



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) 2.1.2.2. "Integral Transformations"
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)*

2.1.2.2 "Integral Transformations"

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 "Integral Transformations" 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.L. Annatorova

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Program summary: The course "Integral Transformations" is an elective course. The program includes several sections of additional chapters of analysis: basic concepts, properties of the Laplace transform; application of integral transforms in the theory of ordinary differential equations. The educational process involves studying theoretical material and solving model problems.

1. Objectives and tasks of mastering the discipline

Objectives of the course: mastering the basic concepts and properties of the Laplace transform; application of integral transforms in the theory of ordinary differential equations.

Objectives of the course:

As a result of the training, the student should:

- know: criteria for system analysis of the tasks set, methods of planning and organizing research;
- be able to: search for information, determine the criteria for system analysis of the tasks set, search, study and generalize scientific experience in the relevant area of research; determine the goals and objectives of the planned research and development; conduct research, compile its description, formulate conclusions based on the results obtained;
- possess: skills in using critical analysis, systematization and generalization of information to solve the tasks set, skills in conducting scientific research in accordance with the goal set, skills in compiling reports on the topic and on the results of the conducted scientific research.

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

The discipline "Integral Transformations" is mandatory. The discipline is taught in the first year (2nd semester). The total workload of the discipline, including midterm assessment, is 2 credits/72 hours, of which contact work with the teacher is 0.5 credits/18 hours (lectures - 6 hours, practical - 12 hours), independent work - 1.47 credits/53 hours, control - 0.03 credits/1 hour. To master the discipline, 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 variational calculus within the framework of the university course for students-mathematicians.

The discipline "Integral Transformations" is designed to help postgraduate students master the skills and knowledge necessary to carry out research work,

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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
goals and objectives of scientific research in the area of activity, basic principles and methods of their organization; main sources of scientific information and requirements for the presentation of information materials	draw up a general work plan on a given topic, propose research methods and ways of processing results, conduct research according to a plan agreed upon with the supervisor, present the results obtained	systematic knowledge in the area of activity; in-depth knowledge in the chosen area of training, basic skills in conducting research work on the proposed topic
fundamental principles of differential equations, dynamic systems, integral transformations and optimal control	apply methods of mathematical analysis, integral transformations, differential equations and dynamic systems in solving problems of higher mathematics	skills in solving problems related to integral transformations

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, integral transformations, modern methods of dynamic systems and optimal control
	develop and apply methods of modern differential equations, integral transformations, 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 of setting problems related to integral transformations



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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	-	72	-	-	72
Contact work:	-	18	-	-	18
Lectures, academic hours	-	6	-	-	6
Practical (seminars), academic hours	-	12	-	-	12
Laboratory work, academic hours	-	-	-	-	-
Independent work, academic hours	-	53	-	-	53
Control	-	1	-	-	1
Type of control (credit, exam)	-	Graded credit	-	-	

4.2. Contents of the discipline

№	Section name	Count of hours					Form of current control	
		Total	Contact work			Independent work		
			Lectures	Practical, seminars	Lab. work			Control
1	Basic concepts. Properties of the Laplace transform	36	4	6	-		26	Report
2	Application of integral transformations in the theory of ordinary differential equations	35	2	6	-		27	Report
	Control	1				1		Graded credit
	Total:	72	6	12		1	53	

№	Section name	Section Contents *
1	Basic concepts. Properties of the Laplace transform	1. Definition of the Laplace transform 2. Properties of the Laplace transform 3. Properties of the Laplace transform 4. Test #1 5. Basic concepts. Properties of the Laplace transform



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2	Application of integral transformations in the theory of ordinary differential equations	<ol style="list-style-type: none">1. Solution of the Cauchy problem for ODE2. Solution of the Cauchy problem for ODE systems3. Duhamel formula and its use in solving the Cauchy problem4. Application of integral transformations in the theory of ordinary differential equations
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*The contents of the sections are compiled in accordance with the passport of 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 main 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 "Integral Transformations" 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 the most 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.

