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

Programme for the final state attestation (defence of the graduation thesis)
Preparation for and Taking State Examination in Mathematics/Подготовка к сдаче и сдача государственного экзамена по математике

by direction (speciality):	Applied Mathematics and Informatics
orientation (profile):	Computer Science/Информатика
	Chair of Higher Mathematics
course:	3
qualification:	Bachelor
semester:	6 (Spring)

The programme was drawn up by: O.E. Orel, candidate of physics and mathematical sciences, associate professor, associate professor

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1. Goals and objectives

Goals

The purpose of the state exam in mathematics is to establish the level of training of students in mathematical disciplines and the compliance of the results of the development of the educational program by students with the requirements of the educational standard in the field of training.

Objectives

- Assessment of the degree of mastering by students of the theoretical provisions of the main disciplines that form special knowledge in the framework of mastering the educational program;
- assessment of the ability to apply the knowledge gained to solve specific problems;
- assessment of the relevance of the knowledge gained by students and their compliance with the requirements of potential employers.

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 Search and identify, critically evaluate and synthesize information, apply a systematic approach to problem-solving	UC-1.1 Analyze problems, highlight the stages of their solution, plan the actions required to solve them
	UC-1.2 Find, critically assess, and select information required for the task in hand
	UC-1.3 Consider various options for solving a problem, assess the advantages and disadvantages of each option
	UC-1.4 Make competent judgments and estimates supported by logic and reasoning
UC-6 Use time-management skills, apply principles of self-development and lifelong learning	UC-6.2 Plan independent activities in professional problem-solving; critically analyze the work performed; find creative ways to use relevant experience for self-development

3. List of sample questions for the state examination

1. The Cauchy criterion for the existence of the limit of a sequence.
2. The Bolzano-Weierstrass theorem.
3. Boundedness of a convergent sequence. Uniqueness of the limit of a sequence.
4. The Bolzano-Cauchy intermediate-value theorem.
5. Rolle's theorem. Lagrange's finite-increment theorem. Cauchy's finite-increment theorem.
6. The local Taylor formula.
7. Extrema of a function of a single variable. Necessary conditions. Sufficient conditions.
8. Partial derivatives. Differentiability of a function of multiple variables.
9. Extrema of a function of a multiple variables. Necessary conditions. Sufficient conditions.
10. Numerical series. Convergence, absolute convergence. Comparison theorems. D'Alambert's test, Cauchy's test.
11. Functional sequences, functional series.
12. Power series. Radius of convergence. Taylor series.
13. Integral. Integration by substitution. Integration by parts. Newton-Leibniz formula.
14. Multiple integral. Fubini's theorem. Changing the order of integration.
15. Change of variables in multiple integral.
16. Line integrals of first and second kind. Green's theorem.
17. Surface integrals of first and second kind.
18. The Gauss-Ostrogradskii formula. Stokes' formula.

19. Fourier series. Parseval's identity.

20. Fourier transform, inverse Fourier transform. Derivative of a Fourier transform, Fourier transform of a derivative.

21. Straight lines in the space. Vector and coordinate representations of a straight line in the space. Plane in the space. Representations of a plane in the space. Angles between lines and planes.

22. Ellipse, hyperbola and parabola, their properties. Tangent lines to ellipse, hyperbola and parabola. Central lines.

23. Systems of linear equations. Kronecker – Capelli theorem. Fundamental system of solutions and the general solution of a homogeneous system of linear equations. General solution of a nonhomogeneous system. Gauss method. Fredholm theorem.

24. Linear transformations and linear mappings. Kernel and image of a linear mapping. Inverse mapping.

25. Invariant subspaces of linear transformations. Eigenvectors and eigenvalues. Eigenspaces. Linear independence of eigenvectors corresponding to different eigenvalues.

26. Self-adjoint transformations. Properties of their eigenvectors and eigenvalues. Existence of an orthonormal basis of eigenvectors of a self-adjoint transformation.

27. Lagrange reduction of quadratic form to canonical form. Sylvester's law of inertia. Definite quadratic forms. Sylvester's criterion. Reduction of a quadratic form to a diagonal form by elementary

transformations.

