in conducting their own theoretical research in applied mathematical modeling.

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

As a result of studying the course the student should

know:

theoretical knowledge of the basic properties of equilibrium models

be able to:

understand the main approaches to building equilibrium models in complex systems and their applications

master:

skills of formulating and solving the simplest equilibrium models

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

1. Types of equilibria in the market of a homogeneous product

Aggregated equilibrium models of interaction of economic agents. Types of equilibria in the market of a homogeneous product, static and dynamic market models.

2. Equilibrium for the study of complex systems

Construction of models of applied problems using the concept of equilibrium. Investigation of the properties of equilibrium problems.

3. Perfect competition models

Microeconomic models of interaction between economic agents and information exchange. Exchange model. Individual demand and balance. Arrow-Debreu model. Equilibrium price establishment processes.

4. Equilibrium game models

Oligopolistic markets according to Cournot and Bertrand, strategies of participants' behavior.

5. Dynamic models of the economy

Generalized dynamic Leontief model.

6. Equilibrium models based on duality theory

Duality in linear programming. Economic interpretation of the simplex method. Generalized optimality conditions.

7. General models of economic equilibrium

Equilibrium models of Kassel-Wald and Scarfe.

8. Equilibrium models in distributed information systems

Transport equilibrium models.

9. Population migration patterns

Modeling population migration processes

10. Variational inequalities

Properties of existence and uniqueness of solutions. Variational inequalities and other problems of nonlinear analysis.

11. Methods for solving variational inequalities

Newton's method. Projective method.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Applied Statistics/Прикладная статистика

Purpose of the course:

studying the mathematical and theoretical foundations of modern statistical analysis, as well as preparing students for further independent work in the field of analysis of statistical problems in applied mathematics, physics and economics.

Tasks of the course:

 studying the mathematical foundations of mathematical statistics;

 acquisition of theoretical knowledge in the field of modern statistical analysis by students.

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

As a result of studying the course the student should

know:

 basic concepts of mathematical statistics;

 basic approaches to comparing estimates of parameters of an unknown distribution;

 asymptotic and non-asymptotic properties of estimates of parameters of an unknown distribution;

 basic methods for constructing estimates with good asymptotic properties: method of moments, method of maximum likelihood, method of sample quantiles;

 the concept of effective estimates and inequality of information by Rao-Cramer;

 definition and main properties of the conditional mathematical expectation of a random variable relative to sigma-algebra or other random variable;

 definition of a general linear regression model and least squares method;

 multivariate normal distribution and its basic properties;

 basic concepts of the theory of testing statistical hypotheses;

 Neumann - Pearson lemma and monotonic likelihood ratio theorem;

 Pearson chi-square test for testing simple hypotheses in the Bernoulli scheme..

be able to:

 substantiate the asymptotic properties of estimates using the limit theorems of probability theory;

 construct estimates with good asymptotic properties for the parameters of an unknown distribution for a given sample from it;

 find Bayesian estimates for a given prior distribution;

 calculate conditional mathematical expectations using conditional distributions;

 find optimal estimates using complete sufficient statistics;

 build exact and asymptotic confidence intervals and areas for the parameters of the unknown distribution;

 find optimal estimates and confidence regions in a Gaussian linear model;

 build uniformly the most powerful criteria in the case of a parametric family with a monotonic likelihood ratio;

 Build an F-test to test linear hypotheses in a linear Gaussian model.

master:

 the main methods of mathematical statistics for constructing point and confidence estimates: the method of moments, sample quantiles, maximum likelihood, the method of least squares, the method of central statistics.

 skills of asymptotic analysis of statistical tests;

 skills of applying the theorems of mathematical statistics in applied problems of physics and economics.

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

1. F-test for testing linear hypotheses in a Gaussian linear model.

Binary search, Ternary search. Basic data structures: stack, queue, singly linked list, doubly linked list. Basic definitions of graph theory, DFS, BFS, topsort.

2. Probabilistic-statistical model.

Probabilistic-statistical model. Observation and sampling concepts. Parametric statistical model. Modeling a sample from an unknown distribution that belongs to a parametric family.

3. The main task of mathematical statistics.

The main task of mathematical statistics. Examples: sampling and linear model.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Approximation Algorithms/Алгоритмы аппроксимации

Purpose of the course:

The purpose of mastering the disciplines is to study deterministic and stochastic computational adaptation algorithms. The study of the basics and methods of research, calculations and design of optimal systems for automatic control of production processes.

Tasks of the course:

 Studying the basics of algebraic topology;

 acquisition by students of theoretical knowledge and analysis of problems arising in practice;

 acquisition of theoretical knowledge and practical skills in conducting their own theoretical research in the field of approximation algorithms

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

As a result of studying the course the student should

know:

theoretical knowledge about the concepts and problems associated with the approximation of Sobolev function spaces.

be able to:

to determine weak solutions of boundary value problems of mathematical physics for elliptic equations of the second order.

master:

.skills of independent analysis and solution of theoretical and practical problems related to the numerical solution of boundary value problems.

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

1. The simplest theorems of the Ramsey theory of links

Examples of hypergraphs that are not linearly realizable in three and four dimensions

2. Hypergraph definitions

Definitions of a hypergraph (simplicial complex), linear and piecewise linear embeddings in a c/-dimensional space. General position theorem

3. Embedding of hypergraphs

Embeddability of hypergraphs: low-dimensional examples, formulations of algorithmic and ATP-hard results

4. Van Kampen's algorithm

Van Kampen's algorithm for recognizing the planarity of graphs

5. Building Borromean rings using a torus

Three-dimensional and four-dimensional Borromean ring lemmas

6. Generalization of examples

An example of Friedmann-Kruskal-Teichner of the incompleteness of the Van Kampen obstruction to the embeddability of two-dimensional hypergraphs in four-dimensional space. Generalization of the previous example: construction of a two-dimensional hypergraph Pf by the formula .f for a Boolean function. Part of the proof of the PHR-hardness of recognizing the embeddability of two-dimensional hypergraphs in four-dimensional space.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Chinese/Китайский язык

Purpose of the course:

The formation and development of intercultural, professionally-oriented communicative competence of students at the elementary level to solve communicative problems in the professional, business, socio-cultural and academic spheres, as well as for the development of professional and personal qualities of bachelor graduates.

Tasks of the course:

Achieving the elementary level of intercultural professionally-oriented communicative competence in the course of studying the discipline "Chinese language" requires to solve a number of tasks which consist in the consistent mastering a set of sub-competencies. The main of the latter are:

– linguistic competence: the ability to understand other people's speech and express oneself in Chinese;

– sociocultural competence: the ability to take into account in communication speech and non-speech behavior adopted in China;

– social competence: ability to interact with communication partners using the relevant strategies;

– discursive competence: knowledge of the rules for building 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 communicative problems;

– subject competence: knowledge of subject information when organizing one’s own utterance or understanding of the utterance of other people;

– compensatory competence: he 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, sights, and traditions of China;

– historical, social, political and cultural events in China;

– phonetic, lexical and grammatical, stylistic features of the Chinese language and its difference from the native language;

– main features of written and oral forms of communication.

be able to:

– Generate adequate oral and written texts in the context of a specific communication situation;

– realize the communicative intention with the aim 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, first foreign (second foreign) and Chinese 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 elementary level;

– sociocultural competence for successful understanding in the conditions of communication with representatives of another culture;

– various communication strategies;

– learning strategies for organizing their learning activities;

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

– different methods of memorization and structuring of digestible material;

– Internet technologies to select an optimal mode of obtaining information;

– presentation technologies for providing information.

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

1. Introductory-phonetic and introductory-hieroglyphic course. Meeting Chinese colleagues, fellow students, neighbours.

Introduction into the basics of Chinese pronunciation (putonghua) and the basic rules of calligraphy and hieroglyphics.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To read words, word combinations and phrases both written in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To compose phrases, including everyday life phrases, according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. Participate in a dialogue-inquiry and dialogue-incitement to action. To take part in the role-playing game “Meet the Chinese colleagues”.

Pronunciation: The sound-letter standard for recording Chinese words is pinyin, following the basic requirements for pronouncing Chinese sounds and distinguishing all Chinese sounds by ear. Following the rules of the tone system of the Chinese language, the main types of intonation of Chinese sentences.

Vocabulary: phrases of greeting and farewell, fixed expressions, courtesy phrases. Names of the countries, cities in China and the world. Common last names, social roles, educational supplies.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structures (word order, topic and comment (subject and predicate, inverted object etc.). A sentence with a quality predicate, quality adjective in the commentary position. Negative sentence form with quality predicate, quality adjective in the commentary position. Sentences with a linking verb是shì, the position of the negation 不bù in a sentence with a linking verb是shì, interrogative sentences with particles吗 ma, 吧ba, 呢 ne. Attribute in the possessive meaning. Particle的 de. Order of attributes in a Chinese sentence. Personal pronouns in Chinese, their functions and usage. Demonstrative and interrogative pronouns in Chinese. Interrogative sentences with interrogative pronouns. Word order in an interrogative sentence with an interrogative pronoun. A sentence with a verb predicate (action verb in the commentary position). Adverbs也yěand都dōu, their place in a sentence with regard to the predicate. The combination of the adverb都dōu with the negation不bù.

Writing: basic rules of calligraphy. The basics of hieroglyphics, mastering graphemes and hieroglyphs in accordance with the lexical and grammatical material studied. Writing short written statements according to the communicative task.

2. Getting to know the university campus, orientation in the city.

Buildings inside the campus, the insides of the building, different institutions and their location relative to each other, orientation in space and in cardinal directions. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incitement

to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard een. To describe the university campus, ways to get to one's destination. To take part in the role-playing tour around the campus. To talk about locations and movement directions.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases. Date, time, time of day, days of the week, postpositions (locatives) to specify spatial relationships.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory, and their structure schemes. Sentences of presence and possession with the verb有yǒu. Location indications with verbs在и 是 Postpositions ("adverbs of place") specifying spatial relationships (前边qiánbiān, 后边hòubiān, 上边shàngbiānetc.), in the function of a subject, an object and an attribute. Sentences of location (verb在zài, verb有yǒu, linker是shì).

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

3. Everyday life at work and at home, telling the exact time, plans for the nearest future.

Discussing the daily timetable, class schedule, plans for the nearest future, appointing a meeting. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incitement to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard een. To talk about the past experience in the everyday and professional life. To tell the exact time, the beginning and the ending of events, class schedule, plans for the nearest future.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, telling the exact time, days of the week, part of the day, adverbs of time today, tomorrow, yesterday, counting from 1 to 100, address, phone number.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Adverbial modifier of time; ways to specify time and date. Ordering adverbial modifiers of time in a sentence. Special question to the adverbial modifier of time. The verb 有 and the negation没有. Interrogative words几и 多少, phrasal particles吧и 呢.

Writing: basic rules of calligraphy. The basics of hieroglyphics, mastering graphemes and hieroglyphs in accordance with the lexical and grammatical material studied. Writing small written statements according to the communicative task.

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4. Talking about address, phone number, travel route. Shopping. Family. The weather.

Talking to the shop assistant, discussing the planned purchase, its price and quantity. Talking about the family members and pets. Discussing seasons and the weather in Russia and China, the air temperature. Discussing preferences.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incitement to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk and reason within the topic studied and give examples and arguments. To describe events, to state facts and what one has read/heard een. To construct mini-dialogs with the shop assistant about the planned purchase, its price and quantity. To make dialogs about the family members. To discuss climate peculiarities of Chine and the speaker’s country, the weather in different seasons, temperature conditions.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases, purchase, goods, shops, money, counting words for different objects, money, family members. Family members and pets. Seasons of the year, the weather, natural phenomena.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Interrogative words几и 多少. Numerals二and 两. Using counting words depending on the noun.

Quality predicate and special question to a quality predicate with the interrogative word**怎么样**.

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

5. Talking about present moment of action. Daily and weekly class schedule, plans for tomorrow.

Discussing free time, home tasks, present actions. Discussing plans for the nearest future, at first and then. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incitement to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard een. To discuss present actions, to talk about the class schedule and about what happens every day, every week etc. To discuss planned actions for the nearest future and their sequence.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases. Time expressions from … till ..., present moment, every day, days of the week, at first, then, institutions and purposes to visit those.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Adverbs of present tense现在and**正在**, expressions**每**...**都**, time period expression**从**...**到**, **先**...**然后**… .

Modal verb **打算**, talking about the purpose of a trip using a serial verb construction**去 商店** 买东. Adverb**一起**. General question with an affirmative-negative predicate.

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

6. Discussing the product before purchasing, friend's birthday, choosing a present, talking about preferences.

Talking about choosing the color of the clothes, about preferences. Discussing a purchase, its benefits and drawbacks. Choosing a birthday present for a friend, discussing different options and people's preferences. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incitement to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard een. To discuss a product before purchase, its benefits and drawbacks. To discuss a present for a friend and help with the choice. To give advice and arguments.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases, colors and shades, properties of objects, expression "a little…" (**有一点儿**...), vocabulary related to birthdays.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Attributive construction with the **的**, adverb **有一点儿**... and adverb **挺**, alternative question with the conjunction 还是, attribute with the "prefix" **可** (**可送的**，**可看的**，**可去的**).

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Complex Networks/Сложные сети

Purpose of the course:

mastering basic concepts in the field of complex networks.

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in the field of complex networks;

• acquisition of theoretical knowledge and practical skills in the field of complex networks;

• providing advice and assistance to students in their own theoretical research in the field of complex networks.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of complex networks;

 modern problems of the corresponding sections of complex networks;

 concepts, axioms, methods of proofs and proofs 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.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately present mathematical knowledge in the field orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of setting, analyzing and solving mathematical and applied problems that require the use of mathematical approaches and methods for their solution;

 the subject language of complex networks and the skills of competently describing the solution of problems and presenting the results obtained.

