



MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA
FSBEI HE "Chelyabinsk State University"

Faculty of Mathematics
Department of Mathematical Analysis

Work program of the course (module) 2.1.1.3. "Differential Equations and Mathematical Physics"
Scientific specialty – 1.1.2. Differential equations and mathematical physics
Direction - Differential equations and mathematical physics



APPROVED

Vice-rector for Scientific Affairs

A.I. Biryukov

« 24 » 02 2025

WORKING PROGRAM OF THE COURSE (MODULE)*

2.1.1.3 "Differential Equations and Mathematical Physics"

Scientific specialty – 1.1.2. Differential equations and mathematical physics

Direction - Differential equations and mathematical physics

Higher education – training of highly qualified personnel

Mode of study: Full-time

Chelyabinsk, 2025

* The work program of the course (module) is adapted for inclusive education of disabled people and people with disabilities



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The program for the course "Differential Equations and Mathematical Physics" is compiled in accordance with the passport of the scientific specialty 1.1.2. Differential Equations and Mathematical Physics and federal state requirements (level of education: higher education - training of highly qualified personnel), approved by order of the Ministry of Science and Higher Education of the Russian Federation dated October 20, 2021 No. 951.

Program developers:

Head of the Department of Mathematical Analysis
Doctor of Physical and Mathematical Sciences,
Professor

V.E. Fedorov

The program was approved at the meeting of the Department of Mathematical Analysis on January 24, 2025, protocol No. 7.

The program was approved at the meeting of the Academic Council of the Faculty of Mathematics on January 30, 2025, protocol No. 5.

APPROVED

Dean of the Faculty of Mathematics

E.A. Sbrodova

Head of the Department of
Mathematical Analysis

V.E. Fedorov

Head of the Department of
Postgraduate and Doctoral Studies

N.V. Bochkareva

Head of the Department of
International Cooperation

N.C. Annautova



Program summary: The course "Differential Equations and Mathematical Physics" is related to programs for preparation for candidate exams. The program includes several sections of additional chapters of analysis: ordinary differential equations; partial differential equations. The educational process involves studying theoretical material and solving model problems.

1. Objectives and tasks of mastering the discipline

Objectives of the discipline: study of ordinary differential equations; partial differential equations.

Objectives of the discipline: as a result of training, the student should:

- **know:** the main results of the theory of differential equations, including those related to dynamic systems and optimal control problems;
- **be able to:** integrate differential equations of the main classes, find solutions to initial and boundary value problems for them, solve optimal control problems for systems described by differential equations;
- **possess:** the basic concepts and skills of the theory of differential equations and dynamic systems, optimal control theory.

2. The place of the discipline in the structure of the educational program

The course "Differential Equations and Mathematical Physics" is mandatory. The course is taught in the second year (4th semester). The total workload of the course, including midterm assessment, is 3 credits/108 hours, of which contact work with a teacher is 0.33 credits/12 hours (practical - 12 hours), independent work - 2.45 credits/88 hours, control - 0.22 credits/8 hours.

To master the course, the student must have basic mathematical training, skills in solving standard problems and master the basic concepts of mathematical, complex and functional analysis, algebra and geometry, the theory of ordinary differential equations, equations of mathematical physics and calculus of variations within the framework of the university course for students-mathematicians. The course "Differential Equations and Mathematical Physics" is designed to help postgraduate students acquire the skills and knowledge necessary to carry out research work, including completing a candidate's dissertation, as well as prepare for passing the candidate's minimum in the relevant specialty.

Requirements for the "entry" knowledge, skills and experience of the student, necessary when studying the discipline

Know	Be able to	Possess
Basic methods of scientific research activities	Identify and systematize the main ideas in scientific texts; critically evaluate any	Skills in collecting, processing, analyzing and systematizing information on the research

 MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE "Chelyabinsk State University"
Faculty of Mathematics Department of Mathematical Analysis
Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics" Scientific specialty – 1.1.2. Differential equations and mathematical physics Direction - Differential equations and mathematical physics

	incoming information, regardless of the source; avoid automatic application of standard formulas and techniques when solving problems	topic; skills in selecting methods and means for solving research problems
fundamental principles of differential equations, dynamic systems and optimal control	apply methods of mathematical analysis, differential equations and dynamic systems in solving problems of higher mathematics	skills in solving problems related to differential equations

