**AL-FARABI KAZAKH NATIONAL UNIVERSITY**

**Project**

# EDUCATIONAL PROGRAM

# MATHEMATICS

Specialty 5B060100–Mathematics

Almaty, 2017

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Project

# EDUCATIONAL PROGRAM

# MATHEMATICS

Specialty 5B060100 – Mathematics

Almaty, 2017

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**Employers:**

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"Republican Physics and Mathematics School", non-profit SC – The Chairman of the Board E.Baekov;
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# PASSPORT
# OF EDUCATIONAL PROGRAM IN ENGLISH

# “MATHEMATICS”

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| **Speciality** | 5B060100 – Mathematics |
| **The level of the International standard classification of education (LISC 2011)** | 6 – bachelor |
| **Purpose of program** | The aim of the educational program is the formation of knowledge and competencies needed to provide students with the fundamental knowledge of mathematics to study the new quantitative relations and spatial forms of the real world in accordance with the requirements of technology and natural science.<br>The program focuses on providing students with systematic knowledge of the basic course of mathematics, along with the knowledge of the elective areas, based on the latest achievements of science. |
| **Professional activities** | Mathematics teacher, engineer, technician.<br>Graduates of bachelor can work in research institutes, in government or private educational institutions, in area of communication and banks, actuarial activities.<br>Bachelor graduates can continue their education at the graduate level in this profession or professions related to this one. They can also continue to research activities in economy, where they will directly apply their knowledge. |
| **The types of economic activities NCEA in which this profession is in demand** | 72 Research and development<br>72.1 Research and experimental development on natural sciences and engineering<br>72.19.0 Other research and experimental development on natural sciences and engineering<br>70.22.0 Advice on business and management<br>85 Education<br>85.3 Secondary education (the second and the third stages)<br>85.31.0 Primary and General secondary education<br>85.32 Technical and vocational secondary education<br>85.32.1 Technical and vocational education<br>85.32.2 Specialized Secondary Education<br>85.59 Other education which is not included in |

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| | other categories<br>85.59.1 Activities of evening schools<br>85.59.9 Another education not including other categories<br>85.60.0 Educational support activities |

**Specialist competences** (CC refers to cultural competence, PC refers to professional competence)

| Competency code | Description of competence |
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| CC-1 | Knowledge of basic stages of recent history of progressive development of Kazakhstan, in the context of the World and Eurasian historical process; |
| CC-2 | ability to interpret and creatively use scientific-historical and philosophical knowledge to summarize the success factors of Kazakhstan's model of development on the way to held the country– the Republic of Kazakhstan; |
| CC-3 | communication skills (readiness for effective oral and written communication in the course of their professional activities, including, if it is necessary, a foreign language); |
| CC-4 | knowledge of the social and ethical values based on social, legal norms and tolerance to different cultural and religious traditions in the context of the Constitution of the Republic of Kazakhstan and human rights in general; |
| CC-5 | knowledge of the basic laws of functioning and development of nature and society, the ability to properly navigate the various social, financial, political situations and related emergencies; |
| CC-6 | ability to perceive, analyze, compile information, sett goals and choose the ways of achieving them; |
| CC-7 | willingness to cooperate with colleagues, work in a team; |
| CC-8 | use of information and communication technologies in their professional activity; |
| CC-9 | searching for the necessary information for the effective performance of professional tasks; |
| CC-10 | ability to implement lifelong learning strategies; |
| PC-1 | knowledge of the basic concepts of fundamental mathematical courses and ability to identify their correlations; |
| PC-2 | knowledge of the basic concepts and ability to apply a deep understanding of basic mathematics (limit, continuity, derivative and integral); |
| PC-3 | ability to recognize mathematics-related problems, assess their solvability and solve them within a specified time frame; |
| PC-4 | ability to interpret and master practical skills to work with the basic algebraic structures such as groups, rings, fields, which have applications in various branches of modern science and technology; |
| PC-5 | ability to formulate mathematical hypotheses and have an understanding of how such hypotheses can be verified or falsified using mathematical methods; |

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| PC-6 | ability to analyze and formulate the structure of algorithms, knowledge of structural and modular programming methods, basic data structures and methods of processing and implementation; |
| PC-7 | ability to flexibly apply mathematical methods of fundamental areas of mathematics and transfer the findings to other areas of applications; |
| PC-8 | knowledge of the basic properties of the concept of limit, continuity of functions of several variables; ability to apply the techniques of differentiation and integration of functions of several variables to calculate partial derivatives and their applications; the concept of line integrals; |
| PC-9 | ability to understand the concept and theory of normed linear spaces, metric spaces, Banach spaces, theory of inner product spaces and Hilbert spaces, theory of continuity and bounded linear operators, spectral properties; to apply the theory to solve mathematical problems; |
| PC-10 | ability to abstract and recognize analogues and basic patterns; |
| PC-11 | ability to independently solve the problem of complex variable; develop the skills of using complex analysis techniques in the solution of physical problems; |
| PC-12 | Ability to solve practical problems, apply abstract concept and theorems of functional analysis. |
| PC-13 | ability to analyze in a conceptual, analytical and logical manner; |
| PC-14 | ability to analyze and interpret finance, accounting and other information contained in the reports of enterprises of different ownership forms, organizations, agencies, etc.; |
| PC-15 | ability to create mathematical models of mathematical problems as well as for problems in other areas of science or everyday life, and select problem solving strategies at their disposal; |
| PC-16 | ability to analyze and find methods for effective solutions to the problems of computational mathematics; |
| PC-17 | ability to use basic methods of computer simulation, mathematical software and programming to solve mathematical problems; |
| PC-18 | ability to apply mathematical programming methods for solving optimization problems in the analysis and production planning; |
| PC-19 | ability to analyze and apply the methods of approximate solution of extreme problems; |
| PC -20 | ability to recognize, formulate, classify and solve problem from other areas in a mathematical context; |
| PC -21 | knowledge of the theory of generalized functions and ability to construct fundamental solutions of equations of mathematical physics; |
| PC-22 | ability to solve more extensive mathematical problems (generally |

