

**Federal State Autonomous Educational Institution of Higher Education "Moscow  
Institute of Physics and Technology  
(National Research University)"**

**APPROVED**  
**Head of the Phystech School of  
Aerospace Technology**  
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**Programme for the final state attestation (defence of the graduation thesis)**  
**Preparation for and Taking State Examination/Подготовка к сдаче и сдача государственного  
экзамена**

**by direction (speciality):** Applied Mathematics and Physics  
**orientation (profile):** Beam-Plasma Systems and Technologies/Пучково-плазменные системы и  
технологии  
Chair of Logistics Systems and Technologies  
**course:** 2  
**qualification:** Master  
  
**semester:** 4 (Spring)

Программу составили:

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The programme was discussed at a meeting Chair of Logistics Systems and Technologies 17.05.2021

## 1. Goals and objectives

### Goals

The purpose of the state exam is to establish the level of training of the student in the disciplines and the compliance of the results of mastering the educational program with the requirements of the educational standard in the direction of training.

### Objectives

- assessment of the degree of mastering by students of the theoretical provisions of the main disciplines;
- assessment of the ability to apply the knowledge gained to solve specific problems.

## 2. List of competences, the level of which is assessed in the state examination

| Code and name of competence   | Indicators of competence achievement  |
|---|---|
| UC-1 Use a systematic approach to critically analyze a problem, and develop an action plan  | UC-1.2 Search for solutions by using available sources  |
| UC-2 Able to manage the project through all stages of implementation  | 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-4 Use modern communication tools in the academic and professional fields, 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-4.4 Use modern ICT tools for academic and professional collaboration   |
| Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences  | Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences   |
|   | 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 settings  |
| Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives        | 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 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 within professional communication  |
| Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods                | Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice   |
| Gen.Pro.C-4 Successfully perform a task, analyze the results, and present conclusions, apply knowledge and skills in the field of physical and mathematical sciences and ICTs | Gen.Pro.C-4.2 Apply knowledge in the field of physical and mathematical sciences to solve problems, make conclusions, and evaluate the obtained results   |
|   | Gen.Pro.C-4.3 Justify the chosen method of scientific research  |

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| Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results | Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area                                |
|   | Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model |
|   | Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results        |
| Pro.C-2 Organize and conduct scientific research and testing independently or as a member (leader) of a small research team   | Pro.C-2.1 Plan and conduct scientific research independently or as part of a research team   |
|   | Pro.C-2.2 Test research results through scientific publications and participation in conferences   |
| Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field  | Pro.C-3.1 Understand the operating principles of the equipment and specialized software  |
|   | Pro.C-3.3 Evaluate the accuracy of the experimental (numerical) results  |

### 3. List of sample questions for the state examination

1. What sources did you use when searching for scientific information on the topic of your research?
2. In which publications are the results of your work published?
3. What mathematical models did you use when processing the research results?
4. What is the novelty of your research results? How would you describe this novelty: a concept, an idea that enriches a well-known concept, or as a new technique that expands the boundaries of knowledge?
5. At which conferences were the results of your work presented?
6. Why did you choose this method for research?
7. What is the error of your chosen method of analysis? Show the confidence interval on the graph.
8. Describe your chosen research method.
9. How was the experimental data processed?
10. What is the reliability of the results you received?
11. Formulate the practical value of your research.
12. What is your contribution to the results of scientific works published by the team with your participation?
13. What justifies the theoretical significance of the results of your research?
14. What justifies the practical significance of the results of your research?
15. Your forecast for the prospects of using the results of your work.

### 4. Procedure of taking a state examination

A student who has fully completed the curriculum of the educational program and does not have academic debts is allowed to the state exam in the direction (specialty) of training.

Before the state exam, students are consulted on the state exam program.

The main questions on the state examination are regulated by the Regulations on the final Qualification work of MIPT students.

The defense of the final qualification work is carried out in the form of a report on the results of the completed scientific research (presentation). The duration of the student's report is no more than 15 minutes. At the end of the report, the student answers the questions of the members of the state examination commission without additional time for preparation. The student's survey may not last more than 1 astronomical hour.

