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

Faculty of Physics, Mathematics and Natural Sciences

educational division (faculty/institute/academy) as higher education programme developer

FINAL STATE EXAMINATION SYLLABUS

Recommended by the Didactic Council for the Education Field of:

01.04.01 Mathematics

field of studies / speciality code and title

The final state examination is implemented within the professional education program of higher education:

Functional methods in differential equations and interdisciplinary research

higher education programme profile/specialisation title

2025

1. FINAL STATE EXAMINATION GOAL AND TASKS

The goal of the final state examination within the framework of the higher education programme implementation is to check the conformity of the students' training outcomes as the programme results with the relevant requirements of the Federal State Educational Standard of the Higher Education or the RUDN University Educational Standards.

The tasks of the final state examination include the following:

- checking the quality of teaching a person basic humanitarian knowledge, natural science laws and phenomena necessary for professional activities of a graduate;
- identifying the level of theoretical and practical readiness of a graduate to perform professional tasks in compliance with the qualification obtained;
- establishing the degree of a person's desire for self-development, improving his or her qualifications and skills;
- exploring the formation of a graduate's sustainable motivation for professional activities in compliance with the types of tasks of professional activities provided for by the Federal State Educational Standard of the Higher Education or the RUDN University Educational Standards;
- assessing the level of graduates' ability to find organizational and managerial solutions in non-standard situations and evaluating graduates' readiness to bear responsibility for them;
- ensuring the integration of education and scientific and technical activities, increasing the efficiency of scientific and technological achievements use, reforming the scientific sphere and stimulating innovation;
- ensuring the quality of specialists' training in compliance with the requirements of the Federal State Educational Standards of the Higher Education or the RUDN University Educational Standards.

2. REQUIREMENTS FOR HIGHER EDUCATION PROGRAMME COMPLETION AND LEARNING OUTCOMES

A student who does not have failed tests or exams and who has fully completed the curriculum or the individual curriculum of the higher education programme is allowed to the final state examination.

On the higher education programme completion the graduate is expected to master the following **generic competences** (GC):

Code and descriptor of the generic competences
GC-1. Able to search, critical analysis of problem situations based on a systematic approach, develop an action strategy
GC-2. Able to manage a project at all stages of its life cycle
GC-3. Able to organize and manage the work of the team, developing a team strategy to achieve the goal
GC-4. Able to apply modern communication technologies in the state language of the Russian Federation and foreign language(s) for academic and professional interaction
GC-5. Able to analyze and take into account the diversity of cultures in the process of intercultural interaction

Code and descriptor of the generic competences
GC-6. Able to identify and implement the priorities of their own activities and ways to improve it based on self-assessment GC-7. Able to: search for the necessary sources of information and data, perceive, analyze, memorize and transmit information using digital means, as well as using algorithms when working with data received from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data

- general professional competences (GPC):

Code and descriptor of the general professional competences
GPC-1. The ability to formulate and solve relevant and significant problems in mathematics GPC-2. The ability to build and analyze mathematical models in modern natural science, technology, economics and management GPS-3. The ability to use knowledge in the field of mathematics in teaching activities

- professional competences (PC):

Code and descriptor of the professional competences
PC.1. Able to conduct scientific research and obtain new scientific and applied results independently and as part of a scientific team PC.2. Able to develop and analyze conceptual and theoretical models of scientific problems and tasks to be solved PC.3. Able to develop and apply mathematical methods, system and application software for solving problems of scientific and design and technological PC.4. Able to develop and analyze conceptual and theoretical models of the tasks to be solved in design and production and technological activities PC.5. Able to manage projects, plan research activities, analyze risks, manage a project team PC.6. Able to organize corporate training processes based on information technology and the development of corporate knowledge bases PC.7. Able to develop and optimize business plans for scientific and applied projects PC.8. Able to develop corporate standards and profiles of functional standardization of applications, systems, information infrastructure PC.9. Able to teach mathematical disciplines and informatics in general educational organizations, professional educational organizations and educational institutions of higher education PC.10. Able to manage the educational and research activities of students PC.11. Able to carry out work on the processing and analysis of scientific and technical information and research results

3. FINAL STATE EXAMINATION PROCEDURE

The final state examination can be conducted both in in-person format (students and the state examination committee are at RUDN University during the examination), and through the use of distance learning technologies (DLT) available in the RUDN Electronic Information and Educational Environment.

The procedure for in-person or DLT-facilitated final state examination is regulated by the relevant local normative act of the RUDN University.