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

6.1. Passport of the fund of assessment tools for the discipline "Integral Transformations"

№	Controlled sections of the discipline	Learning Outcomes	Name of the assessment tool
1	Basic concepts. Properties of the Laplace transform	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	Test #1
2	Application of integral transformations in the theory of ordinary differential equations	know: basic concepts, results and methods of modern differential equations and dynamic systems. be able to: solve problems related to integral transformations, modern methods of dynamic systems and optimal control possess: skills in setting problems related to integral transformations	Credit

6.2. Evaluation tools

Current control

Sample version of the test paper

Test #1

- 1) Find the Laplace transform of the function $f(t) = t \cdot e^{-2t}$.
- 2) Represent the function as a Fourier integral $f(x) = x \cdot e^{-x^2}$
- 3) Find the Fourier transform of the function $f(x) = x \cdot e^{-2|x|}$
- 4) Solve the equation $\int_0^{+\infty} \varphi(y) \cdot \cos(xy) dy = \frac{1}{1+x^2}$.



Interim assessment

Questions for differentiated assessment

1. Originals and images of functions according to Laplace
2. Finding images of functions
3. Finding the original from the image (decomposition into simple fractions; first decomposition theorem; second decomposition theorem)
4. Table of image properties
5. Basic theorems of the theory of integral transforms
6. Calculating improper integrals using the Laplace transform
7. Solving the Cauchy problem for ordinary linear differential equations with constant coefficients
8. Integration of systems of linear differential equations
9. Application of the Duhamel integral to the integration of differential equations

Assessment tools for disabled people and people with limited health capabilities are selected taking into account their individual psychophysical characteristics. If necessary, disabled people and people with limited health capabilities are given additional time to prepare an answer for the exam/credit.

When conducting the procedure for assessing the learning outcomes of disabled people and people with limited health capabilities, it is envisaged to use the technical means that they need due to 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 the limitations of their health and perception of information:

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.

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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 written form, in written form 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 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 disabilities and those with limited health capabilities, the procedure for assessing the learning outcomes in 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;



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- 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 economic 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 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). The graduate student should carry out thorough preparatory work with scientific literature in his specialty, master theoretical, general and private scientific methods of search.

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 Chelyabinsk State University library or electronic library system; ** literature available in the electronic library system)

1. ** Practical classes in algebra. Complex numbers, polynomials: a tutorial / Yu. V. Volkov, N. N. Ermolaeva, V. A. Kozynchenko, G. I. Kurbatova. – St. Petersburg: Lan, 2022. – 192 p. – ISBN 978-5-8114-1743-8. – Text: electronic // Lan: electronic library system. – URL: <https://e.lanbook.com/book/211694>.
2. ** Panteleev, A. V. Theory of functions of a complex variable and operational calculus in examples and problems: a tutorial / A. V. Panteleev, A. S. Yakimova. - 3rd ed., corrected. - St. Petersburg: Lan, 2022. - 448 p. — ISBN 978-5-8114-1921-0. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/212138>.
3. ** Course of higher mathematics. Theory of functions of a complex variable : textbook / I. M. Petruschko, A. G. Eliseev, V. I. Kachalov, S. F. Kudin. — St. Petersburg : Lan, 2022. — 368 p. — ISBN 978-5-8114-1064-4. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/210425>.

Further reading

1. ** Tuganbaev, A. A. Functions of a complex variable: textbook / A. A. Tuganbaev. – 2nd ed., erased. – Moscow: FLINTA, 2017. – 48 p. – URL: <https://biblioclub.ru/index.php?page=book&id=115140>.
2. ** Fuks, B. A. Functions of a complex variable and some of their applications: textbook: [16+] / B. A. Fuks, B. V. Shabat. – 3rd ed. – Moscow: Nauka, 1964. – 390 p. – (Engineer's Physics and Mathematics Library). – URL: <https://biblioclub.ru/index.php?page=book&id=116268>.
3. ** Kytmanov, A. M. Integral representations and their applications in multidimensional complex analysis / A. M. Kytmanov, S. G. Myslivets; Siberian Federal University. – Krasnoyarsk: Siberian Federal University (SFU), 2010. – 390 p. – URL: <https://biblioclub.ru/index.php?page=book&id=229174>
4. ** Sokolenko, E. V. Theory of functions of complex variables. Operational calculus: a tutorial / E. V. Sokolenko; Severo-Caucasian Federal University. – Stavropol: North Caucasian Federal University (SKFU), 2017. – 199 p.: table. – URL: <https://biblioclub.ru/index.php?page=book&id=494812>

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.

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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

8. Logistics and technical support

To conduct classes on the discipline "Integral Transformations", 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):

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- lecture halls equipped with multimedia systems 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:

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.

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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.