NJSC «K. Zhubanov Aktobe Regional University»

Modular guide
on educational program
8D05401-Mathematics

Aktobe
2025

Module 1: Research Problems in Fundamental Areas of Mathematics

Module Code and Title	AW 7201 Academic writing
Semester(s) in which the module is taught	1
Module Coordinator	Isimov A.M.
Language of Instruction	Kazakh
Curriculum Connection (Cycle, Component)	Basic (University component)
Teaching Methods	Traditional; Active and interactive teaching methods
Workload (including contact hours and self-study hours)	Total workload: 90 hours. Lectures: 15 hours, practical exercises: 15 hours, student independent work: 60 hours
Credit Points (total for the module)	3 ECTS
Required and Recommended Prerequisites for Enrollment	Master's level courses
Module Objectives / Intended Learning Outcomes	The objective of the module "Academic Writing" is to develop doctoral students' skills in structuring scientific texts, presenting research results clearly and logically, adhering to academic standards, and preparing manuscripts for publication in international journals. Intended Learning Outcomes: 1. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 2. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction.
Content	The discipline contributes to the further development of doctoral students' skills in expressing and justifying their thoughts while carrying out their research projects and programs in their respective fields, using reliable scientific texts (articles, dissertations, reviews, monographs, abstracts) and presenting the results in written form in accordance with the legal norms of the Republic of Kazakhstan and the international academic community in Kazakh, Russian, and English.
Examination Forms	Test
Study and Exam Requirements	Study the materials provided in the UNIVER database and complete assignments on time according to the course and SIW (Student Independent Work) submission schedule.
Literature	1. John Morley, *Academic Phrasebank: An academic writing resource for students and researchers (English Edition)*, 2020 2. *Academic Writing. From Research to Text: Textbook and Workbook for Universities* / Yu. M. Kuvshinskaya, N. A. Zevakhina, Ya. E. Akhapkina, E. I. Gordienko; edited by Yu. M. Kuvshinskaya. — Moscow: Yurayt Publishing, 2024. — 284 p. — (Higher Education). — ISBN 978-5-534-08297-5. — Text: electronic // Yurayt Educational Platform [website]. — URL: https://urait.ru/bcode/541096 (accessed: 11.09.2024). 3. Wendy Laura Belcher, *Writing Your Journal Article in Twelve Weeks, Second Edition: A Guide to Academic Publishing Success* (Chicago Guides to Writing, Editing, and Publishing), 2019 4. Zashikhina I.M., *Academic Writing: One Discipline or Many?* // Higher Education in Russia. 2021. Vol. 30, No. 2, pp. 134–143. DOI: 31992/0869-3617-2021-30-2-134-143.

Module Code and Name	MSR 7202 Methods of scientific research
Semester(s) in which the module is taught	1
Responsible Person for the Module	Akhmet M.U.
Language of Instruction	English
Relation to the Curriculum (Cycle, Component)	Basic (University Component)
Teaching Methods	Online learning. Active and interactive learning methods
Workload (including contact hours, self-study hours)	Total workload: 90 hours. Lectures: 15 hours, practical exercises: 15 hours, student independent work: 60 hours.
Credits (total for the module)	3 ECTS
Necessary and Recommended Prerequisites	Master's degree courses. Basics of scientific research.
Module Objectives / Expected Learning Outcomes	The objective of the discipline "Methods of Scientific Research" is to equip doctoral students with knowledge of modern research methodologies, techniques, and tools, enabling them to design, conduct, and analyze scientific studies effectively and independently. 1. To demonstrate deep and comprehensive knowledge of fundamental branches of mathematics, including the theory of Sobolev space, noncommutative analysis of operators, stochastic analysis, the theory of reducibility of systems of differential equations, the theory of dynamical systems; to apply research methods in solving current problems in the field of modern mathematics; 2. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies; 3. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction.
Content	Introduction to research methodology. Writing abstracts. Concept of scientific article. Methods of teaching scientific article writing. Scientific report. Preparing a poster presentation. Preparing a presentation. Preparing a scientific project. Abstract. Project, its types. Content and structure of the thesis project. Thesis project formatting rules. Within the discipline, students will acquire skills in bibliographic description of printed publications and electronic resources, formatting their own written works, public presentation and discussion of scientific papers, conducting discussions, and defending their own position.
Examination Forms	Traditional (ticket-based)
Learning and Examination Requirements	Study the materials provided through the UNIVER platform and complete assignments on time according to the course schedule and SRO submission deadlines.

Literature	1. Liz and John Soars, Paul Hancock – *New Headway* 5th edition. Student's book / Oxford University Press, 2019 – 162 pages. 2. *Professional English in Use: Mathematics and Physics*, / N. A. Nazarova, E. V. Panasenko, O. M. Tolstykh, / Omsk: Publishing House of Omsk State Pedagogical University. **Core reading:** 1. A.A. Bayakhmetova, M.Zh. Dusenbina *"Academic Writing. Language and Style of Academic Writing"*. Textbook, Kostanay: KSU named after A. Baitursynov, 2019. – 106 p. 2. M.B. Kvittsinia *"Academic Writing"*. Textbook. Abkhazian State University, 2018. -145 p. 3. Yu.M. Kuvshinskaya, N.A. Zevakhina, Ya.E. Akhapkina, E.I. Gordienko *"Academic Writing: From Research to Text"*. Textbook for academic bachelor's degree under the editorial of Yu.M. Kuvshinskaya. M: Yurait Publishing, 2019. – 284 p. 4. Korotkina I.B. *"Academic Writing: Process, Product, and Practice"*. Textbook / Korotkina I.B. — Moscow: Yurait, 2020 — 295 p.