The final state examination within the framework of the higher education programme includes:

- state exam
- defence of the graduation qualifying paper (degree thesis).

4. STATE EXAM PROCEDURE

The total workload of the State Exam is 3 credits.

The state exam is held in one or more disciplines and (modules) of the higher education programme, whose mastery bears a decisive importance for graduates' occupational performance.

The state exam is held in two stages:

The first stage is an assessment of the level of preparation of a graduate in the form of computer testing using the tools available in the RUDN Electronic Information and Educational Environment;

The second stage is the assessment of the graduate's preparation for future professional activity in the form of an oral exam using examination bills.

In order to prepare students for taking the state exam, the head of the educational programme (no later than one calendar month before the start of the final state examination) shall familiarise the graduate students with the final state examination syllabus, the comprehensive list of theoretical issues included in the state exam, examples of work-related (occupational) situational tasks (cases) that the students will have to solve in the process of taking the state exam, as well as with the procedure for each stage of the state exam and the grading system for evaluating its results (with assessment materials).

Before the state exam, students are offered consultations on issues and tasks included in the state exam (mandatory pre-exam consultation).

The procedure for conducting the computer testing within the final state examination is as follows:

1) in the tests of the parts of the state interdisciplinary exam, a minimum number of questions of the main sections of the main educational program is required to comply with the requirements of the general safety of the student's competence in the framework of the free ES of HE RUDN University and the proven educational program of this area of study;

2) the number of questions in the test - 20; The total time allotted to complete the test is 120 minutes.

The procedure for conducting the second stage of the state exam is as follows:

1) in the tests of the parts of the state interdisciplinary exam, a minimum number of questions of the main sections of the main educational program is required to comply with the requirements of the general safety of the student's competence in the framework of the free OS of HE RUDN University and the proven educational program of this area of study;

2) the number of questions in the test - 20; The total time allotted to complete the test is 120 minutes.

Program of the second stage of the state exam

1. Topological space. Continuous mapping. Topology on the product of topological spaces.
2. Homotopy of continuous mappings. Homotopy equivalence of topological spaces. Example: construct a homotopy equivalence of a point and a segment.
3. Quadratic forms and their reduction to the principal axes. Surface type.
4. Definition of a smooth manifold. Examples: circle, sphere, torus.
5. Differential forms in R^n. Exterior multiplication. Exterior differential. Relationship with operations in vector algebra and vector analysis.
6. De Rham complex. De Rham cohomology. Example: de Rham cohomology of an interval and a circle.
7. Space of L. Schwartz's of basic functions.
8. Fourier transforms of basic functions.
9. Convolution of basic functions. Properties of convolution, its relationship with the Fourier transform.
10. Space of L. Schwartz's generalized functions (distributions).
11. Linear continuous operators in the space of distributions.
12. Strong Fourier transform of an integrable function.
13. Definitions of Lebesgue spaces. Basic theorems on the limit transition under the Lebesgue integral sign - the theorems of Levi, Lebesgue, Fatou.
14. Derivation of Hölder's inequality. On the accuracy of Hölder's inequality.
15. Triangle inequality for $1 \le p \le \infty$. Triangle inequality for $0 < p < 1$.
16. Convergence in L_p. The relationship between convergence in and almost everywhere.
17. Generalized Minkowski inequality for integrals and its application to calculating the norm of the convolution operator.
18. Derivation of the classical weighted Hardy inequality.
19. The method of test functions. General theory and examples.
20. Semilinear and quasilinear equations. Definitions, examples.
21. Critical exponent for a nonlinear inequality. Critical exponent for a semilinear inequality with the Laplace operator in the principal part.
22. Nontrivial solutions of inequalities. Physical meaning of the blowup of a solution to the Cauchy problem.
23. The comparison principle. Examples of problems in which the comparison principle is applied.
24. A priori estimate and solvability of a linear second-order differential equation with a parameter and nonlocal boundary conditions on an interval.
25. Solvability and spectrum of a boundary value problem for a linear differential-difference equation on an interval with a nondegenerate difference operator.
26. The problem of damping a control system with a delay linearly dependent on time.
27. Strongly elliptic differential equations and systems of equations.

28. Strongly elliptic differential-difference equations.
29. Strongly elliptic functional-differential equations with expansions and contractions of arguments.

The state exam results evaluation is carried out in accordance with the methodology set forth in the assessment toolkit that is specified in the Appendix to this syllabus.