3. Requirements for the results of mastering the content of the discipline

Learning outcomes for the discipline	
know	modern ways of using information and communication technologies in the chosen field of activity
	basic concepts, results and methods of modern differential equations, dynamic systems and optimal control
	formulation of classical problems of differential equations, dynamic systems and optimal control
be able to	select and apply experimental and theoretical research methods in professional activities
	solve problems related to differential equations, modern methods of dynamic systems and optimal control
	develop and apply methods of modern differential equations, dynamic systems and optimal control to solve problems
possess	the skills of searching (including using information systems and databases) and critical analysis of information on the subject of the research being conducted
	the skills of planning scientific research, analyzing the results obtained and formulating conclusions
	the skills to formulate problems related to differential equations

4. Structure and content of the discipline

4.1 Structure of the discipline

Type of work	Semester				Total
	1	2	3	4	
Total workload, academic hours	-	-	-	108	108
Contact work:	-	-	-	12	12
Lectures, academic hours	-	-	-	-	
Practical (seminars), academic hours	-	-	-	12	12
Laboratory work, academic hours	-	-	-	-	
Independent work, academic hours	-	-	-	88	88



MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA
FSBEI HE "Chelyabinsk State University"

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Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics"
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Control	-	-	-	8	8
Type of control (credit, exam)	-	-	-	candidate exam	

4.2. Content of the discipline

№	Section name	Number of hours						Form of current control
		Total	Contact work				Independent work	
			Lectures	Practical, seminars	Lab. work	Control		
1	Ordinary differential equations	50	-	6	-	-	44	Report
2	Partial differential equations	50	-	6	-	-	44	Paper
	Control	8	-	-	-	8		Cand. exam
	Итого:	108		12		8	88	

№	Section name	Section Contents*
1	Ordinary differential equations	<ol style="list-style-type: none"> 1. Theorem of existence and uniqueness of the solution of the Cauchy problem for a system of ordinary differential equations. 2. Smoothness of the solution of the Cauchy problem with respect to the initial data and parameters included in the right-hand sides of the system of equations. Continuation of the solution. 3. General theory of linear equations and systems (domain of existence of a solution, fundamental Cauchy matrix, Liouville-Ostrogradsky formula, method of variation of constants, etc.). 4. Autonomous systems of equations. Equilibrium positions. Limit cycles. 5. Lyapunov stability. Lyapunov theorem on the stability of an equilibrium position to the first approximation. 6. Optimal control problems. Pontryagin's maximum principle (without proof), application to time-optimal problems for linear systems. 7. Differential games. R. Isaacs's equation. 8. Stable bridges and extreme strategies. 9. Boundary value problem for a linear equation or system of equations. Green's function. Representation of a solution to a boundary value problem. 10. Sturm-Liouville problem for a second-order equation. Properties of eigenfunctions.



MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA
FSBEI HE "Chelyabinsk State University"

Faculty of Mathematics
Department of Mathematical Analysis

Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics"
Scientific specialty – 1.1.2. Differential equations and mathematical physics
Direction - Differential equations and mathematical physics

		<p>11. Systems of ordinary differential equations with complex arguments. Proof of the theorem of existence and uniqueness of an analytical solution by the majorant method.</p> <p>12. Differential equations with discontinuous right-hand side. Theorem of existence and uniqueness of a solution under Carathéodory conditions.</p> <p>13. Linear and quasilinear partial differential equations of the first order. Characteristics. Cauchy problem. Hamilton-Jacobi theory.</p>
2	Partial Differential Equations	<p>1. Systems of partial differential equations of Kovalevskaya type. Analytical solutions. Cauchy - Kovalevskaya theory.</p> <p>2. Classification of linear second-order equations on a plane. Characteristics.</p> <p>3. The Cauchy problem and initial-boundary value problems for the wave equation and methods for their solution. Properties of solutions (characteristic cone, finiteness of the wave propagation velocity, nature of the leading and trailing wave fronts, etc.).</p> <p>4. The Dirichlet and Neumann problems for the Poisson equation and methods for their solution. Properties of solutions (maximum principle, smoothness, mean value theorems, etc.)</p> <p>5. The Cauchy problem and initial-boundary value problems for the heat equation and methods for their solution. Properties of solutions (maximum principle, infinite propagation velocity, source function, etc.)</p> <p>6. Generalized functions. Convolution of generalized functions, Fourier transform.</p> <p>7. Sobolev spaces. Embedding theorems, traces of functions from $W_{p,m}$ on the boundary of the domain.</p> <p>8. Generalized solutions of boundary value problems for a second-order elliptic equation. Problems on eigenfunctions and eigenvalues.</p> <p>9. Pseudodifferential operators (definition, basic properties).</p> <p>10. Nonlinear hyperbolic equations. Basic properties.</p> <p>11. Monotone nonlinear elliptic equations. Basic properties.</p> <p>12. Monotone nonlinear parabolic equations. Basic properties.</p>

