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of the MIPT Academic Council
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Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

THE MAIN EDUCATIONAL PROGRAM OF HIGHER EDUCATION

Level of higher education
MASTER

Domain of study
01.04.02 APPLIED MATHEMATICS AND INFORMATICS

Orientation (specialty)
ADVANCED METHODS OF MODERN COMBINATORICS/ПРОДВИНУТЫЕ МЕТОДЫ СОВРЕМЕННОЙ КОМБИНАТОРИКИ

Starting year of the educational program
2024 y.

The main educational program of higher education in the field domain of study 01.04.02 Applied Mathematics and Informatics, orientation (specialty) Advanced Methods of Modern Combinatorics/Продвинутые методы современной комбинаторики, implemented at MIPT, is a set of basic characteristics of education (volume, content, planned results), organizational and pedagogical conditions, forms of certification, which is presented as a general characteristic of the educational program, curriculum, academic calendar schedule, work programs of disciplines (modules), training programs, evaluation and methodological materials. The main educational program of higher education has been created on the basis of the educational standard domain of study 01.04.02 Applied Mathematics and Informatics, independently developed and approved by MIPT.

1. General characteristics of the educational program

Qualifications awarded to graduate: master.

Form of education: full-time

Education period: 2 years.

The educational program consists of: 120 credits and includes all types of student's classroom and independent work, training, time, allotted for quality control of the mastering of the educational program by the student.

The contact work of students with teachers consists of, at least, 1 260 hours.

Program implementation language: english.

Using a network form of educational program implementation: no.

Program goal:

The program is focused on training highly qualified specialists in the field of modern combinatorics (discrete mathematics) and its applications, as a result of which graduates receive advanced competencies in combinatorial geometry, game theory, discrete analysis, random graphs, additive combinatorics, extreme combinatorics, analysis of complex networks and other related fields, as well as the ability to conduct scientific research based on on the most modern achievements in the field of modern combinatorics.

The professional activity of graduates is associated with conducting research in the field of modern mathematics, applied mathematics, computer science, but it can also be associated with such areas of activity as computer modeling, software development.

The educational program is implemented in a network form together with Faculty of Electronical Engineering, Mathematics and Computer Science, University of Twente.

2. Characteristics of the professional activity of graduates:

Fields of professional activity and areas of professional activity,

in which graduates, who have mastered the master's program, can carry out professional activities:

40 Cross-cutting professional activities in industry (in the field of scientific research in the field of informatics and computer technology, as well as in the field of scientific management of R&D in the field of informatics and computer technology).

Graduates can carry out professional activities in other fields of professional activity and (or) areas of professional activity, provided that their level of education and acquired competencies meet the requirements of the employee's qualification.

Types of tasks of professional activity of graduates:

research.

Tasks of professional activity of graduates:

application of fundamental knowledge gained in the field of mathematical and (or) natural sciences to the creation of new computer models, technologies and algorithms;

preparation of scientific and technical reports, reviews, publications based on the results of research.

Objects of professional activity of graduates, mastered the program Master's:

automated information processing and control systems;

computing machinery, complexes, systems and networks;

mathematical, algorithmic, informational, technical, linguistic, ergonomic, organizational and legal support of the above-listed systems and their applications in the areas of high technology production, management and business;

software for computer hardware and automated systems (programs, software packages and systems).

3. List of professional standard, corresponding to the professional activities of graduates:

40.011 Research and Development Specialist.

Code and name of the professional standard	Generalized labor functions			Labor functions		
	code	name	level of qualification	name	code	level of qualification
40.011 Professional standard "Research and Development Specialist"	C	Conducting R&D work on the subject of the organization	6	Implementation of scientific management of research on individual tasks	C/01.6	6
	B	Conducting research and development in the study of independent topics	6	Conducting work on the processing and analysis of scientific and technical information and research results	B/02.6	6

4. Requirements for the results of mastering the educational program

As a result of mastering the main educational program, the graduate should form universal, general professional and professional competencies.