Module Code and Name	APFDM 7203 Actual problems of fundamental directions of mathematics
Semester(s) in which the module is taught	1
Responsible Person for the Module	Sartabanov Zh.A.
Language of Instruction	Kazakh
Relation to the Curriculum (Cycle, Component)	Basic (University Component)
Teaching Methods	Traditional. Active and interactive teaching methods
Workload (including contact hours, self-study hours)	Total workload: 150 hours. Lectures: 15 hours, practical exercises: 30 hours, student independent work: 105 hours.
Credits (total for the module)	5 ECTS
Necessary and Recommended Prerequisites	Mathematical analysis on manifolds and stochastic analysis; Probabilistic approach to analysis problems; Complex analysis; Probability theory; Functional analysis
Module Objectives / Expected Learning Outcomes	The objective of the discipline "Actual Problems of Fundamental Directions of Mathematics" is to enhance doctoral students' understanding of key modern challenges in core mathematical fields, develop their ability to analyze unresolved problems, and foster skills for conducting original research and contributing to the advancement of mathematical science. 1. To demonstrate deep and comprehensive knowledge of fundamental branches of mathematics, including the theory of Sobolev space, noncommutative analysis of operators, stochastic analysis, the theory of reducibility of systems of differential equations, the theory of dynamical systems; to apply research methods in solving current problems in the field of modern mathematics; 2. To plan, to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas ;

Content	Actual Problems of Fundamental Directions of Mathematics focuses on the study of current challenges and research trends in major areas of mathematics. The course develops doctoral students' ability to analyze fundamental theories, explore unresolved problems, and apply modern methods in mathematical research. Emphasis is placed on critical thinking, independent investigation, and fostering creativity in addressing essential mathematical issues.
Examination Forms	Traditional (ticket-based)
Learning and Examination Requirements	Study the materials provided through the UNIVER platform and complete assignments on time according to the course schedule and SRO submission deadlines.
Literature	1. Ignatochkina L.A. - *Analysis on Manifolds* – Moscow: MPGU, 2015. – 211 pages. https://www.twirpx.com/file/2519855/ 2. Egorov A.I., Kashargin P.E. - *Differentiable Manifolds and Riemannian Geometry* – Kazan: Kazan State University, 2010. – 30 pages. https://www.twirpx.com/file/2052787/ 3. Zorich V.A. - *Mathematical Analysis. Part II* – Moscow: MCNMO, 2017. – 676 pages. http://math.uchicago.edu/~eskin/math203/Analiz%201%20(2012).pdf 4. Zhukovsky M.E., Rodionov I.V., Shabanov D.A. - *Fundamentals of the Theory of Stochastic Processes* – Moscow: MIPT, 2016. – 121 pages. https://istina.msu.ru/download/43787921/1gH3jj:QEdAixNdehcfTxu0P4EH-7D0Pzc/ 5. Gasknikova A.V. - *Lectures on Stochastic Processes* – Moscow: MIPT, 2019. – 254 pages. https://arxiv.org/pdf/1907.01060.pdf 6. Matalytsky M.A. - *Probability Theory, Mathematical Statistics* – Minsk: Higher School, 2017. – 591 pages. https://vshph.com/upload/inf/978-985-06-2855-8.pdf 7. Bekareva N.D. - *Stochastic Processes* – Novosibirsk: NGTU Publishing, 2016. – 127 pages. http://library.kuzstu.ru/meto.php?n=233613.pdf&type=nstu:common 8. Nasirov F.S. - *Local Times, Symmetric Integrals and Stochastic Analysis* – Moscow: Fizmatlit, 2011. – 212 pages. https://www.twirpx.com/file/2421510/

Module Code and Name	DSRW Doctoral student's research work, including the completion of a doctoral thesis
Semester(s) in which this module is taught	1
Person Responsible for the Module	Жұбанышева А.Ж. (Zhubanysheva A.Z.)
Language of Instruction	Kazakh
Relation to the Curriculum (Cycle, Component)	-
Teaching Methods	Uses results and methods of harmonic analysis, approximation theory, embedding theory, real analysis, and numerical methods software
Workload (including contact hours, independent study hours)	Total workload: 450 hours.
Credits (total for the module)	15 ECTS
Required and Recommended Prerequisites	Knowledge of the fundamentals of scientific methodology (hypotheses,

for Joining the Module	experiments, data analysis); proficiency in research methods in the chosen field (theoretical, experimental, computational).
Module Aims / Expected Learning Outcomes	The objective of the discipline "Doctoral Student's Research Work, Including the Completion of a Doctoral Thesis" is to develop doctoral students' ability to conduct independent scientific research, deepen their knowledge in the chosen field, and ensure systematic progress toward writing and completing their doctoral dissertation. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3.To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 4. , to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 5. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies.
Course Content	Classes of Ulyanov, Nikolsky, Nikolsky-Besov (equivalent definitions, relationships, embedding theorems). Construction of test functions belonging to functional classes. Order estimates of approximation errors for exact and inaccurate data presented as Fourier trigonometric coefficients (construction of functions providing lower bounds; construction of optimal computational aggregates based on exact and inaccurate information, confirming lower bounds). Determining the boundaries of inaccurate data – limiting errors that preserve approximation orders for exact data. Determining the massiveness of limiting errors. Implementation of numerical experiments.
Examination Forms	Report
Requirements for Study and Exams	https://zhubanov.edu.kz/media/uploads/tkuanyshev/2024/10/18/24-ru-1.pdf
Literature	1. Zhubanysheva A.Z., Temirgaliev N. "Informational power of Fourier trigonometric coefficients and their limiting error during discretization of the differentiation operator on multidimensional Sobolev classes", J. Comput. Math. and Math. Phys. 55(9), 1474-1485 (2015) 2. Kolmogorov A.N. "Uber die beste Annaherung von Funktionen einer gegebenen Funktionen klasse" (On the best approximation of functions of a given function class), Ann. Math. 37(1), 107–110 (1936) 3. Stechkin S.B. "On the best approximation of given classes of functions by polynomials", UMR 9 (1), 133–134 (1954) 4. Osipenko K.Y. "Best approximation of analytic functions by information about their values at a finite number of points", Math. Notes 19(1), 29–40 (1976) 5. Heinrich S. "Random approximation in numerical analysis", in: K.D. Bierstedt, A. Pietsch, W.M. Ruess, D. Vogt (Eds.), Functional Analysis (Marcel Dekker, New York, 1993), 123–171