### 5. Description of the facilities required for the state examination

auditorium for consultations and certification testing, equipped with workplaces for students and the state examination commission, a blackboard, multimedia equipment.

## 6. List of recommended reading

### Main literature

1. Подготовка и защита бакалаврской работы, магистерской диссертации, дипломного проекта [Электронный ресурс], учеб. пособие / Ю. Н. Новиков. — СПб., Лань, 2019.— URL: <https://e.lanbook.com/book/122187> (дата обращения: 29.01.2021). - Полный текст (Режим доступа : из сети МФТИ / Удаленный доступ)
1. Положение о выпускной квалификационной работе студентов МФТИ (общеинститутское, в том числе для ЛФИ, кроме приложений 1 и 2, которые заменены решением Ученого совета физтех-школы, см. ссылку ниже)  
[https://mipt.ru/docs/download.php?code=prikaz\\_ob\\_utverzhenii\\_polozeniya\\_o\\_vypusknoy\\_kvalifikatsionnoy\\_rabote\\_studentov\\_mfti\\_49\\_1\\_ot\\_21\\_01](https://mipt.ru/docs/download.php?code=prikaz_ob_utverzhenii_polozeniya_o_vypusknoy_kvalifikatsionnoy_rabote_studentov_mfti_49_1_ot_21_01)
2. Правила для студентов ЛФИ (заменяют приложения 1 и 2 общеинститутского Положения о ВКР)  
<https://mipt.ru/education/departments/lpr/students/%D0%9F%D1%80%D0%B0%D0%B2%D0%B8%D0%BB%D0%B0%20%D0%9B%D0%A4%D0%98%20%D0%BF%D0%BE%20%D0%92%D0%9A%D0%A0.pdf>
3. Порядок размещения выпускных квалификационных работ в электронной библиотечной системе МФТИ (общеинститутский)  
<https://mipt.ru/education/departments/lpr/students/%D0%9F%D0%BE%D1%80%D1%8F%D0%B4%D0%BE%D0%BA%20%D1%80%D0%B0%D0%B7%D0%BC%D0%B5%D1%89%D0%B5%D0%BD%D0%B8%D1%8F%20%D0%92%D0%9A%D0%A0%20%D0%B2%20%D0%AD%D0%91%D0%A1.pdf>
4. Порядок проведения ГИА с применением дистанционных образовательных технологий  
<https://mipt.ru/education/departments/lpr/students/%D0%93%D0%98%D0%90%20%D1%81%20%D0%B8%D1%81%D0%BF%D0%BE%D0%BB%D1%8C%D0%B7%D0%BE%D0%B2%D0%B0%D0%B%D0%B8%D0%B5%D0%BC%20%D0%94%D0%9E%D0%A2.pdf>

### Additional literature

1. Искусство писать научные статьи, научно-практическое руководство / Е. З. Мейлихов. — Долгопрудный, Интеллект, 2020.— URL: <http://books.mipt.ru/book/301312> (дата обращения: 18.12.2020). - Полный текст (Режим доступа : из сети МФТИ / Удаленный доступ)

## 7. Guidelines for students preparing for the state examination

When preparing for the state exam, students are advised to recall the topics of the disciplines included in the program of the exam, using, if necessary, lecture notes and recommended literature. After repeating each topic, the student is advised to independently write the formulations and proofs of the theorems contained in the program of the oral part of the state exam, without using literature and aids. If this fails, then it is recommended to repeat this procedure. If there are questions that the student cannot independently solve with the help of the recommended literature, it is recommended to ask these questions at the consultation conducted by the teacher of the department in the relevant discipline.

## 8. Methodology and assessment criteria for the state examination

The results of passing the state exam are determined by the grades "excellent", "good", "satisfactory", "unsatisfactory". Grades "excellent", "good", "satisfactory" mean a successful defense of the Final research project (FRP) with the appropriate qualification.