Universal competencies of graduates and indicators of their achievement:

Code and name of competence	Code and name of the indicator of competence achievement
UC-1 Use a systematic approach to critically analyze a problem, and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them UC-1.2 Search for solutions by using available sources UC-1.3 Develop a step-by-step strategy for achieving a goal, foresee the result of each step, evaluate the overall impact on the planned activity and its participants
UC-2 Able to manage a project through all stages of its life cycle	UC-2.1 Set an objective within a defined scientific problem; formulate the agenda, relevance, significance (scientific, practical, methodological or other depending on the project type), forecast the expected results and possible areas of their application UC-2.2 Forecast the project outcomes, plan necessary steps to achieve the outcomes, chart the project schedule and monitoring plan UC-2.3 Organize and coordinate the work of project stakeholders, provide the team with necessary resources UC-2.4 Publicly present the project results (or results of its stages) via reports, articles, presentations at scientific conferences, seminars, and similar events
UC-3 Able to organise and lead a team, developing a team strategy to achieve a goal	UC-3.1 Organize and coordinate the work of the project stakeholders and help resolve disputes and conflicts UC-3.2 Consider the interests, specific behavior, and diversity of opinions of team members/colleagues/counterparties UC-3.3 Foresee the results (consequences) of both individual and collective actions UC-3.4 Plan teamwork, distribute tasks to team members, hold discussions of different ideas and opinions
UC-4 Use modern communication tools in the academic and professional field, including those in a foreign language	UC-4.1 Exchange business information in oral and written forms in Russian and at least one foreign language UC-4.2 Use the acquired skills to write, translate, and edit various academic texts (abstracts, essays, reviews, articles, etc.) UC-4.3 Present the results of academic and professional activities at various academic events, including international conferences UC-4.4 Use modern ICT tools for academic and professional collaboration

UC-5 Analyze and consider cultural diversity in intercultural interactions	UC-5.1 Identify specific philosophical and scientific traditions in major world cultures UC-5.2 Define the theoretical and practical significance of cultural and linguistic factors within various interrelated philosophical and scientific traditions
UC-6 Determine priorities and ways to improve performance through self-assessment	UC-6.1 Achieve personal growth and professional development, determine priorities and ways to improve performance UC-6.2 Evaluate performance results in correlation with the set objectives and applied methods

General professional competencies of graduates and indicators of their achievement:

Code and name of competence	Code and name of the indicator of competence achievement
Gen.Pro.C-1 Address current challenges in fundamental and applied mathematics	Gen.Pro.C-1.1 Apply fundamental scientific knowledge, new scientific principles, and research methods in applied mathematics and computer science Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional tasks
Gen.Pro.C-2 Iimprove upon and implement new mathematical methods in applied problem solving	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings Gen.Pro.C-2.2 Assess the relevance and practical importance of applied mathematical research in professional settings Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form
Gen.Pro.C-3 Develop mathematical models and conduct their analysis in the processes of professional problem-solving	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches Gen.Pro.C-3.2 Employ research methods to solve new problems, and apply knowledge from various science and technology fields Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations for applying the obtained solutions Gen.Pro.C-3.4 Gather, expand, and apply mathematical knowledge to solve non-standard problems, including problems in a new, unfamiliar environment or interdisciplinary context
Gen.Pro.C-4 Combine and adapt current information and communications technologies (ICTs) to meet professional challenges	Gen.Pro.C-4.1 Use ICTs to search and analyze professional information, highlight, structure, format, and present it in the form of analytical reviews with sound conclusions and recommendations Gen.Pro.C-4.2 Apply ICTs to solve the task in hand, to draw conclusions, and to evaluate the obtained results Gen.Pro.C-4.3 Create original algorithms and use software tools and modern smart technologies for professional problem-solving
Gen.Pro.C-5 An understanding of current scientific and technical problems in the field of informatics and computer technology, and is able to formulate professional tasks in scientific language	Gen.Pro.C-5.1 An understanding of the current state of research within his/her professional thematic area Gen.Pro.C-5.2 Able to assess the relevance of research in informatics and computer technology and its practical relevance Gen.Pro.C-5.3 A good command of the professional terminology used in modern scientific and technical literature, and is able to present the results of scientific work orally and in writing as part of professional communication

Gen.Pro.C-6 Capable of selecting and/or developing approaches to solving typical and new problems in informatics and computer technology, taking into account the characteristics and limitations of different solution methods	Gen.Pro.C-6.1 Able to analyse the problem, plan the solution, suggest and combine ways of solving it Gen.Pro.C-6.2 Capable of developing and upgrading software and hardware for information and automated systems Gen.Pro.C-6.3 Able to use research methods to solve new problems by applying knowledge from different fields of science (technology) Gen.Pro.C-6.4 Proficient in analytical and computational solution methods, and understands and takes into account in practice the limits of applicability of the solutions obtained Gen.Pro.C-6.5 Able to independently acquire, develop and apply mathematical, natural science, socio-economic and professional knowledge to solve non-standard problems, including in new or unfamiliar environments and in an interdisciplinary context