Module 2.1 Theory of oscillations

Code and Title of the Module	RSDE 7301 Reducibility of a system of differential equations
Semester(s) in which the module is taught	1

Module Coordinator	Bekbauova A.U.
Language of Instruction	Kazakh
Relation to Curriculum (cycle, component)	Specialized (Elective component)
Teaching Methods	Traditional, active and interactive teaching methods
Workload (incl. contact hours, self-study hours)	Total workload: 120 hours. Lectures: 20 hours, practical exercises: 20 hours, student independent work: 80 hours.
Credits (total for the module)	4 ECTS
Required and Recommended Prerequisites	Differential equations, mathematical physics equations, algebra, function theory, functional analysis, theory of integral equations, elements of the mathematical theory of multi-frequency oscillations
Module Objectives / Intended Learning Outcomes	The objective of the discipline "Reducibility of a System of Differential Equations" is to provide doctoral students with theoretical knowledge and practical skills in analyzing and simplifying complex systems of differential equations, enabling them to identify equivalent forms, study structural properties, and apply reduction methods to solve advanced mathematical and applied problems. 1. To demonstrate deep and comprehensive knowledge of fundamental branches of mathematics, including the theory of Sobolev space, noncommutative analysis of operators, stochastic analysis, the theory of reducibility of systems of differential equations, the theory of dynamical systems; to apply research methods in solving current problems in the field of modern mathematics;. 2. To apply methods of theoretical and applied scientific research in the field of systems of partial differential equations for the study of systems in the directions of a vector field, boundary value problems for hyperbolic equations with nonlocal conditions, multiperiodic and almost periodic solutions of applied problems for parabolic equations.
Content	Some concepts and definitions from matrix calculus: matrix powers, block matrices, Jordan form of a matrix, matrix series, derivative and integral of a matrix, matrix exponential. Equivalent transformations of polynomial matrices. Elementary transformations of polynomial matrices. Canonical form of a matrix. Elementary divisors of a polynomial matrix. General method of constructing a transformation matrix. General concepts of systems of differential equations with variable coefficients. Lyapunov transformation. Lyapunov-type matrix. Reducible systems. Canonical form of a reducible system. Yerugin’s theorem. Matricant. Multiplicative integral. Integration of linear systems with constant coefficients. Reduction of homogeneous linear systems with constant coefficients to canonical form.
Examination Forms	Written (ticket-based)
Learning and Examination Requirements	Study materials provided on the UNIVER platform and timely completion of assignments according to the course and self-study schedule

Literature	1. Gantmacher F.R. *Matrix Theory*. Moscow: Fizmatlit, 2015. 560 p. 2. Ospanov Q.N. *Singular Differential Equations*. Textbook. – Almaty: Evero Publishing, 2020. – 72 p. (Rmeb) 3. Asanova A.T., Zholamankyzy A. *On a family of two-point boundary value problems for loaded differential equations*, Izv. VUZov. Math., 2021, No. 9, 13–24 4. Oleinik O.A. *Lectures on Partial Differential Equations*. Moscow: BINOM, 2016. – 260 p. 5. Omarov T.E., Shayakhmetova B.K. *Partial Differential Equations: Textbook*. – Almaty: Evero Publishing, 2016. – 188 p. (elib.kz) 6. Sagyndykov B.Zh. *Equations of Mathematical Physics*. 2014. (Rmeb) 7. Abdikalikova G.A., Assanova A.T., Shekerbekova Sh.T. *Nonlocal Problem for Fourth-Order Loaded Hyperbolic Equations*, Russ Math. 66, 1–18 (2022). https://doi.org/10.3103/S1066369X22080011, https://link.springer.com/article/10.3103/S1066369X22080011

Code and Title of the Module	OSDISEMT 7302 Oscillatory solutions of differential and integro-differential systems of equations with multidimensional time
Semester(s) in which the module is taught	2
Module Coordinator	Sartabanov Zh.A.
Language of Instruction	Kazakh
Relation to Curriculum (cycle, component)	Specialized (Elective component)
Teaching Methods	Traditional, active and interactive teaching methods
Workload (incl. contact hours, self-study hours)	Total workload: 150 hours. Lectures: 15 hours, practical exercises: 30 hours, student independent work: 105 hours.
Credits (total for the module)	5 ECTS
Required and Recommended Prerequisites	Elements of the mathematical theory of multi-frequency oscillations; Almost periodic functions and their applications; First-order partial differential equations and their applications; Differential equations, equations of mathematical physics, and numerical methods for their solution
Module Objectives / Intended Learning Outcomes	The objective of the discipline "Oscillatory Solutions of Differential and Integro-Differential Systems of Equations with Multidimensional Time" is to equip doctoral students with advanced knowledge and research skills in studying oscillatory behavior of complex systems, analyzing existence and stability of solutions, and applying modern mathematical methods to investigate multidimensional dynamic processes. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3. To plan, to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 4. To apply methods for finding periodic solutions of differential and integro-differential equations with multidimensional time, solve the problem of stability of a multiperiodic solution and holomorphism in a small parameter; 5. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction.