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| | to be considered within the framework of a Bachelor's thesis); |
| PC-23 | knowledge of theoretical bases and methods of the stochastic differential equations and ability to solve related theoretical and practical problems; developing skills to study the spectral theory of linear operators. |

**Correlation of the expected learning outcomes with the components of the educational program in the competence formation**

| The cipher of competence | Expected results | Components of the educational program |
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| | **1.State Compulsory Module** | |
| CC-1.<br>CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-8.<br>CC-9.<br>CC-10. | Modern history of Kazakhstan, Philosophy, Foreign Language, Kazakh (Russian) Language<br><br>Knowledge. The students will know:<br>The modern history of the Republic of Kazakhstan; leading trends, key facts, events and processes in Kazakhstan throughout its history; higher value-ideological norms and attitudes of selected experiences of historical development, ownership of cultural tradition, society and its people.<br>The basic stages of the recent history of progressive development of statehood of Kazakhstan in the context of the world and Eurasian history.The ability to interpret and creatively use a scientific-historical and philosophical knowledge to summarize the success factors of Kazakhstan's model of development on the way to hold the state the Republic of Kazakhstan.<br>Competent use of language, linguistic and cultural knowledge to solve the problems of communication in multilingual and multicultural society of the Republic of Kazakhstan and in the international arena.<br>Skills:In modern conditions, implementing the study of the history of the state and law, based on research experience and knowledge in order to recreate an objective picture of state's history and the law of the country;<br>As a result of the study of philophophy, the student must know the main directions, problems, theories and methods of philosophy, the content of contemporary philosophical discussions on problems of social development. Must be able to form and reasonably defend one's own position on various problems of philosophy; use the provisions and categories for evaluating and analyzing various social trends, facts and phenomena<br>To be able to express their thoughts and to speak in a foreign language, respectively, speak language standards, ask questions and answer them, hold a conversation in a foreign language in the volume of the studied subjects, using adequate communication cues to convey the contents read and heard.<br>To develop and keep their own scientific positions; to resolve the theoretical and methodological issues in the branch of science. | **1.1 GENERAL EDUCATION**<br><br>**Obligatory Component**<br><br>**(18 credits)** |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7. | Culture of Speech and LanguageCommunication, Psychology of interpersonal communication, Theoretical and Applied Political Science, General and Applied Sociology, Ecology and Sustainable Development, Human Life Safety, Spiritual Revival and the Formation of Historical Consciousness, Kazakhstan's law, Fundamentals of Economics, Al-Farabi and modernity, Culture and religion, Methods of teaching mathematics, the history of mathematics.<br>Knowledge (Culture of Speech and LanguageCommunication): to create a social system where everyone will have maximally available situations of experiencing success and where the success of individuals and groups will directly contribute to the | **1.2 GENERAL EDUCATION**<br><br>**Elective** |

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| CC-8.<br>CC-10. | common good.<br>Knowledge (Psychology of interpersonal communication): analysis of interpersonal communication is an analysis of the conditions under with means of presentation, ideas, knowledge, mood, i.e. Subjective experience of one subject can be moved and more or less accurately interpreted by another. The task of the study thus becomes the identification and description of various prerequisites and conditions for successful (or, alternatively, unsuccessful, difficult) communication.<br>Knowledge (Theoretical and Applied Political Science): analysis of the political situation of private political problems developing in the society at the given moment, contribution to the constructive solution of actual practical tasks of the political life of the society, developing and offering practical advice and recommendations to participants in political events in resolving current political problems and conflicts.<br>Scientific analysis and development of practical recommendations are carried out by applied political science in the spheres: regulation of political conflicts and achievement of the necessary social consensus (consent); organization and conduct of election campaigns; forming public opinion and using the media.<br>Knowledge (Culture and religion): choosing the area for research that you prefer, from the rituals of African tribes to the problems of modern society. Everything depends on your personal preferences, if one condition is met then the religion should be the main subject of your interest.<br>Knowledge (General and Applied Sociology): Global problems of social life and universal values. Theories of the middle level (the sociology of communications, the sociology of education, the sociology of youth, economic sociology, the sociology of religion, etc.). Social conflicts and the logic of their resolution. Methodology and methods of sociological research. Ability to develop programs for sociological research. Methods of collecting sociological information. Analysis and technique of processing empirical sociological research.<br>Knowledge (Human Life Safety):protection of human and habitat from harmful and dangerous factors of natural and technogenic origin. Classification of emergencies of various types. Stability of functioning of objects of economy in emergencies. Possession of basic principles and methods of protecting the population in emergencies of civil and military time. Provision of first aid in emergencies. Organization of measures for evacuation of the population. Protection against weapons of mass destruction. Organizational and practical security measures for earthquakes. Protection of the population in natural disasters, fires, accidents and explosions at production facilities. Ability to use the basics of organizing and conducting rescue operations. Emergencies of a social nature. Psychological aspects of emergencies.<br>Knowledge (Ecology and Sustainable Development): concepts of biocenosis, biogeocenosis, ecosystem. Types of terrestrial and aquatic ecosystems. The doctrine of the biosphere and the noosphere. Living matter of the biosphere and its functions. Ability to use natural resources and rational nature management. Protection of nature and environmental problems of our time. Problems of eco-development.<br>Knowledge (Kazakhstan law): the basic financial rights of the Republic of Kazakhstan. Fundamentals of the tax law of the Republic of Kazakhstan. Fundamentals of the labor law of the Republic of Kazakhstan. Fundamentals of Criminal Law of the | **Course**<br><br>**(4 credits)** |