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

1. Dynamic evolution of complex networks

Comparative analysis of the percolation transition for the Bethe lattice and scale-invariant graphs

2. Classification of complex networks

Critical indices of the percolation transition for the Bethe lattice

3. Complex networks in problems of economics and finance

Relationships linking critical indicators.

4. Phase transitions on random networks

Properties of the one-dimensional Ising model

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Computational and Complexity/Сложность вычислений

Purpose of the course:

mastering additional chapters of complex calculations.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of complex computing;

• acquisition of theoretical knowledge and practical skills in the field of complex computing;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of complex calculations;

 modern problems of the relevant sections of complex calculations;

 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 complex calculations.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of EC;

 evaluate the correctness of task 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 the field of complex computing 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 requiring the use of mathematical approaches and EC methods for their solution;

 the subject language of complex calculations 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. What is an algorithm? Computation models. Computable functions. General purpose computable functions. Computing resources.

Decidable and enumerable sets. Several equivalent properties and basic properties. Post's theorem.

2. Algorithmically unsolvable problems: self-applicability problem, halting problem, “busy beavers”, etc.

The concept of m-reducibility. Construction of a non-enumerable set whose complement is also non-enumerable (the totality problem).

3. Links between computability and formal arithmetic. Gödel's Incompleteness Theorem.

Computing with an oracle: the concept and its properties. Relativization of computability. Non-deterministic computing. Complexity classes P, NP, coNP. The problem of equality between P and NP.

4. The concept of polynomial reducibility (according to Karp). NP-hardness and NP-completeness. Cook-Levin theorem and examples of NP complete problems from combinatorics, logic, graph theory, etc.

Spatial complexity. Complexity classes PSPACE, L and NL. Game-theoretic interpretation of PSPACE.

5. Probabilistic computing. Complexity classes BPP, RP and coRP. Reducing the error. Probabilistic tests of simplicity and equality of polynomials.

Interactive communication protocols and evidence systems. Complex IP class: examples and applications.

6. Average Difficulty and Foundations of Cryptography. One-way functions and pseudo-random number generators. Cryptographic protocols, their correctness and reliability.

Zero knowledge proofs. Perfectly, statistically and computationally zero knowledge properties.

7. Вероятностно проверяемые доказательства и их связь с приближённым решением NP-трудных задач.

Derandomization techniques and pseudo-random designs. Why are we confident that probabilistic algorithms do not expand computational power (i.e. P = BPP).

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Computer Vision/Компьютерное зрение

Purpose of the course:

- Learn how to apply Computer Vision techniques in practice
- Get familiar with both fundamental and most recent approaches in Computer Vision
- Get hands on experience in Computer Vision problems solutions

Tasks of the course:

- Computer Vision problem statement and ability to develop the general pipeline of the solution
- Choose relevant approach and model for particular problem
- Ability to apply the Computer Vision techniques to the real world problems
- Essential experience with PyTorch framework

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

As a result of studying the course the student should

know:

- basic methods and algorithms for analyzing a single image;

- examples of computer vision problems arising in the real world;

- existing heuristic methods of analysis, classification and image search.

be able to:

- understand the task at hand; use your knowledge to research images;

- independently find algorithms for solving problems, including non-standard ones, and analyze them;

- independently see the consequences of the results obtained.

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 setting, analyzing and solving practical problems of computer vision.

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

1. Computer Vision problem statements: classification, detection, segmentation

Metrics in CV: IoU, mAP Main datasets: PASCAL VOC, ImageNet, COCO, OpenImages Variational Autoencoders: structure, loss function, training process

2. R-CNN -> Fast -> Faster structure, main ideas, metrics and performance

Focal Loss Non Maximum Suppression algorithm Generative Adversarial Networks: structure, loss function, training process

3. YOLO v1 -> v3 main ideas

Separable convolutions MobleNet v1, v2 blocks

4. Upsampling methods: poolings, transposed convolutions

FCN, DeconvNet, SegNete U-Net architecture

5. Mask R-CNN approaches

Neural style transfer technique Model compression methods (distillation and quantization concepts) KL divergence. Relations to crossentropy

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Discrete Structures/Дискретные структуры

Purpose of the course:

studying the mathematical foundations of modern combinatorics, as well as preparing students for further independent work in the field of combinatorial problems of applied mathematics, physics and economics.

Tasks of the course:

 study of the mathematical foundations of modern combinatorics;

 acquisition by students of theoretical knowledge in the field of combinatorial analysis of problems arising in practice;

 mastering the analytical and algebraic apparatus of discrete mathematics and gaining skills in working with basic discrete structures.

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

As a result of studying the course the student should

know:

 fundamentals of combinatorics and asymptotic combinatorial analysis;

 fundamentals of the theory of generating functions and applications of the theory to enumeration problems of combinatorics;

 the foundations of the Mobius theory of inversion and its application to enumerative problems of combinatorics;

 fundamentals of graph theory: planarity, isomorphism, Eulerianity, Hamiltonianity, chromatic number, chromatic polynomial and Tatt polynomial, trees, multigraphs, digraphs, tournaments, admissible sequences of degrees of vertices, number of connected graphs with a given number of vertices and edges (Cayley formula for the number of trees and its generalization);

 fundamentals of the theory of hypergraphs: the theorems of Erdшas-Ko-Rado, Frankl-Wilson and Alsvede-Khachatryan, intersection graphs and edge graphs, chromatic numbers of Kneserov graphs;

 fundamentals of the theory of random graphs: connectivity, distribution of tree components, evolution of a giant component, the concept of a random web graph;

 fundamentals of combinatorial geometry and its connection with the theory of graphs and hypergraphs;

 the fundamentals of coding theory and its connection with the theory of graphs and hypergraphs: Hadamard matrices, error correction codes, Hamming and Reed - Muller codes;

 main probabilistic methods in combinatorics: linearity of mathematical expectation, alternation method, second moment method and estimation of large deviations;

 basic linear algebraic methods in combinatorics: linear independence of polynomials over a finite field;

 basic topological methods in combinatorics: application of the Borsuk – Ulam – Lyusternik – Shnirelman theorem;

 the basics of Ramsey theory: Ramsey numbers for graphs and hypergraphs, bipartite Ramsey numbers, constructive estimates;

 the fundamentals of the theory of representative systems for graphs and hypergraphs, including the concept of the Vapnik – Chervonenkis dimension and its application to problems of combinatorial geometry and mathematical statistics;

 fundamentals of extreme combinatorics: Turan's theorem and its refinement for distance graphs.

be able to:

 calculate the number of different combinatorial objects: combinations, placements, permutations, cyclic sequences;

 prove combinatorial identities;

 calculate approximate values (asymptotics) of combinatorial expressions;

 make and solve recurrence relations;

 prove the various properties of graphs and hypegraphs;

 solve extreme combinatorics problems;

 build representative systems for graphs and hypergraphs;

 solve Ramsey problems;

 evaluate chromatic numbers of graphs, construct Tatt polynomials and chromatic polynomials;

 Build error correction codes.

master:

 independent work skills;

 skills of mastering a large amount of information;

 culture of formulation and modeling of combinatorial problems;

 probabilistic method in combinatorics;

 linear-algebraic method in combinatorics;

 topological method in combinatorics;

 method of generating functions;

 using the Mobius method.

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

1. Recall of basic objects and facts

Sums, sets, sequences, floor and ceiling functions, basic notions of graph theory.

2. Proof techniques

Induction vs. minimal counterexample, potential method, pigeonhole principle vs. taking means, double counting.

3. Elementary counting

Multiplication principle, inclusion-exclusion

4. Counting

Recurrence relations (isolating an element), Redfield—Polya theory (employing symmetries).

5. Ramsey theory

Ramsey numbers, Ramsey theorem for finite graphs and hypergraphs,obtaining bounds for Ramsey numbers.

6. Introduction to probabilistic method

Existence proofs via counting, applications of Markov inequality, Lovasz' local lemma.

7. Introduction to linear algebraic methods

Rank bound (Fisher's inequality), quadratic forms (Graham—Pollack theorem), introduction to linear error-correcting codes.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

English Language. Intercultural Communication/Английский язык. Межкультурная коммуникация

Purpose of the course:

Formation of cultural and linguistic competence as a basis for a respectful intercultural attitude towards spiritual, national, and other values of other countries and nations; development of graduate students' cultural sensitivity, the ability to correctly interpret specific manifestations of communicative behavior in different situations; intercultural contacts, practical skills and abilities in communicating with representatives of other cultures, the ability to correctly interpret specific manifestations of communicative behavior and tolerant attitude to them; mastering intercultural interaction up to the necessary and sufficient level to solve communicative and social problems in different cultural, everyday, academic and professional tasks, in communication with representatives of other cultures.

Tasks of the course:

To form the learner's ability to solve communicative tasks by language means in various situations of intercultural communication, to interact on the interpersonal and professional level in a foreign language, considering the peculiarities of the culture of the language being studied, as well as the ability to overcome intercultural differences in situations of everyday, social and professional communication; to develop the ability to reflect on one's own and other cultures, which initially prepares one to have a respectful attitude to cultural manifestations of the target language; to expand the knowledge on the corresponding culture for deep understanding of diachronic and synchronic relations between one' own and the culture of the target language; to acquire new insights into the conditions of socialization and enculturation in one's own and other cultures, social stratification, and sociocultural forms of interaction in shared cultures.

To achieve the goals and objectives of mastering the discipline, students must master a foreign language professional communicative competence, including:

Ethnographic competence: the ability to understand the country of the studied language, its history and culture, everyday life, prominent representatives, traditions and manners; the ability to compare the history, culture, customs of their own and other cultures, understanding of cultural specificity and the ability to explain the causes and origins of a particular cultural characteristic.

Linguistic competence: the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people's statements.

Subject-professional competence: the ability to operate with knowledge in real world communication with representatives of the studied culture, showing empathy as the ability to understand the norms, values and motives of behavior of representatives of another culture.

Communicative competence: the ability to establish and maintain contacts with representatives of different age, social and other groups of both their own and other cultures, the ability to be a mediator between their own and other cultures.

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 set.

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

As a result of studying the course the student should

know:

- interrelation, mutual influence and interaction of language and culture;

- the role of language as an organic part of culture in human life, behavior and communication with speakers of other languages and other cultures, national individuality and identity of peoples;

- the concept of a cultural and anthropological view of a person, his/her way of life, ideas, attitudes, customs, system of values, perception of the world - his/her own and others';

- the influence of culture through language on human behavior, worldview and life in general;

- the history of emergence, development stages and teaching methods of intercultural communication;

- the meaning of the concept of "culture", its role in the communication process, as well as the relationship with such concepts as "socialization", "inculturation", "acculturation", "assimilation", "behavior", "language", "identity", "global citizenship";

- the impact of various social transformations on cultural identity changes;

- the specifics of how other cultures are perceived, the causes of prejudice and stereotypes in intercultural encounters;

- mechanisms of forming intercultural tolerance and dialogue of cultures;

- types, kinds, forms, models, structural components of intercultural communication;

- the norms and styles of intercultural communication;

- features of mentality and national customs of different cultures, cultural standards of ethnic, political and economic plans;

- linguistic worldview of native speakers of foreign languages, their distinctive features of outlook and understanding of the world;

- ethical and moral norms of behavior in a culturally different environment;

- language standards of oral communication culture, ethical and moral norms of behavior adopted in the country of the studied language; stereotypes and ways to overcome them; norms of etiquette in the country of the studied language;

- methods of systematic and critical analysis; methods of developing an action strategy for identifying and solving a conflict situation;

- stages of the project life cycle; stages of project development and implementation; methods of project development and management;

- team building techniques; methods of effective team management; basic leadership theories and leadership styles;

- rules and patterns of personal and business oral and written communication; modern communication technologies in Russian and foreign languages; existing professional communities for professional interaction;

- regularities and peculiarities of social and historical development of different cultures; peculiarities of intercultural society diversity; rules and methods of effective intercultural interaction;

- methods of self-assessment, self-control and self-development

be able to:

- apply the techniques of studying cultural systems and intercultural situations;

- perceive, analyze, interpret and compare cultural facts;

- determine the role of basic cultural concepts in intercultural communication;

- find adequate solutions in various intercultural communicative situations;

- analyze the peculiarities of intercultural communication in a team;

- reflect on the reference system of one's own culture;

- recognize and correctly interpret nonverbal signals in the process of intercultural communication;

- compose a communicative portrait of a representative of another linguistic culture;

- discover the meanings of concepts and actions in an intercultural situation;

- analyze coincidences and differences in communicative behavior from the perspective of the cultures in contact;

- adequately implement one' s communicative intentions when communicating with representatives of other linguistic cultures;

- switch when encountering another culture based not only on linguistic, but also on non-linguistic norms of behavior;

- identify the causes of communicative problems and apply ways to overcome them;

- take the position of a partner in intercultural communication and identify possible conflicts as conditioned by the values and norms of one' s culture;

- successfully overcome barriers and conflicts in communication and achieve mutual understanding;

- reveal the relationship and mutual influence of language and culture;

- be tolerant of other cultures and languages;

- analyze the main stages and regularities of the historical development of society to form their civic position;

- respect and preserve the historical heritage and cultural traditions;

- use models of social situations, typical scenarios of interaction of participants of intercultural communication;

- guide the principles of cultural relativism and ethical norms, which imply rejection of ethnocentrism and respect for the diversity of foreign language culture and value orientations of foreign-language societies;

- overcome the influence of stereotypes and carry out intercultural dialogue in general and professional lines of communication;

- model possible communicative situations between representatives of different cultures and societies;