Content	Differential operator. Vector field. Space of continuously differentiable multiperiodic functions. Operator equation. Integro-differential equation. General solution. Cauchy problem. Problems of multiperiodic functions. Methods for solving operator equations in integrable fields. System of linear equations, its general theory. Floquet theory. Reduction of systems of linear equations. Conditions for multiperiodicity of solutions. Integral expressions of solutions. Methods for multiperiodic solutions of quasi-systems.
Examination Forms	Traditional (ticket-based)
Learning and Examination Requirements	Study materials provided on the UNIVER platform; active participation in lectures and seminars is required for each module, along with completion of assignments according to the course schedule
Literature	1. Nysambaev Zh. *Differential Equations*, 2016 2. Sagyndykov B.Zh. *Equations of Mathematical Physics*, 2014 (Rmeb) 3. Mirzakulova A.E., Dauylbayev M.K. *Boundary Problems for Integro-Differential Equations with Small Parameters*, 2013 (Rmeb) 4. Kulzhumieva A.A., Sartabanov Zh.A. *Periodic Solutions of Differential Equation Systems with Multidimensional Time*, Uralsk: RIC WKSU, 2013. 168 p. 5. Kolekeev K.D. *Differential Equations*, 20126. Tokybetov Zh.Ä. *Equations of Mathematical Physics*, 2010

Code and Title of the Module	MAPSSPE 7303 Multiperiodic and almost periodic solutions of a system of parabolic equations
Semester(s) in which the module is taught	2
Module Coordinator	Abdikalikova G.A.
Language of Instruction	Kazakh
Relation to Curriculum (cycle, component)	Specialized (elective component)
Teaching Methods	Traditional. Active and interactive teaching methods
Workload (incl. contact hours, self-study hours)	Total workload: 150 hours. Lectures: 15 hours, practical exercises: 30 hours, student independent work: 105 hours.
Credits (total for the module)	5 ECTS
Required and Recommended Prerequisites	For successful course completion, knowledge of the course "Oscillatory Solutions of Differential and Integro-Differential Systems of Equations with Multidimensional Time" is required.

Module Objectives / Intended Learning Outcomes	The objective of the discipline "Multiperiodic and Almost Periodic Solutions of a System of Parabolic Equations" is to develop doctoral students' ability to analyze and investigate the existence, uniqueness, and qualitative properties of multiperiodic and almost periodic solutions, fostering advanced research skills in the theory of parabolic systems and their applications in mathematical modeling. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To plan, to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 3. To apply methods of theoretical and applied scientific research in the field of systems of partial differential equations for the study of systems in the directions of a vector field, boundary value problems for hyperbolic equations with nonlocal conditions, multiperiodic and almost periodic solutions of applied problems for parabolic equations; 4. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction;
Content	Multiperiodic and almost periodic functions. Construction of the fundamental solution of parabolic-type equations with constant coefficients. Multiperiodic and almost periodic solutions of the Cauchy problem for parabolic-type equations. Construction and analysis of the fundamental solution of parabolic-type equations with variable coefficients using the Levi method. Multiperiodic and almost periodic solutions of boundary value problems for linear and nonlinear parabolic-type equation systems.
Examination Forms	Essay
Learning and Examination Requirements	Study materials provided via the UNIVER/Platonus platform. Active participation in lectures and seminars, completion of assignments, and submission according to the course schedule are required for each module.
Literature	1. Demidovich B.P. Lectures on the Mathematical Theory of Stability. Moscow, 1967. 469 p. 2. Filippov A.F. Problem Book on Differential Equations. Izhevsk: Research Center "Regular and Chaotic Dynamics", 2000. 176 p. 3. Levitan B.M., Zhikov V.V. Almost Periodic Functions and Differential Equations. Moscow, 1978. 205 p. 4. Pankov A.A. Bounded and Almost Periodic Solutions of Nonlinear Differential-Operator Equations. Kyiv, 1985. 182 p. 5. Umbetzhanov D.U. Almost Multiperiodic Solutions of Partial Differential Equations. Alma-Ata, 1979. 212 p. 6. Umbetzhanov D.U. Almost Periodic Solutions of Evolution Equations. Almaty, 1990. 184 p.

Code and Title of the Module	DSRW Doctoral student's research work, including the completion of a doctoral thesis
Semester(s) in which the module is taught	2
Module Coordinator	Zhubanysheva A.Zh.
Language of Instruction	Kazakh

Relation to Curriculum (cycle, component)	-
Teaching Methods	Methods and results from harmonic analysis, approximation theory, embedding theory, real analysis, and numerical methods software are used
Workload (incl. contact hours, self-study hours)	Total workload: 300 hours
Credits (total for the module)	10 ECTS
Required and Recommended Prerequisites	Knowledge of the basics of scientific methodology (hypotheses, experiments, data analysis); proficiency in research methods in the chosen field (theoretical, experimental, computational)
Module Objectives / Intended Learning Outcomes	The objective of the discipline "Doctoral Student's Research Work, Including the Completion of a Doctoral Thesis" is to strengthen doctoral students' capacity for independent research, enhance their analytical and methodological skills, and ensure steady progress in developing, structuring, and advancing their doctoral dissertation toward successful completion. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3.To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 4. , to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 5. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies.
Content	Ulyanov, Nikolsky, Nikolsky-Besov classes (equivalent definitions, relations, embedding theorems). Construction of test functions belonging to functional classes. Order estimates of approximation errors based on exact and inexact data represented by Fourier trigonometric coefficients (construction of functions providing lower estimates; construction of optimal computational aggregates based on exact and inexact information confirming lower bounds). Definition of boundaries for inexact data – limiting errors preserving approximation orders based on exact data. Definition of the massiveness of limiting errors. Implementation of numerical experiments.
Examination Forms	Report
Learning and Examination Requirements	https://zhubanov.edu.kz/media/uploads/tkuanyshev/2024/10/18/24-ru-1.pdf