Professional competencies of graduates and indicators of their achievement:

Code and name of competence	Code and name of the indicator of competence achievement	Basis (professional standarts, analysis of other requirements for graduates)
type of professional activity tasks: research		
Pro.C-1 Become part of a professional community and conduct local research under scientific guidance using methods specific to a particular professional setting	Pro.C-1.1 Apply principles of scientific work, methods of data collection and analysis, ways of argumentation; prepare scientific reviews, publications, abstracts, and bibliographies on research topics in Russian and English Pro.C-1.2 Understand the verification process of software models used to solve related scientific problems Pro.C-1.3 Use practical knowledge of scientific argumentation when analyzing a research subject area	Research and Development Specialist
Pro.C-2 Understands and is able to apply modern mathematical apparatus and algorithms, the basic laws of natural science, modern programming languages and software; operating systems and networking technologies in research and applied activities	Pro.C-2.1 Demonstrate expert knowledge of research basics in the field of ICTs, philosophy and methodology of science, scientific research methods, and apply skills to use them Pro.C-2.2 Demonstrate practical experience of applying methods and digital signal processing algorithms, using the Internet, abstracting, referencing, searching for bibliographic sources, and working with scientific sources Pro.C-2.3 Use fundamental knowledge in the field of information theory to carry out research tasks	Research and Development Specialist
Pro.C-3 Participate in scholarly discussions, make speeches and presentations (oral, written, and online) on scientific topics, present research materials, proofread, edit, reference scientific works	Pro.C-3.1 Learn the basics of scholarly discussion and the forms of verbal scientific communication Pro.C-3.2 Hold an appropriate discussion of ICTs and information systems, ask and answer questions related to a particular scientific subject Pro.C-3.3 Participate in student science conferences, hold discussions on IT topics in various formats (face-to-face, online, by correspondence)	Research and Development Specialist

5. Curriculum

The curriculum (Appendix 1) determines the list, labor input, sequence and distribution by periods of study of academic disciplines (modules), trainings, other types of educational activities, forms of intermediate and final certification of students. The labor input of the educational program is set in credit units.

The volume of compulsory part, excluding the volume of the state final attestation, is 50 persents percent of the total volume of the program.

The matrix of compliance of competencies with the disciplines of the curriculum is given in Appendix 2.

6. Academic calendar schedule

Academic calendar schedule (Appendix 3) shows the distribution of types of educational activities, periods of attestation of students and vacations by year of study (courses) and within each academic year. The academic calendar schedule of the educational program of higher education includes 97 weeks, of which there are 59 1/6 weeks of theoretical and practical training, 18 1/6 weeks of the credit-examination period, 3weeks of the state final certification and 16 4/6 weeks of holidays.

7. Work programs of disciplines (modules)

Work programs of disciplines (modules), including evaluation materials for ongoing monitoring of progress and intermediate certification, are presented in Appendix 4.

8. Practice programs

The educational program provides for the following trainings:

Introductory Practical Training/Ознакомительная практика: academic practice;

Personal Research Project/Научно-исследовательская работа: practical training.

Work programs of trainings, including assessment materials for ongoing monitoring of progress and intermediate certification are presented in Appendix 5.

9. Program of the state final certification

As part of the state final certification, the following are provided:

Performance of and Defence of Graduation Thesis/Выполнение и защита выпускной квалификационной работы.

The program of the state final certification (Appendix 6) includes requirements for final qualifying works (volume, structure, design, presentation), the procedure for their implementation, the procedure for defending the final qualifying work, criteria for evaluating the results.

10. Material and technical, educational and methodological support of the educational program

The work programs of disciplines (modules), practices determine the material and technical and educational and methodological support of the educational program, including a list of licensed and freely distributed software, a list of electronic educational publications and (or) printed publications, electronic educational resources, a list and composition of modern professional databases and information reference systems.

Classrooms for conducting training sessions provided for by the educational program are equipped with equipment and technical means of training, the composition of which is determined in the work programs of disciplines (modules) and practices.