The assessment for the state exam is made by the state final commission taking into account the opinion of the supervisor, the report of the graduate and the public discussion, as well as taking into account the following criteria –

- validity of the relevance of the research topic, compliance with the content of the topic, completeness of its disclosure;
- clarity of the work structure and logical presentation of the material, methodological validity of the research;
- effectiveness of using the selected research methods to solve the problem;
- possession of the scientific style of presentation;
- validity and value of the research results and conclusions, the possibility of their application in practice;
- compliance of the form of submission of the FRP with all the requirements for the design of works;
- quality of the oral report, fluency in the FRP material;
- depth and accuracy of answers to questions, comments and recommendations during the protection of the work.

When making an assessment, publications, author's certificates, etc. can be taken into account.

The criteria for evaluating the protection of the FRP are given in the Regulations on the final Qualification work of MIPT students.

## **9. Peculiarities of state final examinations for persons with disabilities and persons with special needs**

For students with disabilities, the final state assessment takes into account the particularities of their psycho-physical development, their individual capacities and their state of health (hereinafter referred to as the individual characteristics).

9.1. The following general requirements shall be ensured in the conduct of the FSA:

- conducting state final examinations for persons with disabilities in the same room as students without disabilities, if this does not create difficulties for the students when taking the final examinations;
- presence of assistant(s) in the classroom to provide students with disabilities with the necessary technical assistance, taking into account their individual characteristics (to take the workplace, move around, read and complete an assignment, communicate with members of the SEC);
- the use of technical aids for students with disabilities in taking the FSA, taking into account their individual characteristics;
- ensuring that students with disabilities have unhindered access to and use of classrooms, toilets and other facilities.

9.2. At the written request of a student with a disability, the duration of the state certification test may be extended beyond the established duration of the test:

- the duration of the written state examination - not exceeding 90 minutes;
- the duration of the preparation of the student's answer to a state examination held orally - not more than 20 minutes.

9.3. A student with a disability shall submit a written application no later than 3 months prior to the commencement of the State Attestation Examination regarding the need to create special conditions for him/her when conducting state attestation tests, indicating the specifics of his/her psychophysical development, individual capabilities and state of health. The application shall be accompanied by documents confirming the learner's individual characteristics (in the absence of these documents from the Institute Directorate).

In the application, the student shall indicate the need (lack of need) for the assistant's presence at the state attestation test, the need (lack of need) for increasing the duration of the state attestation test in relation to the established duration.

## **10. Examples of control tasks, tickets**

Examples of tasks are given in the supplement.