Literature	1. Zhubanysheva A.Zh., Temirgaliev N. Informative power of Fourier trigonometric coefficients and their limiting error under discretization of the differentiation operator on multidimensional Sobolev classes, ZhVMiMF 55(9), 1474–1485 (2015) 2. Kolmogorov A.N. "Uber die beste Annaherung von Funktionen einer gegebenen Funktionen klasse" (On the best approximation of functions of a given function classes), Ann.Math. 37(1), 107–110 (1936) 3. Stechkin S.B. On the best approximation of given function classes by arbitrary polynomials, Usp.Mat.Nauk 9(1), 133–134 (1954) 4. Osipenko K.Yu. Best approximation of analytic functions based on values at a finite number of points, Math. Notes 19(1), 29–40 (1976) 5. Heinrich S. Random approximation in numerical analysis, in: K.D. Bierstedt, A. Pietsch, W.M. Ruess, D. Vogt (Eds.), Func.Anal. (Marcel Dekker, New York, 1993), 123–171

Module 2.2: Dynamical systems, non-local boundary value problems and methods for solving systems of differential equations

Code and Module Title	SMSPDE 7301 Special methods for solving systems of partial differential equations
Semester(s) in which the module is taught	1
Responsible Instructor(s)	Bekbauova A.U.
Language of Instruction	Kazakh
Curriculum Link (cycle, component)	Profile (Elective Component)
Credit Points (total for the module)	4 ECTS
Workload (including contact hours, independent study hours)	Total workload: 120 hours. Lectures: 20 hours, practical exercises: 20 hours, student independent work: 80 hours.
Teaching Methods	Traditional, active and interactive methods
Required and Recommended Prerequisites	First-order partial differential equations and their applications; Non-classical equations of mathematical physics and their applications
Module Objectives / Expected Learning Outcomes	The objective of the discipline "Special Methods for Solving Systems of Partial Differential Equations" is to provide doctoral students with advanced theoretical knowledge and practical skills in applying specialized analytical and numerical methods to solve complex PDE systems, fostering the ability to conduct independent research and develop effective approaches for mathematical modeling of real-world processes. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3. plan, to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 4. To apply methods of theoretical and applied scientific research in the field of systems of partial differential equations for the study of systems in the directions of a vector field, boundary value problems for hyperbolic equations with nonlocal conditions, multiperiodic and almost periodic solutions of applied problems for parabolic equations.

Content	The course covers special methods, normal series, construction of irregular solutions, classification of systems of differential equations using rank and anti-rank, and finding finite solutions for the Ains system with irregular singularity.
Examination Forms	Written (ticket-based)
Learning and Examination Requirements	Study of materials provided on the UNIVER platform and timely completion of assignments according to the course and independent study schedule
Literature	1. Gantmakher F.R. *Matrix Theory*. Moscow: Fizmatlit, 2015. 560 p. 2. Ospanov Q.N. *Singular Differential Equations*. Textbook. – Almaty: Evero Publishing, 2020. – 72 p. Rmeb 3. Assanova A.T., Zholamankyzy A., *On a family of two-point boundary value problems for loaded differential equations*, Izv. Vuzov. Mat., 2021, No. 9, 13–24 4. Oleynik O.A. *Lectures on Partial Differential Equations*, Moscow: BINOM, 2016. – 260 p. 5. Omarov T.E., Shayakhmetova B.K. *Partial Differential Equations: Textbook*. – Almaty: Evero Publishing, 2016. – 188 p. (elib.kz) 6. Sagyndykov B.Zh. *Equations of Mathematical Physics*. 2014. Rmeb. 7. Abdikalikova G.A., Assanova A.T., Shekerbekova Sh.T. *Nonlocal Problem for Fourth-Order Loaded Hyperbolic Equations* // Russ Math. 66, 1–18 (2022). https://doi.org/10.3103/S1066369X22080011, https://link.springer.com/article/10.3103/S1066369X22080011

Code and Module Title	DS 7302 Dynamical systems (in English)
Semester(s) in which the module is taught	2
Responsible Instructor(s)	Akhmet M.U.
Language of Instruction	English
Curriculum Link (cycle, component)	Profile (Elective Component)
Teaching Methods	Traditional, active and interactive learning methods
Workload (including contact hours, independent study hours)	Total workload: 150 hours. Lectures: 15 hours, practical exercises: 30 hours, student independent work: 105 hours.
Credit Points (total for the module)	5 ECTS
Required and Recommended Prerequisites	Mathematical analysis on manifolds and stochastic analysis, differential equations, mathematical physics and numerical methods for their solution
Module Objectives / Expected Learning Outcomes	The objective of the discipline "Dynamical Systems" is to develop doctoral students' understanding of the fundamental concepts, qualitative methods, and advanced approaches in the theory of dynamical systems, enabling them to analyze stability, bifurcations, and long-term behavior of complex processes, and to apply this knowledge in scientific research and mathematical modeling. 1. To demonstrate deep and comprehensive knowledge of fundamental branches of mathematics, including the theory of Sobolev space, noncommutative analysis of operators, stochastic analysis, the theory of reducibility of systems of differential equations, the theory of dynamical systems; to apply research methods in solving current problems in the field of modern mathematics; 2. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 3. To build and evaluate phase portraits of dynamic systems, to distinguish between deterministic chaos and nondeterministic systems; to solve problems of