The premises for independent work of students are equipped with computer equipment with the ability to connect to the Internet and are provided with access to the electronic information and educational environment of MIPT.

MIPT's electronic information and educational environment provides access to:
– to EBS:
EBS "University Library online";
"Book on Lime" by the publishing house "University Book House";
EBS of "Lan" publishing house;
EBS of "Yurait" publishing house;

EBS of "IBooks.ru" publishing house;
EBS Books.mipt.ru;
EBS ZNANIUM.COM;
access to the collections of the National Electronic Library.

- scientific foreign and Russian journals and electronic databases:
database “Uspekhi Fizicheskikh Nauk” Autonomous non-profit organization Editorial Office of the journal “Uspekhi Fizicheskikh Nauk”;
journals of the Russian Academy of Sciences;
journals of the Steklov Mathematical Institute of the Russian Academy of Sciences: Mathematical journals (mathnet.ru): Izvestia of the Russian Academy of Sciences. Series mathematical, Mathematical Collection, Uspekhi matematicheskikh nauk;
electronic version of the journal "Quantum Electronics" Lebedev Physical Institute of the Russian Academy of Science;
Russian journals on the East View platform of IVIS;
Full-text journal Science Online (American Association for the Advancement of Science);
Journals database (Bentham Science Publishers);
EBSCO eBooks database (EBSCO Information Services GmbH);
Wiley Journal Database;
archival journal collection Wiley Journal Backfiles (2005-2013);
archival collection of journals Wiley Journal Backfiles (2014 -2022);
journals of the Russian Academy of Sciences;
World Scientific Complete eJournal Collection database (World Scientific Publishing Co Pte Ltd.;
Academic Reference Database (China Academic Journals (CD Edition) Electronic Publishing House Co., Ltd);
The Cochrane Library database (John Wiley & Sons, Inc.);
CSD-Enterprise database (The Cambridge Crystallographic Data Centre).

The material, technical and methodological support of the educational program is carried out on the material and technical base of MIPT at the Department of Discrete Mathematics, the head of the department is Andrey Mikhailovich Raygorodsky, PhD. Computers are also provided with remote access. As part of the research and preparation of theses, students are provided (upon request) access to an installed computer with a massively parallel architecture. A small lecture hall with 36 seats, basic equipment: study tables, chairs, a single-element blackboard, a projection screen, a stationary computer, a projector. A 20-seat classroom for practical classes, basic equipment: study tables, chairs, a two-sided mobile learning board, a laptop, a projector.

11.Features of the educational program implementation for the disabled and persons with special needs

If there are persons with disabilities or persons with special needs among students, the educational program is adapted taking into account the special educational needs of such students.
When teaching according to an individual curriculum for people with disabilities, the period for mastering the educational program can be extended at their request by no more than one year compared to the period for obtaining education for the corresponding form of education.

12. Staff conditions for the implementation of the educational program

The implementation of the basic educational program is provided by managers and scientific and pedagogical workers who have a basic education corresponding to the profile of the discipline taught, and an

academic degree or experience in the relevant professional field and are systematically engaged in scientific and (or) scientific and methodological activities in accordance with the requirements of the MIPT standard 01.04.02 Applied Mathematics and Computer Science. The implementation of the educational program is provided by highly qualified scientific and pedagogical workers - both full–time employees of MIPT and leading scientists – employees of research institutes.

The share of scientific and pedagogical staff (in teaching loads reduced to integer values) with an education corresponding to the profile of the discipline (module) being taught, in the total number of scientific and pedagogical staff implementing the Master's program is more than 70 persents.

The share of scientific and pedagogical staff (in teaching loads reduced to integer values) who have an academic degree (including an academic degree awarded abroad and recognized in the Russian Federation) and (or) an academic title (including an academic title obtained abroad and recognized in the Russian Federation), in the total number of scientific and pedagogical staff implementing the Master's program, is more than 60 persents.

The share of scientific and pedagogical staff (in teaching loads reduced to integer values) from the number of managers and employees whose activities are related to the orientation (specialty) of the ongoing Master's program (having work experience in this professional field for more than 3 years) in the total number of employees implementing the master's program is more than 5 persents.