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| | Republic of Kazakhstan. Fundamentals of environmental law of the Republic of Kazakhstan. Ability to own the basic land rights of the Republic of Kazakhstan. The basis of criminal procedural and civil-procedural rights. Fundamental international rights.<br>Knowledge (Fundamentals of Economics): the laws of the formation of the market and the specifics of their formation in the post-socialist countries; Basic categories and market laws, the principles of individual reproduction; Specificity of cost formation and their types; Features of the market of factors of production, their prices and incomes. Ability to use the interrelation of economic problems at the micro and macro level, the basic laws of functioning.<br>Knowledge (Methods of teaching mathematics, the history of mathematics): Methods of teaching higher education mathematics. Modern approaches of the content of mathematical education. | |
| **2. Vocational Modules** | | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-8.<br>CC-9.<br>CC-10.<br>PC-1.<br>PC-13. | Professionally-oriented Kazakh (Russian) Language<br>Knowledge:Modern vocabulary and terminology in Kazakh (Russian) Language for technology and project management methodology, project management processes, modern software project management.<br>Skill:applying organizational project management tools to determine the hierarchical structure of the project works, using formal methods of evaluating the time and resources of the project objectives, to determine the amount and sources of funding, to plan and to consider the risks.<br>Professional-oriented Foreign Language<br>Knowledge:modern vocabulary and terminology in English for technology and project management methodology, project management processes, modern software project management.<br>Skill:applying organizational project management tools to determine the hierarchical structure of the project works, using formal methods of evaluating the time and resources of the project objectives, to determine the amount and sources of funding, to plan and to consider the risks.<br>Knowledge: Modern vocabulary and terminology in English for technology and project management methodology, project management processes, modern software project management. | **2.1BASIC DISCIPLINES**<br><br>**Compulsory Component**<br><br>**(24 credits)** |
| CC-4.<br>CC-6.<br>CC-7.<br>CC-8.<br>CC-9.<br>CC-10.<br>PC-4.<br>PC-7. | Information and communication technologies<br>Knowledge: The most common applications of ICT. The UNIX-like operating system. The basic concepts of the Internet and World Wide Web; telecommunications media and hardware devices. The database system and the data management. The digital security issue. The purpose of the information systems investigation and system development. What is the algorithm, how to represent it and why it is important to analyze.<br>Skills: Discuss the types of the computer programming, hardware requirements and software development issues. Use the UNIX-like operating system. Choose the web technologies and create the web page. Develop and analyse the algorithm, write the program. | |

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| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-10.<br>PC-13.<br>PC-16. | Mathematical analysis 1. Mathematical analysis 2.<br>Knowledge*:* By the end of the course, students should know the basic fundamental concepts of mathematical analysis; the theory of sequences, the theory of continuous functions, the limit of functions, the differential and integral calculus of functions of one variable; the theory of numerical and functional series, power seriesexpansionsand prove of basic theorems related to the concepts above;<br>Skills: ability to be able to choose a system of representation and understanding the specifics of scientific knowledge and research methodology within the modern paradigms of mathematical analysis; to be able to solve typical problems (finding the exact forms of numerical sets, investigate convergence of a sequence, investigate the limit of a function at a point, continuity at a point and on a set, finding the derivative of a function); to be able to investigate extremum and continuity of one variable function, to calculate limits of a single variable function and construct its graph; student must know, understand and demonstrate the received knowledge on the basic fundamental concepts of univariate functions and integral calculus of functions of one real variable; to be able to use definite integrals; the theory of numerical and functional series, power series; classify and identify methods of integration of univariate functions;<br>To be able to formulate and prove the main theorems of the course; use different methods of integration and its application;include new knowledge in the context of basic knowledge, interpret its contents; analyze educational situation and offer direction to solve it;<br>To be able to synthesize, interpret and evaluate the learning outcomes of discipline, modules, midterm exam content; analyze dynamics of scientific problems decision of the course (scientific reviews of specific issues researches); make an analysis of learning outcomes of the course, generalize them through scientific essays, presentations, reviews, scientific review, etc.; define criteria and requirements to system and application software;<br>Tobe able to construct educational and social interaction and cooperation in the group; propose to consider a problem, reason by its importance; accept criticism, work in a team;<br>To be able to recognize the role of course in the implementation of individual learning paths; to identify areas for further personal and professional development. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-3.<br>PC-4. | Linear algebra. Analytical geometry.<br>Knowledge. Student should know: vector space theory; theory of spaces with inner products; the basic facts of theory of linear transformations (operators)and theory of quadratic forms.<br>Student should know elements of vector algebra and the coordinate method, all forms and equations of geometrical objects of the first and second order.<br>Skills: to recognize vector spaces among other structures, to examine the linear independence of a system of vectors, to find a base of a subspace and to compute the vector coordinates; to apply the Gram–Schmidt orthogonalizationprocess; to construct a matrix representation of a linear operator, to find their eigenvalues and eigenvectors; for the main classes of normal operators, to build ortho-normal bases consisting of eigenvectors; to transform quadratic forms to canonical forms by means of various | |