	qualitative research of a dynamic system.
Content	Linear and nonlinear, continuous and discrete dynamical systems. Phase space, phase trajectories, singular points. Qualitative analysis of dynamical systems: stable and unstable equilibrium states, structural stability, bifurcations. Limit cycles, fixed points of integrable maps. Nonlocal bifurcations. Deterministic chaos.
Examination Forms	Traditional (ticket-based)
Learning and Examination Requirements	Study of materials provided via the UNIVER platform, active participation in lectures and seminars, timely completion and submission of assignments according to the schedule
Literature	1. Arnold V.I. *Ordinary Differential Equations*. — Moscow: Nauka, 1984. 2. Anosov D.V. *Dynamical Systems*. — In: Advances in Science and Technology. Series: Current Problems in Mathematics. Fundamental Directions, 1985. 3. Katok A.B., Hasselblatt B. *Introduction to the Modern Theory of Dynamical Systems*. — Moscow: Factorial, 1999. 4. Shilnikov L.P., Shilnikov A.L., Turaev D.V. *Methods of the Qualitative Theory in Nonlinear Dynamics*. — Moscow–Izhevsk: Regular and Chaotic Dynamics, 2009. 5. Malinetsky G.G., Potapov A.B. *Modern Problems in Nonlinear Dynamics*. — Moscow: URSS, 2002.

Code and Title of the Module	NBVPPDE 7303 Nonlocal Boundary Value Problems for Partial Differential Equations (in English)
Semester(s) in which the module is taught	2
Module Coordinator	Abdikalikova G.A.
Language of Instruction	Kazakh
Relation to Curriculum (cycle, component)	Specialized (elective component)
Teaching Methods	Traditional. Active and interactive teaching methods
Workload (incl. contact hours, self-study hours)	Total workload: 150 hours. Lectures: 15 hours, practical exercises: 30 hours, student independent work: 105 hours.
Credits (total for the module)	5 ECTS
Required and Recommended Prerequisites	For successful course completion, knowledge of the course " Nonlocal Boundary Value Problems for Partial Differential Equations " is required.
Module Objectives / Intended Learning Outcomes	The objective of the discipline "Nonlocal Boundary Value Problems for Partial Differential Equations" is to equip doctoral students with deep theoretical knowledge and research skills for analyzing nonlocal boundary conditions, investigating existence, uniqueness, and qualitative properties of solutions, and applying modern mathematical methods to complex models with long-range interactions and global constraints. 1. To demonstrate deep and comprehensive knowledge of fundamental branches of mathematics, including the theory of Sobolev space, noncommutative analysis of operators, stochastic analysis, the theory of reducibility of systems of

	differential equations, the theory of dynamical systems; to apply research methods in solving current problems in the field of modern mathematics; 2. To plan, to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 3. To apply methods of theoretical and applied scientific research in the field of systems of partial differential equations for the study of systems in the directions of a vector field, boundary value problems for hyperbolic equations with nonlocal conditions, multiperiodic and almost periodic solutions of applied problems for parabolic equations.
Content	Nonlocal boundary value problems for PDEs extend the classical theory by incorporating integral and functional dependencies into boundary conditions. Their study not only enriches the mathematical foundations of PDEs but also provides powerful tools for modeling real-world processes with long-range interactions and global constraints.
Examination Forms	Essay
Learning and Examination Requirements	Study materials provided via the UNIVER/Platonus platform. Active participation in lectures and seminars, completion of assignments, and submission according to the course schedule are required for each module.
Literature	1. Demidovich B.P. Lectures on the Mathematical Theory of Stability. Moscow, 1967. 469 p. 2. Filippov A.F. Problem Book on Differential Equations. Izhevsk: Research Center "Regular and Chaotic Dynamics", 2000. 176 p. 3. Levitan B.M., Zhikov V.V. Almost Periodic Functions and Differential Equations. Moscow, 1978. 205 p. 4. Pankov A.A. Bounded and Almost Periodic Solutions of Nonlinear Differential-Operator Equations. Kyiv, 1985. 182 p. 5. Umbetzhanov D.U. Almost Multiperiodic Solutions of Partial Differential Equations. Alma-Ata, 1979. 212 p. 6. Umbetzhanov D.U. Almost Periodic Solutions of Evolution Equations. Almaty, 1990. 184 p.

Module Code and Title	DSRW Doctoral student's research work, including the completion of a doctoral thesis
Semester(s) the Module is Taught	2
Module Coordinator	Zhubanysheva A.Zh.
Language of Instruction	Kazakh
Curriculum Relevance (Cycle, Component)	-
Teaching Methods	Uses results and methods from harmonic analysis, approximation theory, embedding theory, real analysis, and numerical methods software
Workload (incl. contact hours and independent study)	Total workload: 300 hours
Credit Points (Total for Module)	10 ECTS

Required and Recommended Prerequisites	Knowledge of scientific methodology (hypotheses, experiments, data analysis); proficiency in research methods in the selected field (theoretical, experimental, computational)
Module Objectives / Intended Learning Outcomes	The objective of the discipline "Doctoral Student's Research Work, Including the Completion of a Doctoral Thesis" is to strengthen doctoral students' capacity for independent research, enhance their analytical and methodological skills, and ensure steady progress in developing, structuring, and advancing their doctoral dissertation toward successful completion 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3.To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 4. , to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 5. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies.
Content	Ulyanov, Nikolsky, and Nikolsky–Besov function classes (equivalent definitions, relationships, embedding theorems). Construction of test functions belonging to these classes. Order estimates of approximation errors for exact and inexact data represented via trigonometric Fourier coefficients (constructing functions providing lower estimates; constructing optimal computational aggregates from exact and inexact information confirming the lower bounds). Definition of bounds for inexact data — the limiting errors that preserve the order of approximation for exact data. Determining the magnitude of limiting errors. Implementation of numerical experiments.
Examination Forms	Report
Learning and Examination Requirements	https://zhubanov.edu.kz/media/uploads/tkuanyshev/2024/10/18/24-ru-1.pdf
Literature	1. Zhubanysheva A.Zh., Temirgaliev N. Informative Power of Trigonometric Fourier Coefficients and Their Limiting Error in the Discretization of the Differentiation Operator on Multidimensional Sobolev Classes, ZhVMiMF 55(9), 1474–1485 (2015) 2. Kolmogorov A.N. "Über die beste Annäherung von Funktionen einer gegebenen Funktionenklasse" (On the Best Approximation of Functions of a Given Function Class), Ann. Math. 37(1), 107–110 (1936) 3. Stechkin S.B. On the Best Approximation of Given Function Classes by Any Polynomials, Usp. Mat. Nauk 9(1), 133–134 (1954) 4. Osipenko K.Yu. Best Approximation of Analytic Functions from Values at a Finite Number of Points, Mat. Zametki 19(1), 29–40 (1976) 5. Heinrich S. Random Approximation in Numerical Analysis, in: K.D. Bierstedt, A. Pietsch, W.M. Ruess, D. Vogt (Eds.), Functional Analysis (Marcel Dekker, New York, 1993), 123–171