- apply methods of systematic approach and critical analysis of problem situations; develop action strategies, make concrete decisions to implement them;

- develop a project taking into account the analysis of alternative options for its implementation, determine the target stages, the main directions of work; explain the goals and formulate tasks related to the preparation and implementation of the project; manage the project at all stages of its life cycle;

- develop a plan of collective and organizational communications in preparation and implementation of the project; formulate tasks for team members to achieve the set goal; develop a team strategy); apply effective styles of team leadership to achieve the set goal;

- apply communicative technologies, methods and ways of business communication in practice for academic and professional interaction;

- determine theoretical and practical significance of cultural and linguistic factors in the interaction of different philosophical and academic traditions;

- understand and tolerate intercultural diversity of society; analyze and take into account the diversity of cultures in the process of intercultural interaction;

- solve the problems of personal and professional development, determine and implement the priorities of improvement of own activity; apply the methods of self-assessment and self-control.

master:

- norms of etiquette and behavior when communicating with representatives of other cultures;

- principles of tolerance in resolving intercultural conflicts;

- methods of communicative research, the ability to apply the acquired knowledge in research activities, oral and written communication;

- communicative strategies and tactics characteristic of other cultures;

- skills for proper intercultural communication, independent analysis of intercultural conflicts in the process of communication with representatives of other cultures and ways to resolve them;

- the ability to correctly interpret specific manifestations of verbal and nonverbal communicative behavior across cultures;

- oral and written communication skills in Russian and foreign languages to solve interpersonal and intercultural communication issues;

- skills of operating with a focus on ethical and moral norms of behavior accepted in a foreign cultural society;

- the necessary interactive and contextual knowledge, allowing to overcome the influence of stereotypes and adapt to changing conditions in contact with representatives of different cultures

- methodology of systematic and critical analysis of problematic situations; methods of setting a goal, determining the ways to achieve it, developing action strategies

- methods of project development and management; methods of resource and project efficiency evaluation;

- the ability to analyze, design and organize interpersonal, collaborative and organizational communication in a team to achieve an objective; methods of organization and management of the team;

- methods of interpersonal business communication in Russian and foreign languages, with the use of professional language forms, tools, and modern communication technologies;

- methods and skills of effective intercultural interaction;

- technologies and skills for managing one's own cognitive activity and improving it on the basis of self-assessment, self-control and principles of lifelong learning.

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

1. Topic 1. Culture and language

The fundamental principles of intercultural communication and dialogue of cultures. Cultural worldview: an understanding of the values, norms, and morals of one's own culture and those of others. Types of relations between cultures. Linguistic system. The communicative function of language. Various forms of language communication. Human speech as a means of transmitting and receiving the bulk of vital information. The correlation between human speech and the language system as a whole. The meaning of language in peoples' cultures. Language as a unique means of storing and passing information, as well as controlling human behavior. The relationship between language, culture and communication. Language culture, language personality communication, identity, stereotypes of consciousness, world pictures, etc.

Communicative tasks: to carry out communication in oral and written forms: explaining the values and ethical norms of one's own culture and those of other cultures; discussing the characteristics and types of relationships between cultures; discussing the importance of taking into account the differences in the means of communication and the communication styles of other cultures; expressing hypotheses and one's own perspective on the interaction between language and culture.

2. Topic 2. Typology of cultures

The fundamental principles of intercultural communication and dialogue of cultures. Cultural worldview: an understanding of the values, norms, and morals of one's own culture and those of others. Types of relations between cultures. Parametric model of culture by G. Hofstede. Theory of cultural standards by A. Thomas. Differentiation of cultures by R. Lewis and F. Trompenaars. Perceptual stereotypes, prejudices and their functions, importance for intercultural communication. Tolerance in intercultural communication.

Communicative tasks: to carry out communication in oral and written forms: explaining the differences in various types of cultures; discussing the specifics of cultural standards, models, concepts; describing the values, norms, and morals of one's own culture and those of other peoples; analyzing coincidences and differences in communicative behavior from the perspective of contacting cultures; taking the partner's position in intercultural communication and identifying possible conflicts as conditioned by values and norms of his/her culture; discussing possible problems in communication with the representative of another culture and ways to resolve them in case analysis.

3. Topic 3. The essence and types of intercultural communication

Existing cultural differences between different people. Overcoming intercultural differences as the main goal of interpersonal communication. Cognitive, social and communication styles of intercultural communication. Verbal and nonverbal communication. Forms and methods of verbal and nonverbal communication. Paraverbal communication. National and cultural characteristics of verbal and nonverbal communicative behavior in different cultures.

Communicative tasks: to carry out communication in oral and written forms: describing events, concepts (space, time, personality, life, etc.) in terms of one' own and other cultures; discussing means of verbal and nonverbal intercultural communication; finding similarities and differences in ways of intercultural communication, typical for foreign and one' own cultures; modeling features of communicative behavior of representatives of one' own and other cultures in a role play.

4. Topic 4. Intercultural scientific communication

Forms of academic and intercultural communication: oral, written, formal, informal. Academic communication: intercultural aspect. Intercultural academic communication and the problems of translation. Academic text as a subject-sign model in a monocultural and intercultural environment. Difficulties and contradictions that occur in the perception and understanding of foreign-language texts.

Communicative tasks: to carry out communication in oral and written forms: describing similarities and differences in foreign-language and native-language academic communication; using cultural standards in situations of oral and written intercultural academic communication; transforming academic texts (from oral to written, from formal to colloquial, etc.); translating academic texts with regard to cultural context and genre tyle affiliation.

5. Topic 5. International academic mobility

Academic mobility as a means of intercultural communication. The importance of intercultural communication for academic mobility. Features of social and academic adaptation in the context of academic mobility. Intercultural communication and communicative competence in the process of academic mobility.

Communicative tasks: to carry out communication in oral and written forms: discussing the benefits of international academic mobility; giving examples of academic mobility in foreign-language and native-language cultures; solving issues related to cultural adaptation in an international academic environment; participating in a role play on typical situations of international academic mobility.

6. Topic 6. Intercultural communication in business

Etiquette and business communication features in different countries. General principles of business etiquette. National principles of business negotiations. Comparing the etiquette of business negotiations. European and Asian communication styles. General features of business etiquette in Asian countries. The influence of different cultural factors on business development of companies planning to enter foreign markets. Communication strategies for achieving mutual understanding in international business. Working with Chinese partners. Knowledge of cultural characteristics as a competitive advantage. Participating in international projects and programs. Working in an international team.

Communicative tasks: to carry out communication in oral and written forms: describing corporate cultures, norms of business etiquette and behavior accepted in the native and foreign countries; solving common problem situations in intercultural business communications; using effective interpersonal communication strategies in intercultural business communications; writing a business e-mail to a foreign partner taking into account his/her cultural affiliation; negotiating with representatives of another linguistic culture.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

English Language. Leadership and Communication in Science, Industry and Academia/Английский язык. Лидерство и коммуникация в науке, индустрии и образо

Purpose of the course:

Formation and development of social, business, cultural and professionally-oriented communicative competencies in accordance with the Common European Framework of Reference for solving communicative tasks in the socio-cultural, academic and professional-business spheres of activity, as well as for the development of professional and personal qualities of master's graduates.

Tasks of the course:

To form the learner's ability to solve communicative tasks by language means in various situations of intercultural communication, to interact on the interpersonal and professional level in a foreign language, considering the peculiarities of the culture of the language being studied, as well as the ability to overcome intercultural differences in situations of social and professional communication. To achieve the goals and objectives of studying the course, students are to master a foreign language general professional communicative competence, including:

Linguistic competence: the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people's statements.

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 set.

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

As a result of studying the course the student should

know:

- methods of system and critical analysis;

- methods of developing an action strategy to identify and solve a problem situation;

- stages of the project life cycle;

- stages of project development and implementation; methods of project development and management;

- methods of forming teams;

- methods of effective team management, characteristics of communicative behavior in the process of intercultural communication;

- basic leadership theories and leadership styles;

- rules and patterns of personal and business foreign language oral and written communication;

- modern communication technologies in Russian and foreign languages, culturally determined features of communication in the process of intercultural communication;

- existing professional communities for professional interaction;

- patterns and features of socio-historical development of various cultures;

- features of the intercultural diversity of society;

- rules and technologies of effective intercultural interaction; methods of self-assessment, self-control and self-development.

be able to:

apply methods of a system approach and critical analysis of problem situations;

- to search for solutions to the problem situation and develop a strategy of actions to achieve the goal, to make certain decisions for its implementation, using the skills of foreign language oral and written speech;

- to assess the impact of the decisions taken on the external environment of the planned activity and the relationships of the participants in this activity;

- to develop a project considering the analysis of alternative options for its implementation, to determine the target stages, the main directions of work;

- formulate goals and objectives, relevance, significance related to the preparation and implementation of the project, expected outcomes and possible areas of their application, using the skills of foreign language oral and written speech;

- manage the project at all stages of its life cycle;

- organize and coordinate work with due account for the diversity of the project participants' cultures;

- develop a plan of group and organizational communications during the preparation and implementation of the project;

- formulate tasks for team members to achieve the goal; develop a team strategy using the skills of foreign language oral and written speech;

- apply effective team leadership styles to achieve the set goal;

- exchange business information in oral and written forms in the language being studied;

- to present the results of academic, scientific and professional activities at various events, including international;

- to put into practice communication technologies, methods and patterns of business communication for academic and professional interaction;

- to identify the specifics of the philosophical and scientific traditions of the main world cultures, to understand and tolerate the intercultural diversity of the society;

- analyze and consider the diversity of cultures in the process of intercultural interaction;

- to solve the tasks of personal and professional development, to determine and implement priorities for improving the own activities;

- apply methods of self-assessment and self-control; apply methodologies of improving and preserv health in the process of life.

master:

- methodology of system and critical analysis of problem situations;

- methods of setting goals, determining ways to achieve it, developing strategies for actions using foreign language oral and written speech skills;

- methods of project development and management, forecasting the results of activities using the skills of foreign language oral and written speech;

- methods of assessing the need for resources and the effectiveness of the project using the skills of foreign language oral and written speech;

- ability to analyze, design and organize interpersonal, group and organizational communications in a team to achieve a goal;

- methods of organizing and managing a team, applying the skills of intercultural interaction in the language being studied;

- methodology of interpersonal business communication in the language being studied, using professional language forms, means and modern communication technologies for academic, scientific and professional interaction;

- methods and skills of effective intercultural interaction;

- skills necessary for writing translation and editing various academic texts (abstracts, essays, reviews, articles, etc.);

- ability to determine theoretical and practical significance of the cultural and linguistic factor in the interaction of various philosophical and scientific traditions;

- technologies and skills to manage the own cognitive activity and improve it based on self-assessment, self-control and principles of self-education throughout life.

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

1. Topic 1. The new reality of the leadership concept

Leadership in modern society, science, industry, education. Modern concepts of leadership. Types of leadership and personal characteristics of a leader. Leadership technologies. A team as a social group. Principles of team building, roles and tasks within the team. The role of a leader in a team, leadership communication. Effective and dysfunctional models of leadership communication. Organization of interpersonal, group and organizational communications in a team. Team and motivation, feedback.

Communicative tasks: to carry out communication in oral and written forms:

to discuss basic principles of teamwork; to discuss effective team interaction; to give arguments for the definition of "team spirit"; to collaborate, cooperate, express the own point of view, constructively overcome differences, use the potential of the group and achieve collective results; to use methods of communicative interaction and significantly increase the effectiveness of a multinational team; to establish the most effective rules of communication when interacting with the team; ask clarifying questions, leading the interlocutor to his opinion; conduct interviews, building a system of effective interaction when discussing a given topic; mediate when disagreements arise and successfully resolve them; create an atmosphere of friendliness and openness; convincingly express judgment and influence the opinion of the interlocutor; recognize the needs and interests of the interlocutor and build on them in the process of dialogue.

2. Topic 2. The phenomenon of scientific leadership in the modern world

Scientific leadership and its historical transformations. Scientific potential and leadership in science. Communicative nature of leadership in science as a specific model. World leaders in science and technology. The Strategic Academic Leadership program "Priority 2030" is leadership in the creation of new scientific knowledge. Goals of the program. Objectives of the program. Priorities of the program.

Communicative tasks: to carry out communication in oral and written forms:

to describe and discuss effective models of leadership communication; to discuss conditions conducive to competitiveness and scientific leadership; to reason the choice of effective methods in scientific communication; to discuss their features; to discuss the main characteristics of the chosen method; to evaluate models of leadership communication and effective methods in scientific communication; to describe and discuss the goals, objectives and priorities of the academic leadership program; to describe stages of the research project.

3. Topic 3. Leadership in academia, science and industry

Successful career at the university. The program "Leaders of Russia". The program "School of Rectors". Development of strategic plans for the development of the university. The connection of science, technology and education in universities. Personnel reserve. Research leadership. Creation of scientific schools. Scientific projects in education. The MIPT project "Talents in the Regions". Institute of mentoring in science, education, entrepreneurship. Practices of scientific, educational and corporate volunteering.

Communicative tasks: to carry out communication in oral and written forms:

discuss the principles of modern scientific leadership, functions and competencies of a leader in education, science, industry; discuss responsibility for the results and consequences of their scientific activities; give arguments for the definition of "scientific ethics"; coordinate the efforts of all project participants (team, working group), delegate authority; predict the possible development of the technological system in terms of influence the impact of technology on society; to reveal the relationship between the leadership style and the effectiveness of innovation; analyze the results of the implementation of large-scale projects in the field of science and education and their impact on the scientific and technological development of the country; determine the conditions for the disclosure of leadership potential; use effective strategies of the communicative behavior of a leader in science, education and industry.