28. Linear differential equations and linear systems of differential equations with constant coefficients. The formula for the general solution of n-th order linear homogeneous equation. Finding a solution

to a linear nonhomogeneous equation in the case when the right-hand side of the equation is a quasi-polynomial. Euler equation.

29. The formula for the general solution of a linear homogeneous system of equations in the case of simple eigenvalues of the matrix of coefficients of the system. The formula for the general solution

of a linear homogeneous system in the case of repeated eigenvalues of the coefficient matrix of the system.

30. The simplest problem of calculus of variations. The problem with free ends. Necessary condition for a weak local extreme, Euler equation.

31. Linear differential equations and linear systems of differential equations with variable coefficients. Existence and uniqueness of the solution to the Cauchy problem for normal linear systems of

equations and for n-th order linear equation in the normal form.

32. Fundamental system and fundamental matrix of solutions to a linear homogeneous system of differential equations. The structure of the general solution to a linear homogeneous and heterogeneous system of equations. Wronskian. Liouville-Ostrogradski formula.

4. Procedure of taking a state examination

The state exam consists of an oral exam.

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

The oral part of the exam includes the student's answer to the questions on the exam ticket.

The oral exam tickets contain two questions from different parts of the math courses. The student is given 1 hour to prepare for the oral exam, and no more than 1 hour to answer.

When preparing for the answer and during the answer to the ticket questions, the student can only use the discipline program.

At the state exam, the use of technical electronic means of any kind, as well as foreign materials, is not allowed. Violation of these conditions entails the removal of the student from the exam.

When issuing the final grade for the state exam in mathematics, the student's academic performance in mathematical disciplines and his answer to the oral part of the state exam are taken into account. Assessment for the state exam.

5. Description of the facilities required for the state examination

An audience for consultations and certification tests, equipped with working places for students and the state examination commission, a board, multimedia equipment.

6. List of recommended reading

Main literature
1. Mathematical analysis I /V. A. Zorich. Berlin, Springer, 2015
2. Mathematical analysis II /V. A. Zorich. Berlin, Springer, 2016
3. Advanced calculus, A. Friedman ; The Ohio State University. Mineola ; New York, Dover publications, inc., 2016

Additional literature
1. Linear algebra and its applications /G. Strange ; Massachusetts Institute of Technology. USA, Brooks/Cole : Cengage Learning, 2006

7. Guidelines for students preparing for the state examination

When preparing for the oral part of the state exam, students are recommended to recall the topics of mathematical disciplines included in the program of the oral part of the state exam, using, if necessary, lecture notes and recommended literature. After repeating each topic, the student is recommended 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 auxiliary tools. If this fails, we recommend that you repeat this procedure. If there are questions that the student can not independently solve with the help of the recommended literature, these questions are recommended to be asked 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 successful passing of the state exam.

Evaluation criteria for the oral part of the state exam:

excellent (10) - correct, clear and confident answer to both ticket questions and additional questions;

excellent (9) - correct answers to both ticket questions and additional questions with minor inaccuracies are given;

excellent (8) - both ticket questions and additional questions are answered after minor corrections and leading questions from the examiners;

ok (7) - both questions of the ticket are answered, but there is no correct answer to one of the additional questions;

good (6) – there are shortcomings in the answer to one of the ticket questions and there is no correct answer to one of the additional questions;

satisfactory (3) - no answer to one of the ticket questions, but there are answers to additional questions (possibly with flaws);

unsatisfactory (2) - no answer to one of the ticket questions and additional questions;

unsatisfactory (1) – no answer to any of the ticket questions.

The assessment for the state exam in mathematics is determined by the state examination commission, taking into account the student's assessment for the oral part of the state exam.

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).

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.

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.

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.

Examples of Examination Questions for the State Exam in Mathematics

Question Card 1

1. Extrema of a function of a multiple variables. Necessary conditions. Sufficient conditions.

2. Find equations of straight lines that are tangent to the ellipse $\dfrac{x^2}{18} + \dfrac{y^2}{8} = 1$ and pass through the point $(-6, 0)$.

Question Card 2

1. Straight lines in plane and space. Vector and coordinate representations of a straight line in space.

2. Find the arc length of the curve $x(t) = \sin^3(e^t)$, $y(t) = \cos^3(e^t)$, $\quad \ln \frac{\pi}{4} \le t \le \ln \frac{\pi}{2}$.