5. REQUIREMENTS FOR GRADUATION QUALIFYING PAPER (DEGREE THESIS) AND PROCEDURE FOR ITS DEFENCE

The degree thesis is a graduation qualifying paper that the student (several students in a team) prepare to demonstrate his/her/their level of competence and work readiness.

The list of degree theses themes offered to students for further work is approved by the order of the head of the educational division (faculty/institute/academy) that runs the higher education programme, the respective information is delivered to the students by the programme head no later than six months before the date of the final state examination start.

The students are allowed to suggest their own themes for the theses, under the set procedure.

The student who has passed the state exam is admitted to defend the graduation degree thesis *(if there is a state exam in the final state examination procedure)*.

The student (students) is/are allowed to defend his/ her/their thesis only if this fully completed degree paper is signed by the respective graduate (s), the supervisor, the consultant (if any), the heads of the educational department and educational division; the thesis is also subject to the external review procedure (mandatory for master's and specialist's programmes) and the plagiarism check (in the "Antiplagiarism" system). The review of the graduation qualifying paper supervisor shall be attached as well, with a specific emphasis laid on the graduate's activities in the course of the degree thesis drafting.

No later than 14 days before the date of the thesis defence, a rehearsal of the procedure is held at the presence of the degree thesis supervisor and other academic staff of the educational department, in order to timely identify and eliminate shortcomings in the structure, content and design of the degree thesis.

The degree theses are introduced to the State Examination Board members at the public defence procedure. It includes the students' oral reports with mandatory multimedia (graphic) presentations that introduce the thesis main content.

At the end of the reports, the students reply orally to the State Examination Board members' questions regarding the subject, structure, content of the paper and the profile/ specialisation of the higher education programme. The reports and / or answers to the Board members' questions may be delivered in a foreign language.

The stages of the graduation qualifying paper preparation, the requirements for its structure, volume, contents and design, as well as the list of mandatory and recommended documents submitted for defence are specified in the relevant guidelines.

The evaluation of the degree thesis defense results is carried out in accordance with the methodology set forth in the assessment toolkit that is specified in the Appendix to the syllabus.

6. REQUIREMENTS FOR EQUIPMENT AND TECHNOLOGY SUPPORT FOR FINAL STAE EXAMINATION

1) An auditorium for lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of multimedia presentations;

2) Computer class for testing.

7. RESOURCES RECOMMENDED FOR FINAL STATE EXAMINATION

Main readings to prepare for the state exam and/or degree thesis defence:

1. D. B. Fuks, A. T. Fomenko, V. L. Gutenmakher. Homotopic topology. Moscow: Moscow State University Press, 1969.
2. A. L. Skubachevsky. Boundary value problems for elliptic functional-differential equations and their applications. Uspekhi Matematicheskikh Nauk 71 (2016), 3-112.
3. L. E. Rossovsky. Elliptic functional-differential equations with compression and expansion of the arguments of the unknown function. Modern Mathematics. Fundamental Directions 54 (2014), 3-138.
4. S. M. Nikolsky. Approximation of functions of several variables and embedding theorems. Moscow: Nauka, all years of publication.
5. O. V. Besov, V. P. Ilyin, S. M. Nikolsky. Integral representations of functions and embedding theorems. M.: Nauka, all years of publication.
6. V. I. Burenkov. Functional spaces. Sobolev spaces, any edition

Additional readings to prepare for the state exam and/or degree thesis defence: -

Internet sources

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:

- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru
- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

2.*Databases and search engines:*

- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/

The training toolkit and guidelines for student's self-studies to prepare for the state exam and /or to draft the degree thesis and defend it:*

1. The guidelines for drafting and formatting the degree thesis within the higher education programme «Functional methods in differential equations and interdisciplinary research»
2. The procedure for the degree thesis check in the "Anti- plagiarism" system.
3. The procedure for conducting the final state examination under the higher education programme «Functional methods in differential equations and interdisciplinary research» through the use of DLT and proctoring system.

*The training toolkit and guidelines for the student's self-studies are placed on the final state examination page in the university telecommunication training and information system under the set procedure.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF GRADUATES' COMPETENCES LEVEL

The assessment materials and the grading system* to evaluate the graduate's level of competences (competences in part) formation as the results of the higher education programme completion are specified in the Appendix to this syllabus.

* The assessment materials and the grading system are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

HEAD OF DUCATIONAL DEPARTMENT:

Director, **Mathematical institute**		**Muravnik A.B.**
educational department	signature	name and surname

HEAD
OF HIGHER EDUCATION PROGRAMME:

Professor, **Mathematical institute**		**Burenkov V.I.**
position, department	signature	name and surname