4. Topic 4. Scientific, educational and scientific-technical projects

Features of the team of a scientific, educational, scientific and technical project. Professional communication in the project team. Goals, objectives, content, basic requirements for the implementation of the project, expected results; scientific, scientific-technical and practical value. Opportunities and solutions, necessary resources for the implementation of the project.

Communicative tasks: to carry out communication in oral and written forms:

discuss the implementation stages of a scientific, technological and business project; discuss the principles of the distribution of roles in the project team; form a team united by a common professional trajectory based on the principles of team building; create a group project taking into account the genre features of the research plan, business plan, technological solution, etc.; make arguments in favor of choosing one or another shared workspace, identify adequate interpersonal communication strategies in the team and use them while preparing a group project; to have a convincing influence on team members; to give rational arguments in defense of their position; to conduct a discussion based on the principles of eco-friendly communication: adequately express agreement and disagreement, use effective strategies for interacting with an unfriendly audience, create a productive working atmosphere, avoiding conflicts and disagreements; to choose the appropriate way of presenting a project; to defend the project by providing verbal and non-verbal influence on experts and representatives of a wide audience; substantiate the relevance, theoretical, practical, social significance of the project, its investment attractiveness and competitive advantages.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Extremal Combinatorics/Экстремальная комбинаторика

Purpose of the course:

mastering the elective concepts of extreme combinatorics.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of extreme combinatorics;

• acquisition of theoretical knowledge and practical skills in the field of extreme combinatorics;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of extreme combinatorics;

 current problems of the relevant sections of extreme combinatorics;

 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 extreme combinatorics.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of extreme combinatorics;

 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 the field of complex computing 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 requiring the use of mathematical approaches and methods of extreme combinatorics for their solution;

 the subject language of complex calculations 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. Canonical bundle over Grassmann space

Connection of points on a plane by a graph with a small number of intersections with any line, Chazel – Weltzl theorem

2. Basic concepts and definitions of convex geometry

Caratheodory's theorem and Helly's theorem.

3. Polynomial division of one measure in the spirit of Gut – Katz and its properties

The sandwich theorem. Curve of moments and its generalization, polynomial version of the sandwich theorem

4. Applications of Helly's Theorem

Jung's inequality, central point theorem.

5. The Borsuk – Ulam theorem in the simplest case

Technique of minimization and its application. Carathéodory's color theorem and Helly's color theorem. Tverberg theorem.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Extremal Combinatorics/Экстремальная комбинаторика

Purpose of the course:

mastering the elective concepts of extreme combinatorics.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of extreme combinatorics;

• acquisition of theoretical knowledge and practical skills in the field of extreme combinatorics;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of extreme combinatorics;

 current problems of the relevant sections of extreme combinatorics;

 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 extreme combinatorics.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of extreme combinatorics;

 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 the field of complex computing in oral and written form.

master:

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 the culture of the formulation, analysis and solution of mathematical and applied problems requiring the use of mathematical approaches and methods of extreme combinatorics for their solution;

 the subject language of complex calculations 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. Canonical bundle over Grassmann space

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4. Applications of Helly's Theorem

Jung's inequality, central point theorem.

5. The Borsuk – Ulam theorem in the simplest case

Technique of minimization and its application. Carathéodory's color theorem and Helly's color theorem. Tverberg theorem.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Fundamentals of Python Programming/Основы программирования на Python

Purpose of the course:

- Learn how to write effective and readable code
- Learn Software Development best practices
- Gain essential experience with Python

Tasks of the course:

- Software Development
- Python

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

As a result of studying the course the student should

know:

- basic objects and procedures of the Python language;

- methods for handling errors in Python;

- the main library used in practice.

be able to:

- write efficient code, debug and document Python code;

- use the main libraries of scientific computing of the Python language to solve typical applied problems in the field of data analysis and adapt them to your needs in the course of scientific research.

master:

- tools for the development and testing of program code in Python;

- objects and tools offered by the standard libraries of scientific computing language;

- basic principles of computing using Python libraries

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

1. CLI / git

Introduction, Zen Python Installation python 3

2. Code-writing tools

Ipython Notebook IDE Pycharm Interactive cl mode

3. Virtual environment + conda + pip list / pip freeze / Requirements management

Troubleshooting Numbers, Strings, Lists

4. Objects, values and types

Flow control statements: if, for, while Python Data structures Multi-threading: Process Pool, Thread Pool, threading module, multiprocessing

5. PEP8, Style guides

Complex condition Functions: Declaration, Signature, Call by assignment, Call Stack, Closures, Recursions

6. Functional programming elements

Modules: imports, module search path, standard modules, dir() Packages: __init__.py, __all__, dotted imports

7. Scopes and Namespaces

Compilation and interpretation strategies (AOT, JIT) How to speed up the python code: numba, cython, joblib, dask, c++ extensions Data Science toolbox overview

8. Classes: Declaration, Inheritance, attributes, instances, instance variables, private section

Iterators, Generators, Generator Expressions, Context Managers, Decorators Exceptions: Built-In Exceptions, handling exception, raise exception, custom exceptions Standard Library, inspect Logging

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Game Theory/Теория игр

Purpose of the course:

To acquaint students with the basic concepts and results of non-cooperative and cooperative game theory. The central place in the course is occupied by the concept of Nash equilibrium, sequential equilibrium, and also the concept of a kernel in cooperative games with side payments.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in game theory;

• acquisition of theoretical knowledge and practical skills in game theory;

• providing advice and assistance to students in conducting their own theoretical research in game 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, game theory;

 modern problems of the relevant sections of game theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the game theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of game 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 topology orally and in writing.

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 topology 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. What is a game? Games in normal form. Matrix and bimatrix games.

Dominance in static games. Pure Nash equilibria

2. Mixed Nash equilibria.

Algorithms for finding Nash equilibria. Dynamic games with complete information, symmetric case

3. Dynamic games with complete information, asymmetric case

Dynamic games with incomplete information Signaling games.

4. Repeated games.

Cooperative games. Stable matchings

5. Basics of social choice theory.

Fair division. Basics of auction theory.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Game Theory/Теория игр

Purpose of the course:

The main goals of the course:

- To get acquainted with principles of game-theoretic modeling
- To become familiar with game-theoretic language of describing real-world interactions in economy, politics and society.
- To learn how to find equilibria in various frameworks

Tasks of the course:

During the course the students will learn:

- To model various situations with the help of game theory.
- To find equilibria in various types of games.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, game theory;

 modern problems of the relevant sections of game theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the game theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of game 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 topology orally and in writing.

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 topology 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. What is a game? Games in normal form. Matrix and bimatrix games.

Dominance in static games. Pure Nash equilibria.

2. Mixed Nash equilibria.

Algorithms for finding Nash equilibria. Dynamic games with complete information, symmetric case

3. Dynamic games with complete information, asymmetric case

Dynamic games with incomplete information Signaling games.

4. Repeated games.

Cooperative games. Stable matchings.

5. Basics of social choice theory.

Fair division. Basics of auction theory.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Generative Models/Генеративные модели

Purpose of the course:

To systematize and deepen the knowledge of students in the field of image processing methods using generative adversarial networks.

Tasks of the course:

1. Create an understanding of the components of generative adversarial networks.

2. To acquaint with the theoretical basis.

3. To develop students' basic practical skills in setting and solving problems.

4. To bring to the attention of students current problems and some of the latest advances in the field of data generation.

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

As a result of studying the course the student should

know:

formulation of problems of generative modeling and theoretical foundations of methods for their solution.

be able to:

build an analysis of specific data and plan an organizational structure for a specific project.

master:

skills in using neural networks to generate data in specific projects.

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

1. Introduction.

Introduction. Course program. Organizational matters. Tasks. Analog and digital signal, sampling and quantization. Fourier transform of a signal. The Nyquist - Shannon - Kotelnikov sampling theorem. Aliasing Interpolation. Resampling. Perception of color. Receptors in the retina. Color blindness. Space X, Y, Z. Color spaces. Other color spaces.

2. Generative adversarial networks, history, properties, learning.

Eye device. Geometric transformations on the plane. Athenian transformations. Projective transformations (Homography). Homogeneous coordinates. Distortion of optical systems with axial symmetry ("fisheye", "pillow"). Hough transformation. Voronoi diagram. Delaunay triangulation. Distance transform. Hausdorff distance. Sweeping strip method.

3. Streaming models

Possible image defects. Image histogram. Histogram transformations. White balance. Morphological operations. Binary mathematical morphology. Morphology on gray. Morphological gradient. Acceleration of calculations of binary morphology. Median filter. Box filter. Gaussian filter. Computing the gradient. Sharpening (unsharp mask). Filters. Convolution (convolution). Deconvolution. Wiener deconvolution. Deconvolution Lucy-Richardson. Noise detection. Noise filtering. Bilateral filter.

4. Hidden Variables Models

The contours of the image. Sharp borders in the image. First derivative. Sobel filter. Second derivative. LoG (Laplacian of Gaussian). DoG (Difference of Gaussians). LoG is a blob detector. Gradient and directional derivative. Gabor filter. Canny edge detector. LSD (Line Segment Detector). Angle detector. Harris corner detector. Hessian. Steerable filters (rotatable). Recursive filters. Recursive Gaussian filter.

5. Compressing information with a variational autoencoder

CBIR (content-based image retrieval). What do similar images mean? General scheme of image search. Perceptual hash. Perceptual hash, DCT-based hash. GIST. Using singular points to find duplicates. Memory costs. Representation of descriptors. Visual words. Inverted index. TF-IDF, stop sheets. Improving the inverse index schema. Hamming embedding. Weak geometrical consistency. Hamming embedding + weak geometrical consistency. GISTIS (GIST indexing structur). INRIA Copydays dataset. Comparison of different methods for finding duplicates. Accounting for geometric properties.

6. Generative adversarial networks

Selection of objects. Things vs. Stuff. Datasets. ImageNet. Microsoft COCO. The Pascal Visual Object Classes (VOC). TinyImages. CIFAR-10 and CIFAR-100. Object detection. Sliding window. Binary classifier of the image area. Pedestrian detection. HOG, Histogram of Oriented Gradients. Detector training. Visualization of the classifier. Face detection. Viola Jones algorithm. AdaBoost for feature selection. Training a cascade of classifiers. Post-processing. Other weak classifiers. Different angles.

7. Style transfer

Image Classification, ILSVRC2012. AlexNet. NIN (Network in Network). GoogleNet. GoogleNet, Inception module. VGG. Batch Normalization. BN-Inception. Residual network. ResNet. Object detection. R-CNN. R-CNN, regional hypotheses. Fast R-CNN. Faster R-CNN. Region Proposal Network (RPN). YOLO (You Only Look Once). SSD (Single shot detector).

Semantic segmentation. Convert FC layers to convolutional ones. Uosampling. Combining outputs from different levels of the network.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

German for Scientific Purposes/Немецкий язык для научных целей

Purpose of the course:

Formation and development of social, business, intercultural and professionally-oriented communicative competencies for solving communicative tasks in the socio-cultural, academic and professional-business spheres of activity, as well as for the development of professional and personal qualities of a graduate.

Tasks of the course:

To form the learner's ability to solve communicative tasks by language means in various situations in the academic and professional sphere, to acquire knowledge in a wide range of fields of science, to make an in-depth analysis of information and to form his opinion both orally and in writing.

To achieve the goals and objectives of mastering the discipline, students must master a foreign language professional communicative competence, including:

Linguistic competence: the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people’s statements.

Domain expertise: the ability to operate with knowledge in conditions of real communication with the studied culture representatives, manifestation of empathy as the ability to understand the norms, values and motives of behavior of another culture representatives.

Communicative competence: the ability to establish and forge contacts with representatives of various age, social and other groups of native and other linguistic cultures, the ability to be a mediator between the own and foreign-language cultures.

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 set.