Module 3. Scientific and practical

Module Code and Title	PP Pedagogical practice
Semester(s) in which the module is delivered	2

Module Leader	Nugayeva Z.T.
Language of Instruction	Kazakh
Curriculum Link (Cycle, Component)	Basic
Teaching Methods	Innovative teaching methods
Workload (including contact hours and independent study)	Total workload: 300 hours
Credits (Total for the Module)	10 ECTS
Prerequisites	General education organizations; organizations of technical and vocational education
Module Goals / Intended Learning Outcomes	The objective of the pedagogical practice is to develop doctoral students' professional teaching competencies, including lesson planning, delivering lectures and seminars, applying innovative pedagogical methods, and assessing students' knowledge, while fostering communication, leadership, and reflective skills essential for effective academic and educational activity. 1. To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 2. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies.
Content	The practice includes: - Acquisition of empirical knowledge in teaching specialization subjects; - Development of practical teaching skills at universities (colleges, technical schools, vocational institutions); - Familiarization with core aspects of a teacher's work in the mentioned institutions, including types and rules for handling reporting documentation; - Familiarization with the state standard, program, and content of the chosen subject; - Familiarization with the organization and delivery of all forms of instruction in a particular educational institution; - Independent preparation of lesson plans and outlines; - Selection and analysis of primary and supplementary literature according to the topic and objectives of planned lessons; - Development of instructional material content at a modern scientific and methodological level; - Methodologically sound conduct of various types of instructional sessions (lectures, practical sessions, guided self-study); - Conducting scientific and methodological analysis of taught lessons; - Strengthening skills of independent work and self-education.
Examination Format	Report
Learning and Examination Requirements	https://zhubanov.edu.kz/ru/education/category/18/

Literature	1. Alpysov A.K. Methods of Teaching Mathematics. Textbook. – Pavlodar, 2012. 2. Abylkasymova A.E. The Modern Lesson. – Almaty, 2004. 3. Abylkasymova A.E., Kenesh A.S. Fundamentals of Methodological Training for Future Teachers. – Almaty, 2004. 4. Laboratory and Practical Work on Methods of Teaching Mathematics: Teaching Aid for Students of Physics and Mathematics Specialties of Pedagogical Institutes / E.I. Lyashchenko, K.B. Zobkova, T.F. Kirichenko et al.; Ed. by E.I. Lyashchenko. – Moscow: Prosveshchenie, 1988. – 223 p.: ill. 5. Sadykov T.S., Abylkasymova A.E. Didactic Foundations of Higher Education. Textbook. – Almaty, "Gylym" Publishing Center, 2003. 6. Sadykov A.T., Abylkasymova A.E. Methodology of 12-Year Education. – Almaty, 2005. 7. Serikbayeva V.E. Interdisciplinary Connections in Mathematics: Methodical Guide. – Almaty, 2007. – 199 p. 8. Methods of Teaching Mathematics in Secondary School: Special Methods: Textbook for Students of Pedagogical Institutes, Physics and Mathematics Specialties / A.Ya. Blokh, A.A. Gusev, G.V. Dorofeev et al.; Compiled by V.I. Mishin. – Moscow: Prosveshchenie, 1987. – 416 p. 9. Methodology and Technology of Teaching Mathematics, Lecture Course: Manual for Universities / Edited by N.L. Stefanova, N.S. Podkhodova. – Moscow: Drofa, 2005. – 416 p.

Module Code and Title	RP Research practice
Semester(s) in which the module is taught	4
Person Responsible for the Module	Zhubanysheva A.Zh.
Language of Instruction	Kazakh
Relation to the Curriculum (Cycle, Component)	Profile
Teaching Methods	Results and methods of harmonic analysis, approximation theory, embedding theory, real analysis, and software for numerical methods are used.
Workload (incl. contact hours, independent study hours)	Total workload: 300 hours.
Credits (total for the module)	10 ECTS
Required and Recommended Prerequisites for Joining the Module	Research Methodology, Academic Writing