* The content of the sections is compiled in accordance with the passport of the scientific specialty 1.1.2. Differential equations and mathematical physics

5. Educational technologies

- information and communication technologies;
- research methods in teaching;
- interactive technologies;
- application of new teaching methods related to the use of the possibilities of the virtual information environment (multimedia technologies).



In accordance with the approved basic educational program for the scientific specialty 1.1.2. Differential Equations and Mathematical Physics (focus (profile) - Differential Equations and Mathematical Physics), the program of the discipline "Differential Equations and Mathematical Physics" provides for the widespread use in the educational process of active and interactive forms of conducting classes in combination with extracurricular work in order to form and develop professional skills of students. The effectiveness of the use of interactive forms of training is ensured by the implementation of the following conditions:

- creation of a dialogical space in the organization of the educational process;
- use of the principles of social and psychological training in educational and scientific activities;
- formation of psychological readiness of teachers to use interactive forms of training aimed at developing the internal activity of a postgraduate student and achieving a number of important educational goals: stimulation of motivation and interest in the field of in-depth study of the theory of dynamic systems in general educational and professional terms; increasing the level of activity and independence of research work; development of skills of analysis, critical thinking, scientific communication.

6. Assessment tools for ongoing monitoring of academic performance and midterm assessment

6.1. Passport of the fund of assessment tools for the discipline "Differential equations and mathematical physics"

№	Controlled sections of the discipline	Results	Name of the assessment tool
1	Ordinary differential equations	know: modern ways of using information and communication technologies in the chosen field of activity be able to: select and apply experimental and theoretical research methods in professional activities possess: search skills (including using information systems and databases) and critical analysis of information on the subject of the research being conducted	Paper

 MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE "Chelyabinsk State University"
Faculty of Mathematics Department of Mathematical Analysis
Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics" Scientific specialty – 1.1.2. Differential equations and mathematical physics Direction - Differential equations and mathematical physics

2	Partial differential equations	know: basic concepts, results and methods of modern differential equations and dynamic systems. be able to: solve problems related to differential equations, modern methods of dynamic systems and optimal control possess: skills in setting problems related to differential equations	Abstract
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6.2. Evaluation tools

Current control

Paper

It is written in accordance with the general requirements for abstract works, and is a review of opinions, points of view, and scientific provisions on a specific topic. A postgraduate student prepares an abstract of his or her scientific research (dissertation) for the exam, oriented towards the requirements for an abstract of a candidate's dissertation.

Topics of the report

1. Theorem of existence and uniqueness of the solution of the Cauchy problem for a system of ordinary differential equations.
2. Autonomous systems of equations. Equilibrium positions. Limit cycles:
3. Theorem of existence and uniqueness of the solution of the Cauchy problem for a system of ordinary differential equations.
4. The Sturm-Liouville problem for a second-order equation. Properties of eigenfunctions.
5. Generalized functions. Convolution of generalized functions, Fourier transform.
6. Nonlinear hyperbolic equations. Basic properties.
7. The Dirichlet and Neumann problems for the Poisson equation and methods for their solution. Properties of solutions (maximum principle, smoothness, mean value theorems, etc.).

Topics of papers

1. Smoothness of the solution of the Cauchy problem with respect to the initial data and parameters included in the right-hand sides of the system of equations. Continuation of the solution.
2. General theory of linear equations and systems (domain of existence of a solution, fundamental Cauchy matrix, Liouville-Ostrogradskii formula, method of variation of constants, etc.).