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| PC-5.<br>PC-10.<br>PC-13.<br>PC-16. | methods; to construct rigorous mathematical proofs of simple propositions.<br>To know the geometrical meanings of linear dependence and independence of vectors, to recognize affine and Cartesian coordinate systems, and to present polar, cylindrical and spherical coordinates in terms of Cartesian coordinates; to calculate the vector product of two vectors, the box product of three vectors and to know the geometrical meaning of them; to be able to apply the basic theorems and formulas of analytic geometry to solving problems on straight lines on a plane and in a space and on planes in the space, to derive the equations of a curve and surfaces of the second order.<br>To be able to apply the methods of analytic geometry and linear algebra to solving problems; to systematize own ideas, to logically construct and formalize a solution of a problem; to demonstrate the acquired knowledge and to explain to other students; to work in a team; to develop students' critical thinking and a geometrical interpretation; to recognize the role of the course in the implementation of individual learning paths. | |
| CC-3.<br>CC-4.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-7.<br>PC-8.<br>PC-10.<br>PC-11.<br>PC-13.<br>PC-15.<br>PC -20. | Ordinary Differential Equations<br>Knowledge: Basic concepts of ordinary differential equations (solution, singular solution, general solution, general integral, fundamental system of solutions) and existence and uniqueness theorems for solutions of differential equations and systems of differential equations. Linear differential equations of higher orders and linear systems of differential equations. The structure of their decisions. The concept of stability by Lyapunov. A normal, autonomous, symmetric system of ordinary differential equations and a quasilinear partial differential equation of the first order.<br>Skill: to be able to demonstrate an understanding of the formulation of the theorem and methods for solving problems of ordinary differential equations; the knowledge of methods for solving the simplest ordinary differential equations;<br>To be able to apply basic methods, choose the best method for solving the problem; to evaluate the obtained solutions;<br>To be able to carry out a comparative analysis of the application of methods for solving practical problems; to study the theoretical basis of the obtained result; analysis of the results; summarizing the results of the research and solving the tasks in the form of presentations, reports;<br>To be able to critically evaluate their activities; to work individually and in a team, carry out projects;<br>The ability to solve practical problems using the theory of ordinary differential equations. | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1. | Theory of Probability and Mathematical Statistics, Functional analysis<br>Knowledge:basic concepts and theorems of probability and mathematical statistics; the knowledge gained in the field theory of probability and mathematical statistics, namely, to know and to understand, by solving its specific tasks, that probability theory is concerned with the study of the laws of random phenomena, and mathematical statistics in its studies is based on the results and methods of probability theory; to understand and to distinguish the basic concepts and results of the university course in probability theory and mathematical statistics and their connections;<br>Basic ideas and concepts of functional analysis such as normed spaces; metric spaces; Banach spaces; Hilbert spaces; linear continuous operators and linear continuous functionalsdefined on these spaces; dual (conjugate) spaces; reflexive spaces; | **2.2MAJORS Professional disciplines**<br><br>**Compulsory Component** |

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| PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-23. | distributions (generalized function); generalized derivative; completely continuous (compact) operators; closed operators; adjoint and self-adjoint operators; spectrum of the operator and the resolvent set; spectral theory of compact self-adjoint operators and their applications.<br>The three most important and fundamental theorems in basic functional analysis: the uniform boundedness principle, the open mapping principle and the extension principle for linear functionals (the Hahn-Banach theorem); the general form of linear functionals in Hilbert spaces (Riesz representation theorem) and relations between linear normed, metric and Euclidean spaces, linear bounded and continuous operators.<br><br>Skills: to be able to demonstrate the acquired knowledge and to be able to seek recognition of their academic achievements in their learning environment; to demonstrate an understanding of the overall structure and content of the discipline and the links between its basic concepts and results;<br>To be able to understand and to be able to apply the mathematical foundations of the methods and results that are the researches bases matter of this subject. To be able to analyze the results obtained by various methods and to be able to make the necessary conclusions; analyze the educational situation and suggest the direction of its solution; use methods (research, calculation, analysis, etc.), peculiar to the field of study of the course being studied in individual or group teaching and research activities.<br>To be able to achieve the set goal when considering specific problems (tasks, etc.), highlight the most basic elements of this problem and synthesize methods are relevant to the solution of this problem, choose the most optimal of them and determine the order of their application; Adequately assess the results independently and compare it with the known results; Develop their own criteria for assessing the professional qualities of other students and teachers; Adequately assess their strengths and weaknesses, consider the opinions of other students and faculty (PPP) on their own professional qualities;<br>To be able to generalize, interpret and evaluate the learning outcomes obtained in the context of the discipline, the training module, the content of the midterm exam; To analyze the dynamics of the solution of scientific problems of the course (scientific reviews of research of a specific problem); to make an analysis for the results of the course, summarize them in the form of a scientific essay, presentation, scientific review, etc.;<br>To be able to maintain high standards of intellectual honesty; To build mutual relations with co-learning students in the principles of active assistance of each participant to the qualitative and timely fulfillment of tasks; Objectively evaluate the results of their work and the work of other students; Gratuitously share with the other students the results of their work, jointly analyze these results and, if it is necessary, protect their own results; Getting the right information from other trainees and giving them the necessary information, unselfishly sharing ideas for solving specific problems, jointly modifying ideas in appropriate cases, effectively interacting with the team (in a group).<br>To be able to explain the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts; to provide a mathematical proof of simple statements with strong reasoning skills; | **(8 credits)** |