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

As a result of studying the course the student should

know:

- features of speech activities in German;

- the main phonetic, lexical and grammatical phenomena and structures used in oral and written speech when communicating in German, their difference from the native language for the reasoned and logical construction of statements that allow the application of the studied language in everyday, academic, scientific, business and professional communication;

- features of foreign-language academic communication, techniques for extracting and delivering foreign-language information for academic purposes;

- fundamentals of organizing written communication, types of written communicative tasks and functions of written communication tools;

- specifics of using verbal and non-verbal means in situations of foreign-language communication;

- types and features of written texts and oral presentations, general content of complex texts on abstract and specific topics, features of foreign-language texts, universal patterns of structural organization of the text, including highly specialized texts;

- rules of using various technical means for the purpose of searching and extracting foreign-language information, basic rules of determining the relevance and reliability of foreign-language sources, analysis and synthesis of information;

- world achievements, discoveries, events from the field of history, culture, politics, social life;

- general forms of teamwork organization; special aspects of behavior and interests of other participants; fundamentals of strategic planning of the team to achieve the goal;

- standard types of communicative tasks, goals and objectives of business negotiations, socio-cultural features of business negotiations, their communicative-pragmatic and genre features;

- vocabulary and terminology for academic, scientific and professional communication.

be able to:

- understand and use language tools in all types of speech activities in German;

- conduct discussions in German in various spheres of communication: everyday life, socio-cultural, socio-political, professional;

- verbally implement a communicative intention in order to influence a communication partner to start, conduct/maintain and finish a dialogue-asking about what he saw, read, dialogue-exchanging opinions and observing the norms of speech etiquette, if necessary using strategies to restore a failure in the communication process (re-questioning, paraphrasing, etc.);

- extract general and detailed information when reading authentic scientific and scientific-journalistic German-language texts;

- provide information based on the read text in the form of a prepared monologue (presentation on the proposed topic);

- understand monologue and dialogue statements in direct communication and in audio/video recordings;

- understand communicative intentions of the received written and oral messages;

- expand the proposed argument in the form of illustrations, details, explanations;

- use modern information technologies for professional activity, business communication and self-development;

- convey in Russian the content of German-language scientific and scientific-journalistic texts in the field of professional activity;

- select literature on the topic, compile a bilingual glossary, translate and review special literature, prepare scientific reports and presentations based on the read special literature, explain the own point of view and tell about plans;

- carry out oral and written foreign language communication in accordance with the student's field of professional activity;

- use the techniques and principles of building public speech for the report;

- recognize and differentiate linguistic and speech phenomena, distinguish basic and secondary information when reading texts and listening to speech, use standard means of oral and written communication in interpersonal communication; apply adequate communicative means in standard interaction situations on professionally oriented topics;

- use graphic editors, create easily perceived visual materials;

- describe graphical information (circular histogram, table, column and line graphs); write a short article on a given topic;

- write a summary, a review, a short article-advice on the proposed topic;

- abstract and annotate foreign-language professional texts;

- present research results in a written and oral form;

- apply information and communication technologies in communication and speech activity in a foreign language;

- identify and formulate problems that arise in the process of learning a foreign language; evaluate the student's capabilities, the realism and adequacy of the planned ways and ways to achieve the planned goals.

master:

- intercultural professionally oriented communicative competence in different types of speech activity;

- various communication strategies: educational strategies for organizing educational activities; strategies of reflection and self-assessment in order to improve personal qualities and achievements; strategies for perception, analysis, creation of oral and written texts of various types; Internet technologies for choosing the optimal mode of obtaining information; different methods of memorizing and structuring the acquired material;

- presentation technologies for information communication;

- method of searching and analyzing information from various sources in the professional field;

- skills of annotating and abstracting original scientific and scientific-journalistic articles;

- methods of assessing and self-assessing the results of foreign language learning activities;

- methods of identifying and realizing individual language capabilities, personal and professionally significant qualities in order to improve them;

- the ability to understand the speech of native speakers at a fast rate and respond adequately considering cultural norms of international communication;

- the ability to create clear, logical monologue and dialogue statements in various situations of everyday and professional communication, using the necessary set of communication tools;

- techniques of public speech and business and professional discourse in German.

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

1. Topic 1. Flexible skills

Social and emotional intelligence. Personal and social skills. A relationship with the self. Skills and abilities to recognize emotions, understand the intentions, motivation and desires of other people and their own, managing emotions in order to solve practical problems. Inner harmony. Self-understanding. Self-regulation. Motivation. Empathy. Creativity. Sociability. Corporationism. Criticism. Key characteristics of a successful person. Success of the individual. Overcoming difficulties.

Communicative tasks: to carry out communication in oral and written forms: to build logical statements about personal and social skills, to describe various situations using illustrations; to use aphorisms in communication and be able to interpret them; to discourse upon ways of achieving success, possibilities of developing internal potential, life prospects, life meaningfulness, formation of responsibility assumed voluntarily; to talk about ways of self-improvement.

2. Topic 2. Communication in the modern world

Communication in society. Culture of communication based on common values: honesty, respect, mutual trust. Types and forms of communication. Means of communication. Social network.

Communicative tasks: to carry out communication in oral and written forms: to search, receive, transmit and exchange information, to apply in practice various types of information messages: statements, texts, images, sound messages, signals, signs, forum messages, conducting discussions, expressing one's own opinion, reviewing texts, description of illustrations; reasoned essay.

3. Topic 3. Ecology, nature, society

Modern environmental problems. Interaction of nature and society. Environmental protection. Biosphere and humans. Ecological consciousness.

Communicative tasks: to carry out communication in oral and written forms: to exchange opinions on the role of ecology and modern humans' attitude to nature; to discourse upon the dependence of public health on environmental factors; to discuss the impact of environmental factors on the generation of the future; to make descriptive essays on the subject; to draw conclusions, formulate an opinion on the role of society in the preservation of natural habitats on the planet.

4. Topic 4. Social and ethical issues in science, industry, and consumption

Globalization of consumption and social consequences. Science for sustainable development. Production and consumption. Conscious consumption. Principles and strategies of minimalism. Consumer culture. Consumption as a new form of control in society.

Communicative tasks: to carry out communication in oral and written forms: to discuss the problems of consumption globalization to meet the needs of the individual, society, the state; to express a reasoned opinion about the role of science and the impact of economic development on consumer attitudes to the world; to discuss socio-ethical issues and social consequences of consumerism.

5. Topic 5. The New Digital World

Global technological processes related to digitalization. Digital technologies – the Internet of Things. The digital world of science and business. Immersion in the digital world. Safe gadgets. Young hackers. The influence of the digital world on the perception of modern life.

Communicative tasks: to carry out communication in oral and written forms: to be able to search for the necessary information on the topic; to prepare reports on the topic; to express their own judgments about the advantages, limitations and prospects of using digital technologies, and their capabilities; to participate in a group discussion; to exchange opinions on technological innovations for solving various problems using technical means of the digital world; to compose essay-reasoning on the proposed topic.

6. Topic 6. Industry 4.0: on the way to "digital" production

Integration and cooperation with the use of digital technologies and increased flexibility in the organization of work. Transformation of economic sectors and types of activities and its impact on employment. Creating new markets and new forms of work through digital platforms. Problems

related to big information data. Relation between the use of human and machine labor (devaluation of experience, individual support). Possibility of flexible working conditions in terms of time and location. Profound changes in the structures of organizations.

Communicative tasks: to carry out communication in oral and written forms: to discuss flexibility in the organization of work in the context of the Work 4.0 concept; to talk about transformation of economic sectors and its impact on employment and activities in the world of labor; to recognize needs and interests of the interlocutor and base on them in the process of dialogue; to make messages about the creation of new markets and new forms of work through digital platforms; to express the own point of view, to speak constructively about the relationship between the use of human and machine labor; to make messages about the choice of a strategy for flexible working conditions; to be able to justify the chosen strategy; to prepare a report on the proposed topic.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

History, Philosophy and Methodology of Natural Science/История, философия и методология естествознания

Purpose of the course:

To familiarize students with the historical experience of world philosophical thought, give a clear idea of the main stages, directions and problems of the history and philosophy of science, contribute to the formation of skills to work with extreme issues related to the boundaries and foundations of various sciences and scientific rationality, and mastery of the principles of a rational philosophical approach to processes and trends in the development of modern science.

Tasks of the course:

- systematic study of the philosophical and methodological problems of natural science, taking into account the historical and philosophical context and the current state of science;

- the acquisition by students of theoretical ideas about the diversity of forms of human experience and knowledge, the nature of thinking, the ratio of truth and error;

- understanding the role of science in the development of civilization, the relationship between science and technology and related modern social and ethical problems, the ability to distinguish between historical types of scientific rationality, to know the structure, forms and methods of scientific knowledge in their historical genesis, modern philosophical models of scientific knowledge;

- acquaintance with the main scientific schools, directions, concepts, with the role of the latest information technologies in the world of modern culture and in the field of humanities and natural sciences;

- understanding the meaning of the correlation of biological and social in man, man’s attitude to nature, discussions about the nature of changes taking place with man and humanity at the turn of the third millennium;

- knowledge and understanding of the dialectic of personality formation, its freedom and responsibility, the uniqueness of the intellectual, moral and aesthetic experience of different historical eras.

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

As a result of studying the course the student should

know:

- the structure of the natural and socio-humanitarian sciences, the specifics of their methodological appa-ratus;

- the ratio of principles and hypotheses in the construc-tion of scientific systems and theories;

- the foundations of a modern scientific picture of the world, the basic principles of scientific knowledge and key areas of interdisciplinary research;

- concepts of the development of science and different approaches to the problem of the cognitive status of scientific knowledge;

- the problem of matter and motion;

- concepts of energy and entropy;

- problems of space-time;

- modern problems of physics, chemistry, mathematics, biology, ecology;

- great scientific discoveries of the XX and XXI centu-ries;

- key events in the history of the development of science from ancient times to the present day;

- the relationship of worldview and science;

- the problem of forming a worldview;

- a system of interdisciplinary relations in science, the problem of reductionism in science;

- theoretical models of fundamental processes and phenomena in physics and its applications to the natural sciences;

- about the Universe as a whole as a physical object and its evolution;

- about the relationship between order and disorder in nature, about the problems of non-linear processes and self-organizing systems;

- dynamic and statistical patterns in nature;

- of the role of probabilistic descriptions in the scientific picture of the world;

- principles of symmetry and conservation laws;

- The latest discoveries of natural science for the creation of technical devices;

- Features of the biological form of organization of mat-ter, principles of reproduction and development of living systems;

- About the biosphere and the direction of its evolution.

be able to:

- effectively use in practice the theoretical components of science: concepts, judgments, conclusions, hypotheses, evidence, laws;

- - apply the methodology of science in the organization of specific research;

- - give a panorama of the most universal methods and laws of modern science.

master:

- - scientific methodology as the initial principle of cognition of the objective world;

- - the principles of choosing an adequate methodology for the study of specific scientific problems;

- - system analysis;

- - knowledge of the scientific picture of the world;

- - the conceptual and methodological apparatus of interdisciplinary approaches in science.

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

1. The formation of science and philosophy in the West and in the East.

The problem of the emergence of science in antiquity. Prescription and applied nature of knowledge in the Ancient East. The birth of philosophy. Scientific programs of Plato, Aristotle and Democritus. The origin of ancient science: mathematics, physics, astronomy and biology. The problem of the social organization of ancient science. "Musical" cult and scientific and philosophical schools. The Alexandrian Museyon and the further development of Hellenistic science. The science of ancient Rome. Arab medieval science.

Science in Europe in the Middle Ages. Christianity and science The dispute of faith and reason. Rethinking Antique Heritage. Medieval empiricism. Nikolay Kuzansky and the concept of infinity. The ideological turn of the Renaissance.

2. The main periods and basic forms of the development of science

The emergence of modern science: basic concepts and key personalities. Key research programs in modern European science. The triumph of Newtonian physics and the formation of mathematical science. Central theoretical postulates and methods of classical science.

3. Rationalistic and empiricist traditions in the philosophy of the Modern Times

The dispute of rationalism and empiricism Rationalistic direction: the method of deduction and the concept of intellectual intuition in the philosophy of Descartes and Spinoza. Cartesian probabilism. The theory of innate ideas. Leibniz’s teaching on the “truths of fact” and “truths of the mind”, on the types of knowledge, on analysis and synthesis. Rationalist interpretation of the thesis of the correspondence of being and thinking.

The tradition of English empiricism: Bacon's doctrine of experience, the role of induction, the “idols” of knowledge. Locke's model of scientific knowledge. Berkeley thesis: to be means to be perceived. Humeian skepticism and psychologism, criticism of the concept of causality.

4. Kant’s solution of the problem of knowledge

Kant's solution to the problem of knowledge. The question of the possibility of knowledge. Space and time as forms of sensuality. The construction of objectivity in the process of cognition. Reason as a legislator. The specifics of Kant's understanding of thinking. Critique of the possibility of supersensory knowledge The concept of "things in themselves." Antinomies of the mind.

5. The approach to knowledge in neokantian philosophy

Interpretation of knowledge in neo-Kantianism. Marburg and Baden schools of neo-Kantianism. Neo-Kantian development of the theory of knowledge. Division of sciences into nomothetic and idiographic. The problem of values in the Baden school.

6. Positivism

Positivism and postpositivism. The first and second positivism of the XIX century. Analytical philosophy of B. Russell and L. Wittgenstein. Logical positivism and the “linguistic turn”. Postpositivism of K. Popper, T. Kuhn and I. Lakatos.

7. Critique of positivism from the point of view of logic. Critical rationalism of Karl Popper

Logical criticism of positivism by K. Popper: problems of induction and demarcation; falsification principle; attitude to the truth. K. Popper's concept of science growth: fallibilism and likelihood theory. The development of modern cosmology and elementary particle physics.

8. Historical criticism of positivism. Historical approach in the philosophy of science.

Historical criticism of positivism. Are there “crucial experiments”? The thesis of the "incommensurability of theories." The Kuhn’s model of the development of science: the scientific community and the scientific paradigm, “normal” and “abnormal” phases in the history of science. The model of research programs by I. Lakatos: “hard core” and “protective belt of hypotheses”; “Progressive problem shift” as a criterion for rejecting research programs. Historical Relativism of P. Feyerabend.

The dispute between realism and antirealism in modern philosophy of science. Sociologization of modern philosophy of science. The debate about the model of the "external" and "internal" history of Lakatos. Laboratory place in science. The relationship of science and technology in the second half of the XX - beginning of the XXI century.

9. The structure of scientific knowledge

The structure of science. Place of mathematics and measurements. Place of foundations and theories of phenomena. Place of methodological principles.

10. Philosophical problems of natural sciences

The concept of dynamic and statistical laws and probability as an objective characteristic of natural objects. Place of principles of symmetry and conservation laws.

Synergetics, selforganization and the ratio of order and disorder. Model of global evolutionism.

Specific features of life sciences. Question of the reduction of biology and chemistry to physics. Contradictions between nature and man today. Global problems of modern civilization, the

possibility of environmental disaster. Biosphere, noosphere, ecology and the problem of sustainable development.