3. Lyapunov stability. Lyapunov theorem on the stability of the equilibrium position to the first approximation.
4. Differential equations with discontinuous right-hand side. Theorem of existence and uniqueness of a solution under Carathéodory conditions.
5. Linear and quasilinear partial differential equations of the first order. Characteristics.
6. The Cauchy problem and initial-boundary value problems for the wave equation and methods of their solution. Properties of solutions (characteristic cone, finiteness of the wave propagation velocity, nature of the leading and trailing fronts of the wave, etc.).
7. Monotone nonlinear elliptic equations. Basic properties.

Interim assessment

The exam questions are formed in accordance with the candidate minimum program and the passport of the scientific specialty 1.1.2. Differential equations and mathematical physics.

Abstract

It is written in accordance with the general requirements for abstract works, it is a review of opinions, points of view, scientific provisions on the topic of the dissertation (an interview is conducted and a grade is given).

The exam is conducted using tickets, each of which contains 3 questions.

A grade is given for the answer to each question. Based on the results of the exam answers, a single grade is derived on a five-point system.

Questions for the candidate exam

1	Theorem of existence and uniqueness of the solution of the Cauchy problem for a system of ordinary differential equations.
2	Smoothness of the solution of the Cauchy problem with respect to the initial data and parameters included in the right-hand sides of the system of equations. Continuation of the solution.
3	General theory of linear equations and systems (domain of existence of a solution, fundamental Cauchy matrix, Liouville-Ostrogradsky formula, method of variation of constants, etc.).
4	Autonomous systems of equations. Equilibrium positions. Limit cycles.
5	Stability according to Lyapunov. Lyapunov's theorem on stability of the equilibrium position to the first approximation.
6	Optimal control problems. Pontryagin's maximum principle (without proof), application to time-optimal problems for linear systems.
7	Differential games. R. Isaacs equation.
8	Stable bridges and extreme strategies.



MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA
FSBEI HE "Chelyabinsk State University"

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Department of Mathematical Analysis

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Scientific specialty – 1.1.2. Differential equations and mathematical physics
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9	Boundary value problem for a linear equation or system of equations. Green's function. Representation of the solution of a boundary value problem.
10	Sturm-Liouville problem for a second-order equation. Properties of eigenfunctions.
11	Systems of ordinary differential equations with complex arguments. Proof of the theorem of existence and uniqueness of an analytical solution by the majorant method.
12	Differential equations with discontinuous right-hand side. Theorem of existence and uniqueness of solution under Carathéodory conditions.
13	Linear and quasilinear equations with partial derivatives of the first order. Characteristics. Cauchy problem. Hamilton-Jacobi theory.
14	Systems of partial differential equations of the Kovalevskaya type. Analytical solutions. Cauchy-Kovalevskaya theory.
15	Classification of linear equations of the second order on the plane. Characteristics.
16	The Cauchy problem and initial-boundary value problems for the wave equation and methods for their solution. Properties of solutions (characteristic cone, finiteness of the wave propagation velocity, nature of the leading and trailing fronts of the wave, etc.).
17	Dirichlet and Neumann problems for the Poisson equation and methods for their solution. Properties of solutions (maximum principle, smoothness, mean value theorems, etc.)
18	The Cauchy problem and initial-boundary value problems for the heat equation and methods for their solution. Properties of solutions (maximum principle, infinite propagation velocity, source function, etc.)
19	Generalized functions. Convolution of generalized functions, Fourier transform.
20	Sobolev spaces W_p^m . Embedding theorems, traces of functions from W_p^m on the boundary of the domain.
21	Generalized solutions of boundary value problems for a second-order elliptic equation. Problems on eigenfunctions and eigenvalues.
22	Pseudodifferential operators (definition, basic properties).
23	Nonlinear hyperbolic equations. Basic properties.
24	Monotone nonlinear elliptic equations. Basic properties.
25	Monotone nonlinear parabolic equations. Basic properties.

Assessment tools for disabled people and people with disabilities are selected taking into account their individual psychophysical characteristics.

If necessary, disabled people and people with disabilities are given additional time to prepare an answer for an exam/credit.