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| | To be able to include new knowledge in the context of basic lore, interpret its contents; to analyze educational situation and offer a direction to solve it; to use methods (research, calculation, analysis, etc.) inherent to the field of study (linear normed space, metric space, linear operators and functionals, etc.) individually or in a group of educational and research activities; to reveal the similarities and differences between normed and metric spaces; to prove mathematical statements rigorously;<br>To be able to synthesize, interpret and evaluate the learning results in the context of discipline, educational module and midterm exam's content (normed and Banach space, Hilbert space, linear operators and functionals, basic principles of functional analysis, dual space, strong and weak convergence, compact operators, spectrum of a compact operator, adjoin operators, self-adjoint operators, spectrum of self-adjoint operator);<br>To analyze dynamics of scientific problems' solutions of the course (scientific reviews of concrete issue's researches); to make an analysis of learning results of the course, to generalize them through scientific essays, presentations, reviews, scientific review, etc.; to own calculative skills to solve various exercises;<br>To be able to interact and cooperate in the group socially and educationally; to offer a problem for its consideration and to reason its importance; to accept criticism; to work in a team and independently; to recognize the role of the taken course in the implementation of individual learning paths. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-7.<br>PC-8.<br>PC-10.<br>PC-11.<br>PC-13.<br>PC-15.<br>PC -20.<br>PC -21.<br>PC-22. | Multivariable Calculus. Vector Analysis. Complex Analysis<br>Knowledge: the fundamental concepts (functions of several variables, partial derivatives, extremaofmany variable functions, conditional extremum) and methods of multivariate analysis (computation of partial derivatives, finding the extremum and conditional extremum of many variable functions); the fundamental concepts (line integrals, surface integrals, Stokes theorem, Ostrogradsky theorem) and methods of vector analysis (evaluation of line integrals, evaluation of surface integrals and finding the divergence and the curl of the vector field, evaluating flux integrals, using divergence theorem to find flux); techniques of complex analysis; complex integration; Taylor series of a complex variable.<br>Skills: the ability of the system representation and understanding the specifics of scientific knowledge and research methodology within the modern paradigms of mathematical analysis; the student must know, understand and be able to demonstrate the received knowledge on the basic fundamental concepts of functions of several variables (computation of partial derivatives and differentials, research on the local extremum of a function of several variables); be able to use methods of multivariate analysis (computation of partial derivatives, finding extremum of functions of several variables by Sylvester's criterion);classify and identify characteristics of the extremum and conditional extremum of a function of many variables; be able to formulate and prove the main theorems of the course; use different methods of integration proper integrals depending on parameters; to apply uniform convergence of improper integrals depending on a parameter and its application; to decompose the functions by Taylor's formula for functions of several variables; include new knowledge in the context of basic knowledge, interpret its contents; analyze educational situation and offer direction to solve it; the ability of the system representation and understanding the specifics of scientific knowledge and research methodology within the modern paradigms of mathematical analysis; the student must know, understand and be able to demonstrate the obtained knowledge | **2.3. Basic Professional Disciplines Elective Course**<br><br>**(38 credits)** |

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| | on the basic fundamental concepts of functions of several variables (evaluation of line integrals and surface integrals, research on the directional derivative of a function of several variables); be able to use methods of vector analysis (finding flux using divergence theorem, finding the divergence and the curl of the vector field);classify and identify relationship between Green's theorem and Stokes' theorem; be able to synthesize, interpret and evaluate the learning results of discipline, modules, midterm exam content; analyze dynamics of scientific problems decision of the course (scientific reviews of specific issues researches);make an analysis of learning results of the course, generalize them through scientific essays, presentations, reviews, scientific review, etc.; define criteria and requirements to system and application software; formulate and prove the main theorems of the course; use different methods of integration line integrals and surface integrals; to apply the learned material in specific situations; identify problems related to line and surface integrals; include new knowledge in the context of basic knowledge, interpret its contents; analyze educational situation and offer direction to solve it;<br>Being engaged inconstructive educational and social interaction and cooperation in thegroup; be able to to consider a problem to reason its importance; accept criticism, work in a team; recognize the role of course in the implementation of individual learning paths. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-3.<br>PC-4.<br>PC-5.<br>PC-10.<br>PC-13.<br>PC-16.<br>PC-20.<br>PC-22. | Basics of algebra. Discrete mathematics. Mathematical logic. Differential geometry. General topology.<br>Knowledge (Basics of algebra): students should know: elementary properties of groups, rings and fields; basic facts of matrix theory; the Gauss elimination method and the Gauss-Jordan algorithm; the theory of determinants; the theory of linear algebraic equations; basic facts of the theory of polynomials over a field<br>Skill: to be able to perform algebraic calculations in the fields of complex numbers and residues, to solve systems of linear equations; to perform calculations with matrices and determinants, including a calculation of the inverse matrix; to find a base and the rank of a row system; to perform calculations with vectors; to perform operations over polynomials, to find the greatest common divisor and its linear representation.<br>Knowledge (Discrete mathematics):At the end of the course students should know the basic concepts of discrete mathematics and methods of solution of typical problems; be able to formulate and prove the main statements of the course, to solve typical problems, to use the theory for solving problems;<br>Skill: to have skills of solving recurrent equations, diophantine equations, the study of binary relations on the possession of certain properties, to use the mathematical induction and the formula of inclusion-exclusion to find the generating functions of sequences, to study the graph connectivity, Eulerian, guadalest, planarity, self complementarity.<br>Knowledge (Mathematical logic): at the end of the course, students should know the basic concepts of mathematical logic and methods of solving typical problems; to be able to formulate and prove the main statements of mathematical logic, to solve typical problems, to use theory to solve problems.<br>Skill: To construct truth tables, to construct the conjunctive and disjunctive normal forms of formulas, to solve logical equations, to represent formulas in different bases, to investigate logical functions on linearity and monotonicity, to construct derivations of | |