The general management of the scientific content of the master's program is carried out by the Doctor of Physics and Mathematical Sciences, Full Professor Raygorodskiy Andrey Mikhaylovich, who carries out independent research projects and participates in the implementation of such projects in the field of study, who has annual publications based on the results of this research activity in leading Russian and international peer-reviewed scientific journals and publications, as well as carrying out annual approbation of the results of this research activity at national and international conferences.

Andrey Mikhailovich Raygorodsky is a prominent specialist in the field of discrete mathematics – combinatorics, graph theory and random graphs, combinatorial geometry, author of more than 200 scientific papers, including 25 books and monographs. As a scientific supervisor , he has 28 defended candidates of sciences and three doctors of sciences in the following specialties 01.01.09, 01.01.05, 01.01.04, 05.13.17, 05.13.18.

A.M. Raigorodsky obtained significant results in several classical problems of combinatorial and discrete geometry. First of all, we are talking about the problems of Nelson–Erdos–Hadwiger, Borsuk and Grunbaum. The first of these problems consists in finding colorings of metric spaces with restrictions on the distances between single-color points.The second problem arose from combinatorial and algebraic topology, and it consists in finding optimal partitions of sets in spaces into parts of smaller diameter. The third problem is related to the construction of the most economical coverings of various spatial sets with balls. All these problems and the methods that are being developed to solve them are closely related to the problems of coding theory – with packages and coverings of various metric spaces.

A.M. Raigorodsky has developed and continues to develop powerful linear-algebraic and probabilistic methods that allow achieving new bright results in these problems and related problems of discrete geometry and extreme combinatorics. Thus, Raygorodsky owns the best known estimates of the Borsuk and Nelson–Erdos–Hadwiger numbers. He also improved a number of classical results of Frankl and Redl on codes with one and several forbidden distances (or, equivalently, on hypergraphs with forbidden intersections edges)

Back in 2004, A.M. Raigorodsky defended his dissertation for the degree of Doctor of Physical and Mathematical Sciences in the specialty discrete mathematics and mathematical cybernetics on the topic "Borsuk, Nelson-Erdos–Hadwiger and Grunbaum problems in combinatorial geometry". The new methods of alternation and gearing coatings proposed in the dissertation find numerous applications in extreme combinatorics.

Over the past 16 years since the defense, A.M. Raigorodsky has initiated research in a wide variety of fields of combinatorial analysis

Thus, he and his students are actively studying the problems of random graphs and hypergraphs: a number of

profound results on classical random Erdos—Renyi graphs have been obtained (for example, the laws of zero or one for first-order properties and asymptotics of independence numbers, chromatic numbers and other extreme characteristics of random graphs and hypergraphs); a theory of random distance graphs has been created; breakthrough results breakthrough results have been obtained for classical models of random web graphs and a number of new models have been proposed, which are also used in practice (in particular, in Yandex search, and in technologies used in Sberbank). In this important and application-rich area, the Raygorodsky Group, without a doubt, now occupies a leading position in the world.

A.M. Raigorodsky also initiated the study of randomized algorithms for coloring hypergraphs, and in this area the Raigorodsky group successfully competes with the largest scientific centers in the world.

Significant results were obtained by A.M. Raigorodsky and his students in the geometric Ramsey theory, which is one of the most important directions in modern discrete analysis and theoretical computer science. In particular, the so–called Ramsey numbers for complete distance graphs and problems of the Erdos-Szekeres type in combinatorial geometry are investigated. The Raygorodsky Group now has the best results in the world in these areas.

13. Information about the departments involved in the implementation of the educational program

Chair of Discrete Mathematics: head of Chair - Doctor of Physics and Mathematical Sciences, Full Professor Raygorodskiy Andrey Mikhaylovich, chief Researcher-Head of the laboratory. Modern discrete mathematics is an exceptionally beautiful and multifaceted discipline, rich in non—trivial problems of a "fundamental" nature and a variety of applications in the field of high technology.

The department has a team of like-minded people who want to study both pure mathematics and its practical applications. The staff of the department are young and active specialists in the field of discrete (combinatorial) mathematics, theory of algorithms and complexity of calculations, mathematical logic, probability theory and mathematical statistics, combinatorial (algebraic) topology, combinatorial algebra and combinatorial geometry. Many of the employees teach at the Yandex basic Data Analysis department, because in web technologies, in the analysis of the structure of the Internet, etc., they find, in particular, applications of those ideas and methods that discrete mathematics is so rich in.