When conducting the procedure for assessing the learning outcomes of disabled people and people with disabilities, it is envisaged to use the technical means necessary for them in connection with their individual characteristics. These means can be provided by CSU or their own technical means can be used.



The procedure for assessing the learning outcomes of disabled people and people with limited health capabilities in a discipline involves providing information in forms adapted to their health limitations and information perception.

For people with visual impairments:

- in printed form in large print,
- in the form of an electronic document,
- in the form of an audio file,
- in printed form in Braille.

For people with hearing impairments:

- in printed form,
- in the form of an electronic document.

For people with musculoskeletal disorders:

- in printed form,
- in the form of an electronic document,
- in the form of an audio file.

6.3. Criteria for assessing learning outcomes

The assessment of learning outcomes is carried out on a five-point scale:

"Excellent" (5 points) – for the complete completion of assignments.

"Good" (4 points) – for the correct approach with minor errors in reasoning and calculations.

"Satisfactory" (3 points) – for the correct approach with significant errors in calculations.

"Unsatisfactory" (1-2 points) – for failure to complete assignments, for performing calculations without justification.

When conducting the procedure for assessing the learning outcomes of disabled people and individuals with limited health capabilities in a discipline (module), the following additional requirements are met depending on the individual characteristics of the students:

a) instructions on the procedure for conducting the assessment procedure are provided in an accessible form (orally, in writing, in writing in Braille, orally using the services of a sign language interpreter);

b) an accessible form of providing assignments of assessment tools (in printed form, in printed form in large print, in printed form in Braille, in the form of an

	MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE "Chelyabinsk State University"
	Faculty of Mathematics Department of Mathematical Analysis
Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics" Scientific specialty – 1.1.2. Differential equations and mathematical physics Direction - Differential equations and mathematical physics	

electronic document, assignments are read out by an assistant, assignments are provided using sign language interpretation);

c) an accessible form of providing answers to assignments (written on paper, typing answers on a computer, written in Braille, using the services of an assistant, orally).

If necessary, for students with limited health capabilities and disabled people, the procedure for assessing the learning outcomes of a discipline (module) can be carried out in several stages.

7. Educational and methodological support of the discipline

Independent work of postgraduate students is carried out in the form of studying individual theoretical issues on the proposed literature and independently solving problems with their subsequent analysis or discussion in the classroom. During independent preparation, students are provided with access to databases and library collections and access to the Internet.

Independent work contributes to:

- deepening and expanding knowledge;
- developing interest in independent research activities;
- mastering the techniques of the process of cognition and developing cognitive abilities.

Independent work of postgraduate students has the main goal of ensuring the quality of training of graduating specialists.

Educational and methodological materials for independent work of students:

The independent work of a graduate student is an indicator of scientific potential, the ability to work with literary sources and regulations, materials of mathematical and pedagogical practice, the graduate student's ability to independently analyze problematic issues. It consists of studying educational and scientific literature, and performing tasks for independent work.

Full-time graduate students study and develop theoretical and practical material on their own for the most part. At the Department of Mathematical Analysis, the list of recommended literature includes a volume of educational and scientific literature, therefore, a graduate student should consult the collections of scientific libraries as often as possible, as well as periodical literature, and follow the novels in the field of mathematics development. When studying scientific and



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FSBEI HE "Chelyabinsk State University"

Faculty of Mathematics
Department of Mathematical Analysis

Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics"
Scientific specialty – 1.1.2. Differential equations and mathematical physics
Direction - Differential equations and mathematical physics

educational literature, it is necessary to compare the content of the available literature with the program of the candidate's examination in the specialty. In the absence of a particular source of literature, it is necessary to contact the collections of the Russian State Library (Moscow). A postgraduate student must carry out careful preparatory work with scientific literature in his specialty, master theoretical, general and specific scientific search methods.

Educational and methodological materials for independent work of disabled students and individuals with limited health capabilities are provided in forms adapted to their health limitations and information perception:

For visually impaired individuals:

- in printed form in large print,
- in the form of an electronic document,
- in the form of an audio file,
- in printed form in Braille.

For hearing impaired individuals:

- in printed form,
- in the form of an electronic document.

For individuals with musculoskeletal disorders:

- in printed form,
- in the form of an electronic document,
- in the form of an audio file.