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| | formulas; to know the basic concepts of algebra of predicators, of the propositional calculus and of the predicate calculus;to be able to apply mathematical operations to statements, to research the logic of predicates, and the predicate calculus; to prove the completeness and consistency of the propositional calculus, the independence of the system of axioms of the propositional calculus, to formulate Post's theorem on the completeness of functions of the algebra of logic, and the Levenheim-Skolem theorem.<br>Knowledge (Differential geometry): as a result of studying the module, students should know: the modern approach to definition of the basic concepts of theory of curves and surfaces; the basic theorems and formulas of differential geometry.<br>Skill:be able to apply the methods of differential geometry to solving problems, to compute the length of a curve, the curvature and the torsion of spatial curves, to construct the Frenet frame and the Frenet equations, to know first and second fundamental form of a surface; to know elements of Riemannian geometry, covariant differentation, the geodesic curvature of curve on a surface, to develop a figurative thinking and a geometrical intuition.<br>Knowledge (General topology): as a result of studying the module, students should know basic set-theoretic definitions and constructions used in topology, the fundamental concepts in point-set topology, continuity, compactness, and connectedness.<br>Skills: as the result of studying the module, students should know definitions of the basic concepts of topology, the basic theorems, to establish the foundational aspects of topology and to investigate properties of topological spaces; to build a topological structure, to explore its properties, to define and distinguish open and closed sets, compact and connected sets, metric spaces; be able to compare cardinalities, to formulate the Bernstein theorem; to define countable sets, the countability of a product of countable sets, the countability of the set of algebraic numbers, countability axioms, continuous maps, homeomorphisms. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-3.<br>PC-7.<br>PC-8.<br>PC-10.<br>PC-11.<br>PC-13.<br>PC-16. | Variation calculus and Methods of optimization, Partial Differential Equations<br>The aim of the course: to form a system of competences in the context of qualification requirements: be able to demonstrate acquired knowledge (convex programming, nonlinear programming, linear programming, dynamical programming) and it’s understanding; to demonstrate an understanding of the overall structure of the study's field and the relations between its elements (some formalization methods and reduce formulated production tasks to the extreme problems, etc.); to classify and to identify characteristics of optimization methods; discuss choice of the famous methods for finding optimal solutions and application;<br>be able to include new knowledge in the context of basic knowledge, interpret its contents; analyze educational situation and offer direction to solve it; use methods (convex programming, nonlinear programming, linear programming, dynamical programming, etc.) inherent to the field of study (Unconditional extreme, Conditional extreme, Convex functions, Convex sets, etc.) individually or in a group teaching and research activities; reveal the similarities and differences of variation calculus and methods of optimization.<br>Be able to synthesize, interpret and evaluate the learning outcomes of discipline, modules, midterm exam content (convex programming, nonlinear programming, linear programming, dynamical programming, the simplest problem, necessary | |

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| PC-18.<br>PC -20.<br>PC -21.<br>PC-22. | conditions for a weak local minimum, isoperimetric problem, etc.);analyze dynamics of scientific problems decision of the course (scientific reviews of specific issues researches);make an analysis of learning outcomes of the course, generalize them through scientific essays, presentations, reviews, scientific review, etc.; define criteria and requirements to extreme theory and its application;<br>be able to construct educational and social interaction and cooperation in the group; propose to consider a problem, to reason its importance; accept criticism and to criticize; work in a team; recognize the role of the taken course in the implementation of individual learning paths.<br><br>Knowledge. At the end of the course the students will know:bases of the theory of boundary problems for ordinary differential equations of the first and the second order; applications received by mathematical knowledge.<br>Skills. At the end of the course the students will be able to: identify, analyse and subsequently solve physical situations which behaviour can be described by ordinary differential equations; determine solutions to first order separable differential equations; determine solutions to the first order linear differential equations; determine solutions to the first order exact differential equations; determine solutions to the second order linear homogeneous differential equations with constant coefficients; determinesolutions to the second order linear non-homogeneous differential equations with constant coefficients. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-3.<br>PC-5.<br>PC-6.<br>PC-7.<br>PC-10.<br>PC-13.<br>PC-16.<br>PC-17.<br>PC-18.<br>PC-22. | Programming, Mathematical modeling, Numerical methods<br>Knowledge: studying of programming bases, studying of the basic meanings and possibilities of high level programming languages, libraries and packages, studying of algorithms and their realizations in high level programming languages.<br>General mathematical models of natural and social sciences; creation of the contemporary understanding of the methods of determinations and analysis of mathematical models of natural and social sciences.<br>Skills: to demonstrate a setting a task and to develop algorithm of its decision; to demonstrate the work with modern programming systems, including object-oriented; carried out competent statement of the tasks arising in practical activities for their decision by means of the computer; to carry out the formalized description of objectives; to use applied programming systems; to analyze development of the main documents; to write programs in language C ++.<br>By studying this discipline, the students should get an idea of the methods of mathematical description of nature and social processes and the methods of researching models by means of modern mathematics and computer technology; demonstrate a setting a task and to develop algorithm of its decision; demonstrate the work with modern programming systems, including object-oriented; carry out competent statement of the tasks arising in practical activities for their decision by means of the computer; carry out the formalized description of objectives; use applied programming systems; analyze development of the main documents; write programs in language C ++; carry out debugging and testing of the programs written in language C ++ in the integrated environment; carry out the analysis of a correctness and computing complexity of algorithms and programs. The methods of determinations and analysis of mathematical models of natural and social sciences.<br>Be able to make comparative analysis of the application of numerical methods to solve practical problems; to examine the | |