Interdisciplinary approaches in modern science.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Industrial Programming and DevOps/Промышленное программирование и DevOps

Purpose of the course:

- Learn how to write effective and readable code
- Learn Software Development best practices
- Gain essential experience with Python
- Get used to testing and documenting the code
- Get ready to implement the Machine Learning and Deep Learning techniques

Tasks of the course:

- Software Development
- Python
- Testing
- Working with different environments

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

As a result of studying the course the student should

know:

- idea of the structure, functioning of the visual analyzer;

- understanding of psychophysiological and information models of binocular vision;

- principles of video interface functioning in relation to VR / AR systems.

be able to:

- principles of functioning and methodology for the development of distributed systems in relation to the tasks of creating VR / AR systems;

- the structure and principles of functioning of existing and future graphics API.

master:

- methodology for the development of software for all links of VR / AR systems (including the graphics core, virtual environment control subsystems, video interface, etc.);

- an object-oriented methodology for designing and developing software code for the entire range of tasks for creating VR / AR systems.

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

1. Objects, values and types

Flow control statements: if, for, while Python Data structures Multi-threading: Process Pool, Thread Pool, threading module, multiprocessing

2. PEP8, Style guides

Complex condition Functions: Declaration, Signature, Call by assignment, Call Stack, Closures, Recursions

3. Functional programming elements

Modules: imports, module search path, standard modules, dir() Packages: __init__.py, __all__, dotted imports

4. Scopes and Namespaces

Compilation and interpretation strategies (AOT, JIT) How to speed up the python code: numba, cython, joblib, dask, c++ extensions Data Science toolbox overview

5. Classes: Declaration, Inheritance, attributes, instances, instance variables, private section

Iterators, Generators, Generator Expressions, Context Managers, Decorators Exceptions: Built-In Exceptions, handling exception, raise exception, custom exceptions Standard Library, inspect Logging

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Introduction to Combinatorics/Введение в комбинаторику

Purpose of the course:

studying the mathematical foundations of modern combinatorics, as well as preparing students for further independent work in the field of combinatorial problems of applied mathematics, physics and economics.

Tasks of the course:

 study of the mathematical foundations of modern combinatorics;

 acquisition by students of theoretical knowledge in the field of combinatorial analysis of problems arising in practice;

 mastering the analytical and algebraic apparatus of discrete mathematics and gaining skills in working with basic discrete structures.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of combinatorial geometry;

 modern problems of the corresponding sections of combinatorial geometry;

 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 combinatorial geometry.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of combinatorial geometry;

 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 the field of complex computing 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 requiring the use of mathematical approaches and methods of combinatorial geometry for their solution;

 the subject language of complex calculations 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. Introducing combinatorics as the art of counting (enumeration)

Why counting? Introducing combinatorics as the art of counting (enumeration). Rules of summation and multiplication. Counting tuples and subsets. Structuring the counting with decision trees.

2. Pigeonhole principle, double counting, averaging techniques

Pigeonhole principle, double counting, averaging techniques. Using counting to prove existence

3. Estimates in combinatorics. Combinatorial sums

Binomial theorem, binomial coefficients. Big-O notation, Stirling's formula and asymptotic estimates.

4. Recurrence relations in combinatorics.

The number of independent sets in a path, Fibonacci numbers. Binet's formula. Fast computation of Fibonacci numbers via matrix multiplication. A glimpse into general linear recurrences.

5. More on recurrence relations in combinatorics and graph theory

Integer partitions, counting graph colorings (chromatic polynomial).

6. Formal power series and generating functions

Generating functions for linear recurrences. Derivation of a formula for Catalan numbers. Generating functions and integer partitions.

7. Combinatorics of permutations. Cyclic structure of permutations

Permutation groups. Other examples of groups. Cayley’s theorem. Counting w.r.t. group actions.

Counting w.r.t. group actions (continued). Cauchy—Frobenius—Burnside lemma and Redfield—Polya counting framework.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Introduction to Discrete Geometry/Введение в дискретную геометрию

Purpose of the course:

mastering an advanced discrete geometry course.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of discrete geometry;

• acquisition of theoretical knowledge and practical skills in the field of discrete geometry;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of discrete geometry;

 current problems of the corresponding sections of discrete geometry;

 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 discrete geometry.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of discrete geometry;

 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 the field of complex computing 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 discrete geometry methods for their solution;

 the subject language of complex calculations 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. Examples of combinatorial geometry in the line and in the plane. Basic notions of convex geometry.

Covering, coloring, and piercing. The Hahn–Banach separation theorem (finite-dimensional case for closed sets). The polar body and the polar cone.

2. Extremal points of convex sets, examples. Existence of extremal points for convex compact sets.

Dimension of a convex set and its relative interior, stability of the relative interior under taking the closure. Separation from not necessarily closed sets. The Krein–Milman theorem for convex compact sets in Rn. Polytopes and polyhedra.

3. Faces of polytopes, the face lattice and its behavior under polarity. Basic results of combinatorial geometry in arbitrary dimension.

Simple and simplicial polytopes, h-vector of a simple polytope and the Dehn–Sommerville relations. Geometric view on linear programming. Basic results of combinatorial geometry in arbitrary dimension. Carath´eodory's, Radon's, and Helly's theorems.

4. Applications of Helly's theorem:

Compactness of the convex hull of a compact set, the Jung inequality, the centerpoint theorem, covering a point set by a translate of a convex body.

5. Kirchberger's theorem about separation by hyperplanes. Examples of the minimization technique.

Kirchberger's theorem about separation by hyperplanes. Examples of the minimization technique. The colorful Carath´eodory theorem and the colorful Helly theorem by B´ar´any and Lov´asz. Tverberg's theorem. Basic point-line incidence problems. Sylvester's lemma and number of lines determined by a finite point set. The usage of point-line polarity.

6. Helly-type theorems for algebraic sets. Voronoi partitions and Delaunay triangulations. Correctness of the flipping algorithm

Helly-type theorems for algebraic sets. Piercing algebraic sets and Helly–Gallai-type theorems. Voronoi partitions and Delaunay triangulations. A Delaunay triangulation in the plane from the algorithmic viewpoint. Existence proof: A Delaunay triangulation as the convex hull of the points lifted to a paraboloid (or to a sphere). A Voronoi partition as a projection of a polyhedron outscribed about the paraboloid (or about the sphere). Correctness of the flipping algorithm: A sequence of flips as a triangulation of this convex hull. Generalized Voronoi partitions (regular partitions).

7. Tilings of the space and Voronoi's conjecture on parallelohedra. Volume of a union of balls.

Tilings of the space and Voronoi's conjecture on parallelohedra. Shellability of polyhedra, ordering properties of Voronoi partitions and Delaunay triangulations. The notion of a simplicial or cellular complex and its Euler characteristic. Volume of a union of balls. Generalized Voronoi partition corresponding to a set of balls. Simplification of the inclusion-exclusion formula for the volume of a union of balls by Edelsbrunner. Kirszbraun's theorem and extension of Lipschitz maps by kopyan. Reduction of Jung's theorem to Kirszbraun's theorem.

8. The Kneser–Poulsen problem on the intersection or the union of balls. Tarski plank problem. The Kadets theorem on the total sum of inradii of convex bodies covering unit ball

The Kneser–Poulsen problem on the intersection or the union of balls. The continuous motion case of the Kneser–Poulsen problem by Gromov and by Csik´os. Reduction of the case of at most n + 1 ball in Rn or Sn to the case of continuous motion. Tarski plank problem, Bang's proof of Tarski plank problem. Proof of L´aszl´o Fejes Tothzone conjecture. The Kadets theorem on the total sum of inradii of convex bodies covering unit ball. Kadets-type results by Karasev and Akopyan.

9. The Danzer–Gr¨unbaum theorem on antipodal sets. The incribed ellipsoid of maximal volume in a convex body.

The Danzer–Gr¨unbaum theorem on antipodal sets. Arrangements of pairwise touching or intersecting translates and homothets. Applications to the problem on maximal cardinality of k-distants sets. The incribed ellipsoid of maximal volume in a convex body. John's theorem. Quantative Helly's theorem by Nasz´odi. Minkowski's theorem on areas of facets: A proof of the equality. Triangulation of polytopes and their "circumcenter of mass" by Akopyan.

10. The functional Brunn–Minkowski inequality, the logarithmic Brunn–Minkowski inequality, and the ordinary Brunn–Minkowski inequality. Convexity of the set of differentials of a convex function.

The functional Brunn–Minkowski inequality, the logarithmic Brunn–Minkowski inequality, and the ordinary Brunn–Minkowski inequality. Logarithmic concavity and the Pr´ekopa–Leindler inequality. Convexity of the set of differentials of a convex function. Minkowski's theorem: A proof of existence and uniqueness. The Knaster–Kuratowski–Mazurkiewicz theorem and Brouwer's theorem on fixed points. Applications: piersing number of d-intervals. The Borsuk–Ulam theorem for odd maps between spheres. Equivalent versions of the Borsuk–Ulam theorem;

the degree of an odd map of a sphere into itself. Crofton's formula and the preimage of zero for an odd map of a sphere into a Euclidean space.

11. The ham-sandwich theorem for measures and signed measures. The Szemer´edi–Trotter theorem on point and line incidences. Dol'nikov's theorem on intersection by hyperplanes and the chromatic number of the Kneser graph.

The ham-sandwich theorem for measures and signed measures. The moment curve and its generalizations, the polynomial ham-sandwich theorem. The Szemer´edi–Trotter theorem on point and line incidences. Some easy sum and product set estimates for a set of real numbers. Dol'nikov's theorem on intersection by hyperplanes and the chromatic number of the Kneser graph. The canonical vector bundle over the Grassmann manifold, coincidence of its sections, and Dol'nikov's transversal theorem. The central transversal theorem.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Introduction to Graph Theory/Введение в теорию графов

Purpose of the course:

mastering the main modern methods of graph theory

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in graph theory;

• acquisition of theoretical knowledge and practical skills in graph theory;

• providing advice and assistance to students in conducting their own theoretical research in graph 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, graph theory;

 modern problems of the relevant sections of graph theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the graph theory cycle;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of graph 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 topology orally and in writing.

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 requiring the use of mathematical approaches and methods for their solution;

 the subject language of topology 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. Definitions of basic graphs-theoretic notions

Graphs/digraphs/multigraphs, adjacency and incidence, degrees and neighbourhoods, connectivity, paths, cycles. Trees and their basic properties. Examples of graph-theoretic models in the real world

2. Counting objects up to equivalence. Example

The number of cycles in graphs. Graph isomorphism. Estimating the number of classes of isomorphism of trees. Cayley's formula for the number of trees; a proof by constructing a bijection with integer tuples, one or two other proofs as time permits. Handshake lemma and variations, two-coloring a uniform hypergraph, finding a large bipartite subgraph in an arbitrary graph

3. Planar graphs

Triangulations, the maximal number of edges in a planar graph. Euler's formula. Better bound for the number of edges in a triangle-free graph. Proving non-planarity of certain graphs. Estimating the number of crossings in a drawing of a complete graph. A forbidden minor ubgraph approach to characterizing planar graphs (Wagner and Kuratowski criteria).

4. Graph colorings. Definitions and example applications

Graph colorings. Definitions and example applications. Greedy coloring. Chromatic number. Simple bounds for the chromatic number. Coloring planar graphs. Digraphs. Some similarities and differences between directed and undirected graphs. Tournaments. Kernels.

5. Ford—Fulkerson's "Max-Flow-Min-Cut" theorem on flows in networks

Cuts and flows as an example of “combinatorial duality”. Combinatorial application of integer flows: Hall’s theorem on matchings in bipartite graphs.

6. More on connectivity of graphs. Menger’s theorem. Proof of Menger’s theorem via Ford—Fulkerson’s

Biconnectivity. Bridges, cut-vertices and blocks. Importance of blocks in planarity testing, coloring, shortest paths. Two notions of k-connectivity, Graph traversals. Breadth-first search (BFS) and depth-first search (DFS).

7. BFS: Lovasz’ proof of Brooks’ theorem via greedy coloring; fundamental cycles in graphs

Eulerian and Hamiltonian circuits. The TSP problem. Euler’s criterion: inductive and algorithmic proofs. Dirac’s sufficient conditions for the existence of a hamiltonian circuit. An approximate solution to the TSP problem on graphs with triangle inequality using any Eulerian walk or DFS.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Linear Algebra/Линейная алгебра

Purpose of the course:

Theoretical and practical development of the main sections of linear algebra and analytical geometry. The course should provide students with an idea of the mathematical rigor of evidence. Particular attention is paid to the practical applications of linear algebra methods in various mathematical and interdisciplinary problems, to the ability to apply the apparatus of linear algebra to a wide range of problems.

Tasks of the course:

 acquisition by students of theoretical knowledge and practical skills in the field of vector algebra, matrix algebra;

 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:

- basic concepts of linear algebra: vector space, linear functions and operators, bilinear forms, matrix, eigenvalues and eigenvalues; - basic concepts of general algebra: groups, rings, fields;

- ideas of the coordinate method in analytic geometry;

- key theorems of linear algebra: matrix rank theorem, linear space isomorphism theorem, Jordan normal form theorem, Kronecker theorem, theorems on reducing a quadratic form and a pair of forms to canonical form.

be able to:

- solve systems of linear algebraic equations;

- perform coordinate replacement for linear and bilinear functions, linear operators;

- find the eigenvalues and eigenvectors of the linear operator;

- lead to the canonical form of a matrix of a quadratic form and a linear operator;

- solve the main problems of analytic geometry;

- prove the key theorems of linear and general algebra;

- use the apparatus of linear algebra to solve applied problems.

master:

- general concepts and definitions associated with vectors: linear independence, basis, orientation of the plane and space;

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

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

1. Vector Spaces. Linear Independence. Basis. Dimension. Linear Maps. Coordinates.

Affine Spaces. Affine Hull. Euclidean Affine Geometry

2. Affine Transformations and Motions.

Bilinear Functions (Forms).

3. Symmetric Bilinear Functions (Forms). Quadratic Forms. Inertial Law. Orthogonal Basis for Symmetric Bilinear Forms.

Euclidean and Hermitian Spaces. Gram matrices. Euclidean Affine Spaces. Convex Sets and Convex Polyhedra. The Minkowski-Weyl Theorem.