Main literature

(* literature available in the CSU library or electronic library system; ** literature available in the electronic library system)

1. * Arnold, V. I. Ordinary differential equations [Text]: [textbook] / V. I. Arnold. – 2nd ed., reprinted. – Moscow: MCNMO, 2018. – 343 p.
2. ** Panteleev, A. V. Optimization methods in examples and problems: a tutorial / A. V. Panteleev, T. A. Letova. - 4th ed., corrected. - St. Petersburg: Lan, 2022. - 512 p. - ISBN 978-5-8114-1887-9. - Text: electronic // Lan: electronic library system. — URL: <https://e.lanbook.com/book/212129>.
3. ** Rozendorn, E. R. Partial differential equations: textbook / E. R. Rozendorn, E. S. Soboleva, G. M. Fateeva. — 2nd ed. — Moscow: FIZMATLIT, 2017. — 336 p. — ISBN 978-5-9221-1756-2. — Text: electronic // Lan: electronic library system. — URL: <https://e.lanbook.com/book/104991>.
4. * Filippov, A. F. Introduction to the theory of differential equations [Text]: textbook for universities / A. F. Filippov. — Stereotype ed. — Moscow: [Lenand,



2015]. — 239 p.

Further reading

1. *Isaacs, R. Differential Games [Text] / R. Isaacs; trans. from English by V. I. Arkin, E. N. Simakova; edited by M. I. Zelikin; foreword by L. S. Pontryagin. – Moscow: Mir, 1967. – 479 p.
2. *Alekseev, V. M. Optimal Control [Text]: a textbook for universities / V. M. Alekseev, V. M. Tikhomirov, S. V. Fomin. - Moscow: Nauka, 1979. - 430 p.
3. ** Arnold, V. I. Geometric Methods in the Theory of Ordinary Differential Equations: a textbook / V. I. Arnold. - 4th, ed. — Moscow : MCNO, 2012. — 384 p. — ISBN 978-5-4439-2069-6. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/56388>.
4. ** Arnold, V.I. Additional chapters of the theory of ordinary differential equations / V.I. Arnold. – Moscow : Nauka Publishing House, Main Editorial Board of Physical and Mathematical Literature, 1978. – 306 p. – URL: <http://biblioclub.ru/index.php?page=book&id=479567>.
5. ** Vasilyeva, E. V. Periodic systems of differential equations with an infinite set of stable periodic solutions : monograph / E. V. Vasilyeva. — St. Petersburg : Lan, 2022. — 130 p. — ISBN 978-5-8114-1893-0. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/212081>.
6. ** Vladimirov, V. S. Equations of mathematical physics : textbook / V. S. Vladimirov, V. V. Zharinov. — Moscow : FIZMATLIT, 2000. — 400 p. — ISBN 5-9221-0011-4. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/2363>.
7. ** Gelfand, I. M. Generalized functions and actions on them : study guide : [16+] / I. M. Gelfand, G. E. Shilov. - 2nd ed. – Moscow : State Publishing House of Physics and Mathematics, 1959. – 473 p. – (Generalized Functions. Issue 1). – URL: <https://biblioclub.ru/index.php?page=book&id=459735> .
8. ** Gelfand, I. M. Spaces of Basic and Generalized Functions / I. M. Gelfand, G. E. Shilov. – Moscow : State Publishing House of Physics and Mathematics, 1958. – 308 p. : ill. – (Generalized Functions. Issue 2). –URL: <https://biblioclub.ru/index.php?page=book&id=468172>.
9. *Demidenko, G. V. Equations and Systems Not Resolved with Respect to the Highest Derivative [Text] / G. V. Demidenko, S. V. Uspensky. — Novosibirsk : Nauch. kn., 1998. — 438 p.
10. * Ioffe, A. D. Theory of Extremal Problems [Text] / A. D. Ioffe, V. M. Tikhomirov. — Moscow : Nauka, 1974. — 479 p.
11. *Krasovskii, N. N. Positional differential games [Text] / N. N. Krasovskii, A. I. Subbotin. – Moscow : Nauka, 1974. – 456 p. : ill. – Subject index: p. 456.