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| | accuracy of the resulting approximate solution; to analyze the numerical results; summarize the results of research and analysis of numerical solving of inverse problems in the form of essays, presentations, reports;<br>Be able to apply basic numerical methods; select the best numerical method to solve the problem; to estimate the accuracy of the resulting numerical solutions; to develop algorithms and software for solving typical problems. To make comparative analysis of the application of numerical methods to solve practical problems; to examine the accuracy of the resulting approximate solution; to analyze the numerical results; summarize the results of research and analysis of numerical solving of inverse problems in the form of essays, presentations, reports. | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-23. | Fundamentals of financial mathematics, The theory of random processes, Theory of life contingencies, Actuarial principles and their applications-1, Actuarial principles and their applications-2, Measure and Lebegues Integration theory.<br>Knowledge (Fundamentals of financial mathematics): Teaching the theoretical foundations of actuarial science. Developing critical thinking to solve complex problems from the first principles rather than memorization. Developing an ability to abstract and recognize analogues and basic patterns. Incorporating examples and problems in class and at the home. Providing an understanding of the time value of money and its impact among many different payment streams. Teaching how to systematically analyze the learning outcomes of the course and to generalize them.<br>Knowledge (The theory of random processes): Demonstrating knowledge and comprehension of basic ideas and concepts of random processes such as Markov property; ergodicity; memoryless property; transient evolution; filtration; etc.; Demonstrating and understanding the most important and fundamental theorems in random processes and a general properties of random processes and relations between them; Providing a mathematical proof of simple statements, with strong reasoning skills.<br>Knowledge (Actuarial principles and their applications): basic ideas and concepts of Actuarial principles and their applications such as Applications of Theory of Interest; Life Annuities; Valuation of Reserves: Net Level Premium, Gross Premium methods; Multiple Life Annuities; Life Insurance: Product Design, Marketing, Underwriting; The Economics of Insurance: Utility Theory, Insurance and utility, Optimal insurance, Minimum Required Capital (Risk-Based Capital); Property and Casualty Insurance: Ratemaking, Loss Reserving in Property And Casualty Insurance; Demonstrating and understand to the determination of premiums and rates, reserving and the valuation and funding of the Life Annuities; Life Insurance; Ratemaking and Loss Reserving in Property and Casualty Insurance; Providing a mathematical proof of simple statements, with strong reasoning skills.<br>Skills: To prepare students for the first half of the first course to become a licensed actuary in Kazakhstan. To prepare students for the taking of the Financial Mathematics exam to become a licensed actuary in almost any other country, including the USA.<br>To prepare students to become knowledgeable members of an insurance market. To give students good exposure to both financial calculators and software programs such as Microsoft Excel.<br>To give an opportunity for students to work together in groups. To give an opportunity for students to practice their | **2.3. Basic Professional Disciplines Elective Course**<br><br>**(40 credits)**<br><br>**For actuaries** |

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| | presentation skills. To teach students how to explain financial terms in a simple language. To teach students to become part of an Actuarial Society of Kazakhstan.<br>To link the course with the recent history and development of Kazakhstan's insurance market<br>Knowledge (Measure andLebegues Integration theory): to understand the notion of algebra and sigma algebra; Define a measure, the Lebesgue measure and external(outer) measure; to determine if a function is Lebesgueintegrable or not; to understand the difference between the Riemann integral and the Lebesgue one; to use the difference theorems of convergence: monotone convergence, Fatou and dominated convergence theorem; to understand the difference type of convergence: almost everywhere convergence, convergence in measure and strong convergence; To know and understand the notions of measure theory, measurable functions and Lebesgue integrations.<br>Skills: to know the structure of the Lebesgue measure and integration and be able to apply the concepts of measure and integration in typical theoretical and practical problems. | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15. | Physics. Theoreticalmechanics.<br><br>Knowledge (Physics): Kinematics and Dynamics. Forces. Work. Energy. Power. Laws. Impulse. Linear momentum.Conservation. Celestial mechanics of Newton. Kepler's laws. Molecular Physics. Kinetic theory.Ideal and real gases. Gas laws. Thermodynamics. Optics. Interference and diffraction of light. Photoelectric effect. Electrostatics. Electrodynamics. Coulomb's law.Dielectrics. Polarization. Electric current and its characteristics. Ohm's Law. Magnetism. Substance in a magnetic field: ferro-, para- and diamagnetism. Superconductivity and magnetic properties of new materials. Critical temperature. Cooper pairs. Barden-Cooper-Schrieffer theory. Meissner effect. Magnetic levitation. Abrikosov vortex. Superconductivity type I, I1/2, II. Atomic nucleus. Binding energy. Isotopes. Nanotechnology and Nanomaterials.<br><br>Knowledge (Theoretical Mechanics): the ability to demonstrate knowledge and understanding of the basic ideas of mechanics; physical concepts and means with mathematical methods of classical mechanics.<br>The ability to demonstrate knowledge of the model of material bodies, studied in theoretical mechanics, in the statics and dynamics of point mass and the system;<br>The ability to apply scientific knowledge on direct and inverse problems of dynamics, in analytical mechanics. | **2.4 Natural science (STEM) module**<br><br>**(6 credits)**<br><br>**For mathema ticians** |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7. | Programming in C#. Database management system.<br>Knowledge (Programming in C#):On completion of the course the student should be able to: show knowledge and understanding of the fundamental principles of the object-oriented programming; show knowledge and understanding of the fundamentals of writing applications to solve problems, demonstrate fundamental knowledge and understanding of the general structure of the C# programming language;<br>Knowledge (Database management system):the data and data organization needs of organizations; application of the Entity- | **2.4 Natural science (STEM) module (6 credits) For actuaries** |