Module Objectives / Intended Learning Outcomes	The objective of the research practice is to strengthen doctoral students' research competencies through active involvement in scientific projects, literature analysis, problem formulation, and application of modern research methods, ensuring systematic progress toward high-quality publications and the successful completion of the doctoral dissertation. 1. To plan, coordinate, implement, and forecast research outcomes; critically analyze, evaluate, and compare various scientific theories and ideas; 2. To generate one's own new scientific ideas, synthesize the results of scientific research and analytical work in the form of a doctoral dissertation; be competent in conducting scientific projects and research in the professional field; 3. To formulate and solve current scientific and practical problems in mathematics, organize and conduct research and experimental-research activities in the selected field; 4. To plan and forecast one's further professional development; possess skills for acquiring new knowledge in the specialized field and in the theory and methodology of professional education; 5. To use modern methods of data analysis, demonstrating skills in searching, collecting, processing, storing, and transmitting scientific information using modern informational and innovative technologies;
Content	Research Practice provides doctoral students with the opportunity to gain practical experience in conducting scientific investigations. The course focuses on developing research skills, methodology, and academic writing. Students engage in analyzing current literature, formulating research problems, and applying appropriate methods to obtain results. Emphasis is placed on independence, critical thinking, and preparing materials for publications and dissertation work.
Examination Forms	Report
Learning and Examination Requirements	https://zhubanov.edu.kz/ru/education/category/54/
Reading List	1. Magaril-Ilyaev G.G., Osipenko K.Yu., Sivkova E.O. Optimal recovery of pipe temperature from inaccurate measurements, *Trudy MIAN*, 312, 216–223, 2021. 2. Traub J. F., Wasilkowski G. W., Wozniakowski H. *Information, Uncertainty, Complexity*, Addison-Wesley Publ., Reading, MA, 1983. 3. Tikhonov A.N., Samarskii A.A. *Equations of Mathematical Physics*, Moscow: Nauka, 2004. 798 p. 4. Korobov N.M. *Number-Theoretic Methods in Approximate Analysis*. 2nd ed. Moscow: MCNMO, 2004. 5. Bailov E.A., Temirgaliev N. Discretization of the solutions to Poisson's equation, *Computational Mathematics and Mathematical Physics*, 46(9), 1515–1525 (2006). 6. Bailov E.A. *Approximative Integration and Restoration of the Functions from Anisotropic Classes and Restoration of the Solutions of the Poisson Equation* (Candidate's Dissertation). Almaty, 1998. 7. Kudaibergenov S.S., Sabitova S.G. Discretization of Solutions to Poisson's Equation in the Korobov Class, *Computational Mathematics and Mathematical Physics*, 57(3), 896–907 (2013). 8. Tashatov N.N. *Approximate Recovery of Functions and Solutions of the Poisson Equation with Initial Condition from Anisotropic Classes E and SW* (Candidate's Dissertation). Karaganda, 2002. 9. Utesov A.B. On Error Estimates for Discretization Operators for the Solution of the Poisson Equation, *Differential Equations*, 60(1), 136–143 (2024). 10. Vybiral J. Sampling numbers and function spaces, *Journal of Complexity*, 23, 773–792 (2007).

Module Code and Title	DSRW Doctoral student's research work, including the completion of a doctoral thesis
Semester(s) in which the module is taught	3, 4, 5, 6
Module Coordinator	Zhubanysheva A.Zh.
Language of Instruction	Kazakh
Relation to Curriculum (cycle, component)	–
Teaching Methods	Results and methods of harmonic analysis, approximation theory, embedding theory, real analysis, and numerical methods software are used.
Workload (including contact hours and self-study hours)	Total workload: 450 hours.
Credit Points (total for the module)	30, 20, 30, 18 ECTS
Required and Recommended Prerequisites for Joining the Module	Knowledge of the basics of scientific methodology (hypotheses, experiments, data analysis); proficiency in research methods in the chosen field (theoretical, experimental, computational).
Module Objectives / Expected Learning Outcomes	The objective of the Doctoral Student's Research Work, Including the Completion of a Doctoral Thesis is to develop doctoral students' ability to conduct independent and original scientific research, deepen expertise in their chosen field, and ensure consistent advancement toward writing, structuring, and successfully defending the doctoral dissertation. 1. To be able to plan and predict the further professional development; to have skills of acquisition of new knowledge in special area, in the field of the theory and a methodology of professional education; 2. To generate own new scientific ideas, to synthesize the results of research and analytical work in the form of a doctoral dissertation, be competent in carrying out scientific projects and research in the professional field; 3.To be able to formulate and solve modern scientific and practical problems in mathematics, to organize and conduct research, experimental research activities in the chosen direction; 4. , to coordinate, to implement and to predict research results, to critically analyze, to evaluate and to compare various scientific theories and ideas; 5. To use modern methods of data analysis, demonstrating the skills of searching, collecting, processing, storing and transmitting scientific information using modern information and innovative technologies.
Content	Doctoral Student's Research Work, Including the Completion of a Doctoral Thesis provides an opportunity for doctoral candidates to conduct independent scientific research under the guidance of a supervisor. The course involves identifying relevant problems, conducting literature reviews, applying modern research methodologies, and obtaining original results in the chosen field of study. Special attention is given to the development of academic writing, preparation of scientific articles for peer-reviewed journals, and participation in conferences. The discipline also ensures systematic progress toward structuring, writing, and finalizing the doctoral dissertation, fostering critical thinking, creativity, and the ability to make an original contribution to science.
Examination Forms	Report
Requirements for Learning and Examination	https://zhubanov.edu.kz/media/uploads/tkuanyshev/2024/10/18/24-ru-1.pdf
Literature	1. Zhubanysheva A.Zh., Temirgaliev N. Informative power of trigonometric

	Fourier coefficients and their ultimate error under discretization of the differentiation operator on multidimensional Sobolev classes, ZhVMiMF 55(9), 1474–1485 (2015). 2. Kolmogorov A.N. "Über die beste Annäherung von Funktionen einer gegebenen Funktionenklasse", Ann. Math. 37(1), 107–110 (1936). 3. Stechkin S.B. On the best approximation of given classes of functions by arbitrary polynomials, UMN 9 (1), 133–134 (1954). 4. Osipenko K.Yu. Best approximation of analytic functions based on their values at a finite number of points, Mat. Zametki 19(1), 29–40 (1976). 5. Heinrich S. Random approximation in numerical analysis, in: K.D. Bierstedt, A. Pietsch, W.M. Ruess, D. Vogt (Eds.), Functional Analysis (Marcel Dekker, New York, 1993), 123–171.

Considered and approved at the department meeting.
date _____ 2022 protocol No. ___

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(Full name) (signature) (date)