12. *Kurant, R. Partial differential equations [Electronic resource] / R. Kurant ; edited by O. A. Oleinik ; trans. from English by T. D. Ventzel. – Moscow : Mir, 1964. – 830 p.
13. *Laks, P. D. Hyperbolic partial differential equations [Text] / P. D. Laks ; trans. from English by A. A. Korshunova ; edited by O. S. Rozanova. – Moscow ; Izhevsk: Regular and Chaotic Dynamics: Institute of Computer Research, 2010
14. *Pontryagin, L. S. Mathematical Theory of Optimal Processes [Text] / L. S. Pontryagin [et al.]. — 4th ed., reprinted — Moscow: Nauka, 1983. — 392 p.
15. *Pontryagin, L. S. Ordinary Differential Equations [Text]: textbook for state universities / L. S. Pontryagin. — Moscow: Fizmatgiz, 1961. — 311 p.
16. ** Sveshnikov, A. A. Applied Methods of the Theory of Random Functions: study guide / A. A. Sveshnikov. — 3rd ed., reprinted — St. Petersburg: Lan, 2022. — 464 p. — ISBN 978-5-8114-1168-9. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/210539> .
17. Sviridyuk, G. A. Linear equations of Sobolev type : Textbook for universities / G. A. Sviridyuk, V. E. Fedorov. — Chelyabinsk : Publishing house of Chelyabinsk State University, 2003. — 179 p.
18. Subbotin, A. I. Generalized solutions of first-order partial differential equations [Text] : prospects for dynamic optimization / A. I. Subbotin ; trans. from English by N. N. Subbotina. — M. ; Izhevsk : Institute of Computer Research, 2003. — 335 p.
19. ** Trenogin, V. A. Ordinary differential equations: textbook / V. A. Trenogin. - Moscow: Fizmatlit, 2009. — 312 p. — URL: <https://biblioclub.ru/index.php?page=book&id=82614>
20. ** Trenogin, V. A. Partial differential equations: textbook / V. A. Trenogin, I. S. Nedosekina. — Moscow: Fizmatlit, 2013. — 227 p. — URL: <https://biblioclub.ru/index.php?page=book&id=275574>
21. *Filippov, A. F. Differential equations [Text]: guidelines for correspondence students of mathematical faculties of universities / A. F. Filippov. — M. : Moscow State University Press, 1986. — 65 p.
22. *Shubin, M. A. Pseudodifferential operators and spectral theory [Text] / M. A. Shubin. — M. : Nauka, 1978. — 279 p.
23. ** Korpusov, M. O. Nonlinear functional analysis and mathematical modeling in physics: methods for studying nonlinear operators / M. O. Korpusov, A. G. Sveshnikov. — Moscow : KRASAND, 2011. — 474 p. —URL: <https://biblioclub.ru/index.php?page=book&id=467682>.
24. *Oleynik, O. A. Lectures on partial differential equations [Text] / O. A. Oleinik. — 2nd ed., corrected. and add. — M.: BINOM. Knowledge Laboratory, 2005. — 260 p.

	MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE "Chelyabinsk State University"
	Faculty of Mathematics Department of Mathematical Analysis
Work program of the discipline (module) 2.1.1.3. "Differential Equations and Mathematical Physics" Scientific specialty – 1.1.2. Differential equations and mathematical physics Direction - Differential equations and mathematical physics	

Electronic funds and resources

The library website www.lib.csu.ru is the means of access to the system of its own electronic resources. The electronic catalog provides a complete and prompt overview of the library collection, improves the quality and efficiency of information retrieval - more than .5 million records.

1. Electronic catalog. Bibliographic databases.

Books, electronic resources, dissertations and abstracts.

2. Electronic library.

Publications of Chelyabinsk State University, teaching and methodological complex; dissertations defended in the councils of Chelyabinsk State University, reserve collections, rare book collection, electronic reference book "Informio", statistical publications of Russia and the CIS countries.

3. Abstract

Databases of INION RAS, VINITI databases, Scopus (<http://www.scopus.com>), Science (archive).

4. Full-text

Databases of dissertations of the Russian State Library, ARBICON, SIGLA, scientific electronic library <http://elibrary.ru>, subscription to the full-text collection of Russian scientific journals (20-205, 48 titles), publishers: Taylor&Francis, Sage Publications (archive of scientific journals); Springer, Wiley (<http://onlinelibrary.wiley.com>).