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| <b>A. Plasma Physics</b>  | <b>А. Физика плазмы</b>  |
| 1. Ideal and non-ideal plasmas.   | 1. Идеальная и неидеальная плазма.   |
| 2. Equilibrium and non-equilibrium plasmas.   | 2. Равновесная и неравновесная плазма.   |
| 3. Saha equation. System of equations to determine composition of partially ionized equilibrium plasma.   | 3. Уравнение Саха. Система уравнений для определения состава частично ионизированной равновесной плазмы.   |
| 4. Debye theory of shielding. Debye radius. Electrostatic energy of interaction in plasma.  | 4. Теория экранирования Дебая. Радиус Дебая. Электростатическая энергия взаимодействия в плазме.   |
| 5. Electrical conductivity and ambipolar diffusion of plasma.   | 5. Электропроводность и амбиполярная диффузия плазмы.  |
| 6. Ionization. Dominant ionization mechanisms in plasma.  | 6. Ионизация. Доминирующие механизмы ионизации в плазме.   |
| 7. Electron-ion recombination. Recombination mechanisms and products.   | 7. Электронно-ионная рекомбинация. Механизмы и продукты рекомбинации.  |
| 8. Fundamental properties of the Electron-beam plasma; comparison with gas discharge plasmas.   | 8. Основные свойства электронно-лучевой плазмы; сравнение с газоразрядной плазмой.   |
| <b>B. Plasma Chemistry</b>  | <b>В. Химия плазмы</b>   |
| 1. Interaction of ionizing radiation and plasma with matter: similarities and differences.  | 1. Взаимодействие ионизирующего излучения и плазмы с веществом: сходства и различия.   |
| 2. Plasma-stimulated degradation of organic polymers: the role of active plasma particles and plasma electrons. Mechanisms of degradation reaction. The plasma-stimulated ageing of organic polymers.                         | 2. Стимулируемая плазмой деградация органических полимеров: роль активных частиц плазмы и плазменных электронов. Механизмы реакции деградации. Стимулируемое плазмой старение органических полимеров.                                      |
| 3. Plasma-stimulated polymerization of organic polymers: examples and mechanisms. Plasma-stimulated grafting and crosslinking. Applications of plasma-modified polymers in biology, medicine and technology.                  | 3. Плазменно-стимулированная полимеризация органических полимеров: примеры и механизмы. Прививка и сшивание, стимулируемые плазмой. Применение модифицированных плазмой полимеров в биологии, медицине и технике.                          |
| 4. Plasma-stimulated oxidation of organic polymers: main mechanisms and chemical functional groups formed due to the plasma action. The rate constants of the plasma chemical reactions (by an example).                      | 4. Плазменно-стимулированное окисление органических полимеров: основные механизмы и химические функциональные группы, образующиеся под действием плазмы. Константы скорости плазмохимических реакций (на примере).                         |
| 5. Plasma chemistry of saturated and unsaturated hydrocarbons – main pathways.  | 5. Плазмохимия насыщенных и ненасыщенных углеводородов – основные пути.  |
| 6. Plasma-stimulated synthesis of oxides and nitrides on metallic surfaces: plasmachemical reactions and thermal effects. Biomedical and industrial applications of plasmachemically synthesized oxide- and nitride-coatings. | 6. Плазменно-стимулированный синтез оксидов и нитридов на металлических поверхностях: плазмохимические реакции и тепловые эффекты. Биомедицинское и промышленное применение плазмохимически синтезированных оксидных и нитридных покрытий. |
| 7. Plasma chemistry of atmospheric and low pressure plasmas: main differences.  | 7. Плазмохимия плазмы атмосферного и низкого давления: основные различия.  |
| <b>C. Plasma technical systems</b>  | <b>С. Плазменные технические системы</b>   |
| 1. Principle of the Electron-Beam Plasma generation. General design of Beam-Plasma  | 1. Принцип генерации электронно-пучковой плазмы. Общая конструкция пучково-плазменных  |

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| Systems: main subsystems and their co-operation.   | систем: основные подсистемы и их взаимодействие.  |
| 2. Injection windows for electron beams of various power and geometry.   | 2. Инжекционные окна для электронных пучков различной мощности и геометрии.   |
| 3. Combined action of the electron-beam plasma on matter: active factors and their separation.   | 3. Комбинированное воздействие электронно-пучковой плазмы на вещество: активные факторы и их разделение.  |
| 4. Technologies based on thermal action of the Electron-Beam Plasma on solid matter.   | 4. Технологии, основанные на тепловом воздействии электронно-лучевой плазмы на твердое вещество.  |
| 5. Technologies based on non-thermal action of the Electron-Beam Plasma on solid matter.   | 5. Технологии, основанные на нетепловом воздействии электронно-пучковой плазмы на твердое вещество.   |
| 6. Technologies based on thermal and non-thermal action of the Electron-Beam Plasma on gases.  | 6. Технологии, основанные на тепловом и нетепловом воздействии электронно-пучковой плазмы на газы.  |
| 7. Requirements for Beam-Plasma Systems used in industrial and aerospace technologies. Safety of Beam-Plasma Systems: electrical safety, X-ray protection, environment safety. | 7. Требования к пучково-плазменным системам, используемым в промышленных и аэрокосмических технологиях. Безопасность пучково-плазменных систем: электробезопасность, защита от рентгеновского излучения, безопасность окружающей среды. |