4. Linear Operators. Eigenspaces.

Diagonalization of Symmetric Operators. Polar Decomposition.

5. Non-Euclidean Geometry: n-sphere.

Non-Euclidean Geometry: hyperbolic Lobachevsky space.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Linear Algebra/Линейная алгебра

Purpose of the course:

Theoretical and practical development of the main sections of linear algebra and analytical geometry. The course should provide students with an idea of the mathematical rigor of evidence. Particular attention is paid to the practical applications of linear algebra methods in various mathematical and interdisciplinary problems, to the ability to apply the apparatus of linear algebra to a wide range of problems.

Tasks of the course:

 acquisition by students of theoretical knowledge and practical skills in the field of vector algebra, matrix algebra;

 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:

- basic concepts of linear algebra: vector space, linear functions and operators, bilinear forms, matrix, eigenvalues and eigenvalues; - basic concepts of general algebra: groups, rings, fields;

- ideas of the coordinate method in analytic geometry;

- key theorems of linear algebra: matrix rank theorem, linear space isomorphism theorem, Jordan normal form theorem, Kronecker theorem, theorems on reducing a quadratic form and a pair of forms to canonical form.

be able to:

- solve systems of linear algebraic equations;

- perform coordinate replacement for linear and bilinear functions, linear operators;

- find the eigenvalues and eigenvectors of the linear operator;

- lead to the canonical form of a matrix of a quadratic form and a linear operator;

- solve the main problems of analytic geometry;

- prove the key theorems of linear and general algebra;

- use the apparatus of linear algebra to solve applied problems.

master:

- general concepts and definitions associated with vectors: linear independence, basis, orientation of the plane and space;

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

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

1. Vector Spaces. Linear Independence. Basis. Dimension. Linear Maps. Coordinates.

Affine Spaces. Affine Hull. Euclidean Affine Geometry

2. Affine Transformations and Motions.

Bilinear Functions (Forms).

3. Symmetric Bilinear Functions (Forms). Quadratic Forms. Inertial Law. Orthogonal Basis for Symmetric Bilinear Forms.

Euclidean and Hermitian Spaces. Gram matrices. Euclidean Affine Spaces. Convex Sets and Convex Polyhedra. The Minkowski-Weyl Theorem.

4. Linear Operators. Eigenspaces.

Diagonalization of Symmetric Operators. Polar Decomposition.

5. Non-Euclidean Geometry: n-sphere.

Non-Euclidean Geometry: hyperbolic Lobachevsky space.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Machine Learning with Graphs/Машинное обучение на графах

Purpose of the course:

1.Get familiar with classical approaches to graph analysis

2. Learn the novel methods of information retrieval using Graph Neural Networks

3. Get hands on experience in working with graph representation of the data

Tasks of the course:

1.Graph Machine Learning problem statement and ability to develop the general pipeline of the solution

2. Choose relevant approach to and model for particular problem

3. Essential experience with Python, PyTorch and PyTorch frameworks

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of algebraic methods in number theory;

 modern problems of the relevant sections of the theory of algebraic methods in number theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the cycle of the theory of algebraic methods in number theory;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of the theory of algebraic methods in number 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 topology orally and in writing.

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 topology 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. Graph properties

Traditional ML methods for graphs,Graph neural networks, Graph traversing methods

2. Node embeddings

Knowledge graph embeddings, Node propagation

3. Link prediction

Geometrical priors in ML

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Machine Learning/Машинное обучение

Purpose of the course:

- Learn the main theoretical foundations of Machine Learning and Deep Learning
- Get familiar with various approaches to supervised and unsupervised problems
- Gain essential experience in data preprocessing, model development, fitting and validation

Tasks of the course:

- Data preprocessing, model development, fitting and validation
- Skills required in product development and applied research

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

As a result of studying the course the student should

know:

- basic principles and problems of machine learning theory;
- basic methods and algorithms for solving learning problems by precedents;
- the main areas of application of these methods and algorithms;
- classification, clustering and regression.

be able to:

- to formalize the statement of applied data analysis tasks;
- use teaching methods based on precedents to solve practical problems;
- evaluate the accuracy and effectiveness of the solutions obtained.

master:

- the basic concepts of machine learning theory;

-the skills of independent work in solving typical problems;

-the culture of setting and modeling practically significant tasks;

-the skills of theoretical analysis of real problems solved using learning algorithms by precedents.

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

1. Intro, knn, naive Bayes

Linear Regression. Gradient descent Logistic regression

2. SVM, PCA

Bias Variance Decomposition, Train-validation test framework Trees and Ensembling

3. Gradient boosting

Feature types, Missing Values, Feature importances Neural Networks basics

4. Optimization, Regularization in DL

Recurrent Neural Networks Convolutional Neural Networks

5. Text vectorizing, Embeddings, autoencoders

Unsupervised learning Clustering

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Mathematical Foundation of Network Science/Математические основы науки о сетях

Purpose of the course:

mastering basic concepts in the field of complex networks.

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in the field of complex networks;

• acquisition of theoretical knowledge and practical skills in the field of complex networks;

• providing advice and assistance to students in their own theoretical research in the field of complex networks.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of complex networks;

 modern problems of the corresponding sections of complex networks;

 concepts, axioms, methods of proofs and proofs 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.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately present mathematical knowledge in the field orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of setting, analyzing and solving mathematical and applied problems that require the use of mathematical approaches and methods for their solution;

 the subject language of complex networks and the skills of competently describing the solution of problems and presenting the results obtained.

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

1. Dynamic evolution of complex networks

Comparative analysis of the percolation transition for the Bethe lattice and scale-invariant graphs

2. Classification of complex networks

Critical indices of the percolation transition for the Bethe lattice

3. Complex networks in problems of economics and finance

Relationships linking critical indicators.

4. Phase transitions on random networks

Properties of the one-dimensional Ising model

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Mathematical Foundation of Network Science/Математические основы науки о сетях

Purpose of the course:

mastering basic concepts in the field of complex networks.

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in the field of complex networks;

• acquisition of theoretical knowledge and practical skills in the field of complex networks;

• providing advice and assistance to students in their own theoretical research in the field of complex networks.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of complex networks;

 modern problems of the corresponding sections of complex networks;

 concepts, axioms, methods of proofs and proofs 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.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately present mathematical knowledge in the field orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of setting, analyzing and solving mathematical and applied problems that require the use of mathematical approaches and methods for their solution;

 the subject language of complex networks and the skills of competently describing the solution of problems and presenting the results obtained.

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

1. Dynamic evolution of complex networks

Comparative analysis of the percolation transition for the Bethe lattice and scale-invariant graphs

2. Classification of complex networks

Critical indices of the percolation transition for the Bethe lattice

3. Complex networks in problems of economics and finance

Relationships linking critical indicators.

4. Phase transitions on random networks

Properties of the one-dimensional Ising model

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Natural Language Processing/Обработка естественного языка

Purpose of the course:

- Get familiar with classical and novel techniques in the NLP domain
- Get hands on experience in solving Natural Language Processing problems
- Develop skills of applying NLP models to real data

Tasks of the course:

- Natural Language Processing problem statement and ability to develop the general pipeline of the solution
- Choose relevant approach and model for particular problem
- Essential experience with PyTorch framework and Python

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

As a result of studying the course the student should

know:

- statement of tasks of morphological, syntactic analysis;

- methods for solving these problems.

be able to:

- to formulate the tasks of classification of texts, sentences or their elements to highlight structured information;

- implement a suitable text classification algorithm;

- to solve the problem of highlighting keywords and determining the sentiment.

master:

- the main software systems for highlighting hidden topics and reducing the dimension of vector models.

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

1. Text vectorization classical approaches: BoW, TF-IDF.

Text collocations Word embeddings; word2vec and GLoVe Language models

2. Exploding in deep neural networks

Convolutional neural networks in NLP. CNN for text processing Machine translation and Neural Machine Translation.

3. Beam search

Measuring quality of generated text. BLEU/Perplexity scores. Attention mechanism. Self-attention mechanism.

4. Attention in encoder-decoder architecture.

Transformer architecture overview. Pre-training in NLP. Contextual embeddings. ELMo. BERT overview.

5. GPT family overview.

Question answering and knowledge based systems. Bi-directional attention flow (BiDAF) Sentiment analysis POS-tagging, dependency parsing Topic modeling (PLSA. LDA) RL techniques in NLP. Self-critical sequence training.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Neural Networks/Нейронные сети

Purpose of the course:

To provide students with basic knowledge and understanding of the Neural Networks Technology – methods, algorithms and their realization and applications in complex problems.

Tasks of the course:

- to teach students basic principles of neural network theory.

- to introduce students to the history of development of neural network technology

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

As a result of studying the course the student should

know:

- students will gain basic understanding of the Neural Networks Theory.

- will be acquainted with leading scientist's works in Neural Networks Theory and history of its development.

be able to:

- the acquisition of practical skills of application of risk models and methods of system analysis in terms of the multidimensionality of the data for identifying the parameters of web-based attacks, and retrieval of knowledge in information warfare.

- will be able to analyze current and future fields of application of neural network theory and trends

master:

- the acquisition of the ability to interpret the results obtained to build scenarios, forecasts, decision making with the aim of countering web injection attacks and explain the nature of arising in information and communication systems information security incidents

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

1. Basics of Neural Network Theory

Basics of Neural Network Theory familiarize students with basic principles of neural networks theory:

- probabilistic view on world,

- main principles of theory of probability,

- nonlinear and dynamic nature of processes and relationships between their parameters,

- connectionist approach to highly parallel structures of neural networks and oth.

2. Leading scientists in Neural Network Theory

Students will be acquainted with Leading scientists in Neural Network Theory including works of Warren McCulloch and Walter Pitts, Donald Hebb, Frank Rosenblatt, Paul Werbos, Marvin Minsky and Seymour Papert, Alexander Galushkin and many others.

3. Own risk analysis methods and mathematical techniques used in intelligent systems information security

Extreme risk assessment. Metrics for risk assessment.Traditional methods of system analysis of complex systems: a matrix, systematisations, graph, stochastic models.

Maximization, extremal problems, multiextremal problems. Search methods of local and global extrema of functions.

4. Practical examples of the applicability of the models.

Main tasks and methods. System modeling botnet attacks. Components of system modeling: mathematical modeling, computer modeling, information modeling, modeling of decision making, simulation, optimization models, probabilistic (stochastic) simulation

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Optimization Under Uncertainty/Оптимизация в условиях неопределенности

Purpose of the course:

mastering the elective concepts of extreme combinatorics.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of extreme combinatorics;

• acquisition of theoretical knowledge and practical skills in the field of extreme combinatorics;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of extreme combinatorics;

 current problems of the relevant sections of extreme combinatorics;

 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 extreme combinatorics.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of extreme combinatorics;

 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 the field of complex computing 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 requiring the use of mathematical approaches and methods of extreme combinatorics for their solution;

 the subject language of complex calculations 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. Canonical bundle over Grassmann space

Connection of points on a plane by a graph with a small number of intersections with any line, Chazel – Weltzl theorem

2. Basic concepts and definitions of convex geometry

Caratheodory's theorem and Helly's theorem.

3. Polynomial division of one measure in the spirit of Gut – Katz and its properties

The sandwich theorem. Curve of moments and its generalization, polynomial version of the sandwich theorem

4. Applications of Helly's Theorem

Jung's inequality, central point theorem.

5. The Borsuk – Ulam theorem in the simplest case

Technique of minimization and its application. Carathéodory's color theorem and Helly's color theorem. Tverberg theorem.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Populism, Fakes, and Post-Truth: Algorithm-Driven Media Consumption and New Social Phenome/Популизм, фейки и постправда: алгоритмизированное медиапотр

Purpose of the course:

To familiarize students with new media and communication environment and its impact on society, especially in field of public sphere (including political public sphere), provide them tools to analyze media and communication field and its role within the society.

Tasks of the course:

- To introduce students into core concepts of media and their connections with social realm
- To give an overview of the contemporary social media driven media consumption
- To make students able to use social theories in field of media in order to analyze society and role of new technologies within it
- To provide both social-deterministic and techno-deterministic vision of the role of media and make students able to apply them
- To introduce students into the core elements of theory of media effects and make them able to take into consideration the 'effect-driven' approach

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

As a result of studying the course the student should

know:

- Core theories and approaches to the role of media and communication within the society
- Core theories of media effects
- Approaches to new social phenomena
- Criteria for analysis of media complexity
- Role of media in politics

be able to:

- Distinguish between socially-oriented and techno-deterministic theories;
- Criticize contemporary communicative capitalism driven by technological algorithms
- Separate well news sources from bad ones, be able to find a bias in media messages
- Write essays on social topic in English language

master:

- Tools for news analysis
- Tools for analysis of political speech and declarations
- Tools of critical information thinking

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

1. Media, communication and social institutions

Notion of communication and social communication. Differences in communication between animals and humans. 3 types of interactions in societies and their interconnection. Evolution of interactions and evolution of societies. Role of major media innovations in previous communicative revolutions. Role of printing press and printed book. Media and economic institutions. Media and political institutions. Media and cultural institutions. Soft power and hard power.

2. Media and technological determinism in approaching changes in society and its critic

Media and technological determinist vision vs society-centric vision of changes. Linear and non-linear technological development. Everett Rogers and simplistic vision of innovations. Works about technological impact of media: Lerner and MIT school. Latour and Flichy: toward socio-technical complexity. Overview of techno-determinist theories:

- McLuhan and technical thinking on media
- Information society theories
- Castells and network society theory
- Web 2.0 and prosumerist culture
- Works on new media activism

Critic of technological determinism.