5. Electronic library systems with the ability to use licensed materials from any point with access to the Internet (registration from the university network of a personal account): University Library Online (www.biblioclub.ru), Lan (www.e.lanbook.com).

Internet resources

- eLIBRARY.RU [Electronic resource]: electronic library / Scientific electronic library – URL: <http://elibrary.ru/defaultx.asp>

- Lan [Electronic resource]: electronic library system (ELS) / Lan publishing house. – URL: <http://e.lanbook.com>

- University library online [Electronic resource]: electronic library system (ELS) / OOO Directmedia Publishing. – URL: <http://biblioclub.ru>

Licensed software for the discipline (module)

- OpenOffice
- Adobe Reader
- MikTex
- WinDjView

 <p>MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE “Chelyabinsk State University”</p>
<p>Faculty of Mathematics Department of Mathematical Analysis</p>
<p>Work program of the discipline (module) 2.1.1.3. “Differential Equations and Mathematical Physics” Scientific specialty – 1.1.2. Differential equations and mathematical physics Direction - Differential equations and mathematical physics</p>

8. Logistics and technical support

To conduct classes on the subject “Differential Equations and Mathematical Physics”, provided for by the curriculum for the training of postgraduate students, there is the necessary material and technical base that complies with the current sanitary and fire safety rules and regulations, ensuring the implementation of all types of theoretical and practical training, as well as the effective implementation of the final qualifying work (dissertation):

- lecture halls equipped with multimedia complexes based on an anti-vandal tribune;
- specialized computer classes with peripheral devices and equipment connected to them;
- methodological materials for independent work on the discipline.

The Faculty of Mathematics has educational and research laboratories equipped with modern computers and multimedia systems: educational computing laboratory (2 computer classes, 24 computers), laboratory of optimization methods and modeling of game situations, educational and scientific laboratory of computer geometry, educational and scientific laboratory of differential equations and operator theory of the department of mathematical analysis, research laboratory of quantum topology, educational and scientific laboratory of technical teaching aids (10 computers), educational and scientific laboratory "Network polygon" (15 computers). All computers of the departments and laboratories of the Faculty of Mathematics are connected by a local network and have Internet access. The faculty has its own website math.csu.ru, which contains educational and scientific materials developed by the faculty staff. Room for independent work (room 205, 206).

The University has computer rooms connected to a local network, Internet access, and equipped with modern high-performance computers. It maintains its own website: <http://csu.ru>.

For obtaining higher education in postgraduate programs by disabled people and people with limited health capabilities, the University has classrooms equipped with the following equipment:

 <p>MINISTRY OF EDUCATION AND SCIENCE OF RUSSIA FSBEI HE "Chelyabinsk State University"</p>
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Room name	Equipment
Room for the typhlotechnical patient, room A-28 of the first academic building	Typhlotechnical aids: Braille computer with display and printer, typhlocomplex "Reading machine", television magnifying device, tiflocassette tape recorders (3 units) and digital voice recorders (6 units). Special software: speech navigation program JAWS, speech synthesizers ("talking mouse"), screen magnifiers.
Room for the deaf, room A-27 of the first academic building	radio class "Sonet-R" (for 6 people), programmable hearing aids (6 pcs.) for individual use with a device for setting the operating mode on a computer, audio equipment.
Adaptive Information Technologies Room, Room A-27, First Academic Building	Computer class for 2 people, interactive whiteboard ActiveBoard with voting system, acoustic amplifier and speakers, multimedia projector, TV, VCR, VCON HD3000 videoconferencing device.

All disciplines specified in this work program, methodological and technical support for the educational process for disabled people and people with limited health capabilities are provided by the Regional Educational and Scientific Center for Inclusive Education of CSU.

9. Methodological guidelines for students on mastering the discipline (module)

When studying this discipline, seminar (practical) classes and independent work of the postgraduate student are used. During practical classes, the main content of the program topics is presented, the main methods and approaches are considered.

For the most effective study of the discipline, the postgraduate student is recommended to:

- attend classes, briefly and thoughtfully take notes on the material, indicating the date of the class and the topic;
- independently work through the material both after each class and upon completion of the topic, which allows you to connect the information received and create a complete picture.