3. Contemporary algorithmic media reality: social media, prosumerism, sharing economy.

Core technological changes in recent decades driving media development: raise of media channels, digitalization, device individualization. Rising speed and storage capacity for content. Video as a core content. Social media as new media reality. Alone together philosophy.

Convergence culture and prosumer (playbour) vision. Sharing economy ideology. Political economy of sharing and prosumerism (as critique):

- General models of accumulation of capital
- Idea of digital exploitation
- Network and convergence-based society as still capitalist

4. Some basic concepts about news and truth.

The concept of truth in the society and its ambivalence. Truth and opinion dialectical relationship. News and views separation in journalism. Ideology of news in journalism. Principles of news. Dependent journalism as political activism and propaganda but one of the core function of journalism – core normative visions of journalism. Normativistic and non-normativistic view.

5. Fake news as a parallel communicative flow

Historical origins of the term “fake news”. How multi-channel media undermines the principles of news. News and views separation in digital reality of prosumerist media. Lowering bargains for creating content.. Fake news, disinformation and misinformation. Fake news as propaganda. Types of fake news. Fake news and strategic disinformation. Regulation of fake news: fake news laws, strategic disinformation dispositive, algorithmic solutions, media literacy as magic pill.

6. Media bias in new communicative environment: why fake news works?

Notion of media bias. 5 filters of Herman and Chomsky. Core approaches to media effects. Cognitive dissonance effect. Confirmation bias and selective exposure. Agenda setting in new media. Two steps flow model and how it combines personal trust with mass information in new media world. Media and viral content distribution in new environment.

7. Political public sphere and new media reality: populism and radicalization

Approaches to media and politics. Different visions of power. Public sphere as core concept about communication and politics. Crisis of rational debate in contemporary media. Rise of alternative media. Core concepts of alternative media. Rise of informational and public in politics. Populism as informational phenomenon. Radicalization of political media outlets. Echo-chambers and echo-bubbles and fragmentation of the debate.

8. Activism and new media

Political activism as a concept. Political participation and how new media are challenging it. Ideology if participatory media. Arab spring and “Twitter revolutions”: concept of participatory digital media for changing political regimes. Role of digital media in Trump elections. Critique of digital revolutions. Concept of connective and collective actions and their differences.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Probabilistic Graphical Models/Вероятностные графические модели

Purpose of the course:

1.Get familiar with classical approaches to graph analysis

2. Learn the novel methods of information retrieval using Graph Neural Networks

3. Get hands on experience in working with graph representation of the data

Tasks of the course:

1.Graph Machine Learning problem statement and ability to develop the general pipeline of the solution

2. Choose relevant approach to and model for particular problem

3. Essential experience with Python, PyTorch and PyTorch frameworks

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of algebraic methods in number theory;

 modern problems of the relevant sections of the theory of algebraic methods in number theory;

 concepts, axioms, methods of proof and proof of the main theorems in the sections included in the basic part of the cycle of the theory of algebraic methods in number theory;

 basic properties of the corresponding mathematical objects;

 analytical and numerical approaches and methods for solving typical applied problems of the theory of algebraic methods in number 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 topology orally and in writing.

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 topology 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. Graph properties

Traditional ML methods for graphs,Graph neural networks, Graph traversing methods

2. Node embeddings

Knowledge graph embeddings, Node propagation

3. Link prediction

Geometrical priors in ML

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Random Graphs. Part 1/Случайные графы. Часть 1

Purpose of the course:

mastering the basic concepts of random graph theory.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of random graphs;

• acquisition of theoretical knowledge and practical skills in the field of random graphs;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of random graphs;

 current problems of the corresponding sections of random graphs;

 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 random graphs.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of random graphs;

 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 the field of complex computing 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 random graph methods for their solution;

 the subject language of complex calculations 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. Galton-Watson Branching Processes

Central limit theorem for the number of subgraphs of a random graph

2. The law of zero or one for a random graph

The threshold probability theorem for an arbitrary monotone property of random subsets. Determination of the exact threshold probability for a monotonic property, examples.

3. The method of moments.

A sufficient condition for a random variable to be uniquely determined by its moments

4. Models of random graphs.

Classic models: binomial and uniform

5. Threshold probabilities

Possessing monotonic properties by a random subset

6. Theory of random subsets, binomial and uniform models.

Monotonic properties of finite subsets

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Random Graphs. Part 1/Случайные графы. Часть 1

Purpose of the course:

mastering the basic concepts of random graph theory.

Tasks of the course:

• students mastering basic knowledge (concepts, concepts, methods and models) in the field of random graphs;

• acquisition of theoretical knowledge and practical skills in the field of random graphs;

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

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theories of random graphs;

 current problems of the corresponding sections of random graphs;

 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 random graphs.

be able to:

 understand the task;

 use your knowledge to solve fundamental and applied problems of random graphs;

 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 the field of complex computing 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 random graph methods for their solution;

 the subject language of complex calculations 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. Galton-Watson Branching Processes

Central limit theorem for the number of subgraphs of a random graph

2. The law of zero or one for a random graph

The threshold probability theorem for an arbitrary monotone property of random subsets. Determination of the exact threshold probability for a monotonic property, examples.

3. The method of moments.

A sufficient condition for a random variable to be uniquely determined by its moments

4. Models of random graphs.

Classic models: binomial and uniform

5. Threshold probabilities

Possessing monotonic properties by a random subset

6. Theory of random subsets, binomial and uniform models.

Monotonic properties of finite subsets

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Random Graphs. Part 2/Случайные графы. Часть 2

Purpose of the course:

mastering an advanced course in the theory of random counts

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in the field of random graphs;

• acquisition of theoretical knowledge and practical skills in the field of random graphs;

• providing advice and assistance to students in carrying out their own theoretical research in the field of random graphs.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theory of random graphs;

 modern problems of the corresponding sections of random graphs;

 concepts, axioms, methods of proofs and proofs 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 random graphs.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems of random graphs;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately represent mathematical knowledge in complex calculations, orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of formulation, analysis and solution of mathematical and applied problems that require the use of mathematical approaches and methods of random graphs for their solution;

 subject language of complex calculations and skills of competent description of problem solving and presentation of the results.

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

1. Perfect matchings in a random graph

Distribution of degrees of vertices in a random graph

2. Random subgraphs of incomplete graphs

Janson's inequality, consequences from it. Azuma – Heffding inequality for martingales with bounded martingale differences

3. Distribution of degrees of vertices in a random graph

Method of moments. A sufficient condition for a random variable to be uniquely determined by its moments

4. Paths and routes in graphs

Threshold probabilities and threshold functions of possessing monotonic properties

a random subset.

5. Concentration inequalities in probability theory

Phase transition theorem in a random subgraph

6. Hamiltonian cycles in a random graph

A theorem on the existence of a threshold probability for an arbitrary monotone property of random subsets

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Random Graphs. Part 2/Случайные графы. Часть 2

Purpose of the course:

mastering an advanced course in the theory of random counts

Tasks of the course:

• mastering by students of basic knowledge (concepts, concepts, methods and models) in the field of random graphs;

• acquisition of theoretical knowledge and practical skills in the field of random graphs;

• providing advice and assistance to students in carrying out their own theoretical research in the field of random graphs.

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

As a result of studying the course the student should

know:

 fundamental concepts, laws, theory of random graphs;

 modern problems of the corresponding sections of random graphs;

 concepts, axioms, methods of proofs and proofs 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 random graphs.

be able to:

 understand the task at hand;

 use your knowledge to solve fundamental and applied problems of random graphs;

 evaluate the correctness of the problem setting;

 strictly prove or disprove the statement;

 independently find algorithms for solving problems, including non-standard ones, and analyze them;

 independently see the consequences of the results obtained;

 Accurately represent mathematical knowledge in complex calculations, orally and in writing.

master:

 skills of mastering a large amount of information and solving problems (including complex ones);

 skills of independent work and mastering new disciplines;

 culture of formulation, analysis and solution of mathematical and applied problems that require the use of mathematical approaches and methods of random graphs for their solution;

 subject language of complex calculations and skills of competent description of problem solving and presentation of the results.

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

1. Perfect matchings in a random graph

Distribution of degrees of vertices in a random graph

2. Random subgraphs of incomplete graphs

Janson's inequality, consequences from it. Azuma – Heffding inequality for martingales with bounded martingale differences

3. Distribution of degrees of vertices in a random graph

Method of moments. A sufficient condition for a random variable to be uniquely determined by its moments

4. Paths and routes in graphs

Threshold probabilities and threshold functions of possessing monotonic properties

a random subset.

5. Concentration inequalities in probability theory

Phase transition theorem in a random subgraph

6. Hamiltonian cycles in a random graph

A theorem on the existence of a threshold probability for an arbitrary monotone property of random subsets

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Reinforcement Learning/Обучение с подкреплением

Purpose of the course:

- Learn how to apply Reinforcement Learning techniques in practice
- Get familiar with both fundamental and most recent approaches in Reinforcement Learning

Tasks of the course:

- Reinforcement Learning problem statement and ability to develop the general pipeline of the solution
- Ability to apply the Reinforcement Learning techniques to the real world problems
- Essential experience with PyTorch framework

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

As a result of studying the course the student should

know:

- statement and solution of the problem of synthesizing an object with a given combinatorial characteristic;

- an approach to the analysis of cyclic computations based on a fixed point.

- statement and solution of the problem of synthesizing a data structure with specified mathematical properties;

- the relationship between different formulations of the theory of computation;

- various options for immersing object theories.

- the process of compiling combinatorial code;

- connection of syntax and semantics of calculations with selected bases;

- various mechanisms of calculations and ways of improving them by means of various parameterizations;

- ways and methods of eliminating collisions of variables;

- various forms, including equational, theory of computation;

- the cycle of the abstract machine;

- perspectives of applicative computational technologies and languages CAML, Haskell, F #

be able to:

- to synthesize and analyze an object with a given combinatorial characteristic;

- to compute (interpret) the combinatorial program code containing loop constructions;

- to establish a combinatorial basis of calculations and apply it to solve the problem of compiling a combinatorial code;

- to build equational representations of calculations;

- to carry out reduction of abstraction to supercombiners;

- to calculate (interpret) the reduced expression;

- optimize computations by applying parameterizations;

- to perform code generation of the original expression into an intermediate representation;

- optimize and execute the generated code based on the instructions of the abstract machine;

- perform calculations involving a fixed point.

master:

- have practical skills in building and applying simulation models of distributed computing.

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

1. Reinforcement Learning problem statement.

Stochastic and black box optimization. Value based methods in RL

2. Rewards discounting in RL.

Value iteration. Policy iteration. Model free learning. Q-learning, SARSA

3. On policy and off policy algorithms. N-step algorithms

- Approximate Q-learning
- Value function approximation using complex functions and neural networks.

4. DQN

Experience replay buffer Autocorrelation problem Policy gradient for sequence modeling. Self-critical sequence training

5. DDQN

Policy gradient. REINFORCE algorithm. A2C, A3C Policy gradient as optimization approach in different areas.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

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 elementary 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;

– social and cultural competences for successful mutual understanding in terms of communication with representatives of another culture;

– various communication strategies;

– learning strategies for organizing the 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. 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.

2. 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 "o" in unstressed position. [ж], [ш]. Devocalization of sound «ж» at the end of words. Pronunciation of у, г.

3. 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 you were 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].

4. 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!"

5. 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!”

6. 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.

7. 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. Colors. 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.

8. 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".

9. 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.

10. 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?!"

11. 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.

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".

12. 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.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Scientific Workshop: Modern Topics in Applied Mathematics and Computer Science/Научный семинар: Современные проблемы прикладной математики и информати

Purpose of the course:

Obtaining fundamental knowledge by students in the field of their applied activities, familiarization with the latest results of scientific research, teaching the principles of writing scientific papers and preparing scientific reports and presentations.

Tasks of the course:

• familiarization of students with the latest achievements in the scientific field;

• teaching students the methodology of writing scientific papers, reports and presentations;

• formation of approaches to the implementation of research by students in the framework of final works for a master's degree and the rules for preparing master's theses.

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

As a result of studying the course the student should

know:

The main ideas used in the construction of mathematical models;

Basic information about the requirements for modern computational methods;

Modern applied problems and mathematical models used in them.

be able to:

understand the task;

use their knowledge to solve fundamental and applied problems;

evaluate the correctness of problem statements;

strictly prove or disprove the statement;

independently find algorithms for solving problems, including non-standard ones, and analyze them;

independently see the consequences of the results obtained;

accurately present mathematical knowledge in the field of study of the course in oral and written form

accurately present mathematical knowledge in the field of study of the course in oral and written form.

master:

the skills of analyzing a large amount of information and solving problems;

skills of independent work and development of new disciplines.

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

1. Presentation of laboratories, departments.

Discussion of the results presented in the "fresh" scientific periodicals and at the latest scientific conferences.

Discussion of the current status of work on master's theses (degree of readiness, existing problems and approaches to their solution, adjustment of training plans).

2. Principles and means of writing scientific papers. Principles of construction of scientific reports.

Stylistics of written scientific language. Structure, volume, formulas, abstract, citations and references, bibliography.

Stylistics of oral scientific language. Formulation of the topic, introduction, main part, conclusion. Stages of report preparation

3. Principles and means of preparation of presentations. Rules for registration of master's theses.

Presentation types. Defense of the thesis. Defense of the thesis. Conference. Presentation at the seminar.

Title page, volume, appendices.

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Theory of Probability/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. 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.

5. 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

6. Conditional probabilities.

Conditional probabilities. The formula for total probability. Bayes formula. Examples

Annotation

Major: 01.04.02 Прикладная математика и информатика

specialization: Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики

Theory of Probability/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:

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