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| CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-23. | Relationship (E-R) Model for building information systems' data models; transform an E-R diagram into a relational model, and the use of normalization to create a database relational schema;<br>Knowledge (Functional analysis): Basic ideas and concepts of functional analysis such as normed spaces; metric spaces; Banach spaces; Hilbert spaces; linear continuous operators and linear continuous functionals, defined on these spaces; dual (conjugate) spaces; reflexive spaces; distributions (generalized function); generalized derivative; completely continuous (compact) operators; closed operators; adjoint and self-adjoint operators; spectrum of the operator and the resolvent set; spectral theory of compact self-adjoint operators and their applications.<br>The three most important and fundamental theorems in basic functional analysis: the uniform boundedness principle, the open mapping principle and the extension principle for linear functionals (the Hahn-Banach theorem); the general form of linear functionals in Hilbert spaces (Riesz representation theorem) and relations between linear normed, metric and Euclidean spaces, linear bounded and continuous operators.<br>Skills: to discuss the physical database design process of producing an efficient and tuned database; to explain when denormalization is preferred over normalization, to use vertical and horizontal partitioning for data distribution; to elaborate on data storage and indexing options, to perform query optimization; to use SQL for database creation, manipulation and control; to explain the client/server model, to describe the key components used to implement internet database environments; to perform basic database administration tasks.<br>Skills: to apply the techniques of structured (functional) decomposition to break a program into smaller pieces; to write clear and comprehensive program documentation; design, implement, test, debug, and document recursive functions, GUI, event-driven programs; design, implement, test, debug, and document in object-oriented programming language.<br>To write simple but well-documented and structured Windows applications with graphical user interface; to implement the basic concepts of object-orientation with an in-depth focus on encapsulation.<br>To be able to demonstrate and understand the three most important and fundamental theorems of basic Functional Analysis: the uniform boundedness principle, the open mapping principle and the extension principle of linear functionals (the Hahn-Banach theorem); the general form of linear functionals in Hilbert spaces (Riesz representation theorem)and relations between linear normed, metric and Euclidean space, linear bounded and continuous operators; to provide a mathematical proof of simple statements, with strong reasoning skills;<br>to be able to include new knowledge in the context of basic lore, interpret its contents; analyze educational situation and offer a direction to solve it; use methods (research, calculation, analysis, etc.) inherent to the field of study (linear normed space, metric space, linear operators and functionals, etc.) individually or in a group of educational and research activities; to reveal the similarities and differences between normed, metric and topological spaces; prove mathematical statements rigorously;<br>to be able to synthesize, interpret and evaluate the learning results in context of discipline, educational module and midterm exam's content (normed and Banach space, Hilbert space, linear operators and functionals, basic principles of functional analysis, dual space, strong and weak convergence, compact operators, spectrum of a compact operator, adjoin operators, | |

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| | self-adjoint operators, spectrum of self-adjoint operator);<br>To analyze dynamics of scientific problems' solutions of the course (scientific reviews of concrete issue's researches); to make an analysis of learning results of the course, generalize them through scientific essays, presentations, reviews, scientific review, etc.; to have calculative skills to solve various exercises. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-7.<br>PC-8.<br>PC-9<br>PC-10.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-15.<br>PC -20.<br>PC -21.<br>PC-23. | Fourier series. Applied functional analysis.Measure and Lebesgue Integration theory. Spectral theory of linear operators. Approximation Theory. Pseudo-differential Operators on compact Lie groups. Hyperbolic equations with initial data and coefficients.Non-harmonic Analysis.<br>Knowledge (Fourier series): the basic ideas and concepts of Fourier series; orthonormal systems; trigonometric system and its consequences; calculating the coefficients of Fourier series (Fourier sine series, Fourier cosine series); complex form of Fourier series; Fourier integrals and Fourier transforms.<br>Knowledge (Approximation Theory): the meaning of asymptotic solutions in the appropriate context and how to interpret these.<br>Skills: to solve simple linear and nonlinear ordinary and partial differential equations by asymptotic methods; to illustrate with suitable examples the occurrence of asymptotic phenomena in mechanics.<br>Knowledge (Applied functional analysis): To explain the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts; To demonstrate accurate and efficient use of functional analysis techniques; To demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from functional analysis; Apply problem-solving using functional analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts; to be able to reproduce definitions, theorems and proofs of functional analysis; give standard examples of classic normed and Hilbert spaces; treat concrete boundary-value problems and integral equations with functional-analytic methods; manipulate mathematical symbols and use functional-analytic terminology correctly;<br>Knowledge (Measure and Lebegues Integration theory): To understand the notion of algebra and sigma algebra; to define a measure, the Lebesgue measure and outer measure; to determine if a function is Lebesgue integrable or not; to understand the difference between the Riemann integral and the Lebesgue one; to use the difference theorems of convergence: monotone convergence, Fatou and dominated convergence theorem; to understand the difference type of convergence: almost everywhere convergence, convergence in measure and strong convergence; To know and understand the notions of measure theory, measurable functions and Lebesgue integrations.<br>Knowledge (Nonharmonic Analysis): to demonstrate acquired knowledge (of a new view to the linear operators) and it's understanding; to show an overall structure of the study field and the relations between its elements (operator, functional, transformation, kernel, etc.); to classify classes of symbols and operators; to discuss applications of the theory; to be able to include new knowledge in the context of basic mathematical knowledge and apply it to PDEs; to analyze properties of the objects of the mathematical physics; to use methods of the Nonharmonic Analysis; to reveal the differences and similarity of the integral and differential equations;<br>Skills: to know the structure of the Lebesgue measure and integration and be able to apply the concepts of measure and | **2.4. Majors Elective Course (25 credits)** |

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| | integration in typical theoretical and practical problems.<br>To apply mathematical modeling using pure math concepts from set-theory, analysis, linear algebra, probability and geometry/topology; Exploring Finance and Economics – Stock market data exploration;Modeling Data Using Graphs.<br>To be able to synthesize, interpret and evaluate the learning outcomes of discipline, modules, midterm exam content; to analyze dynamics of scientific problems decision of the course (scientific reviews of specific issues researches); to make an analysis of learning outcomes of the course, to generalize them through scientific essays, presentations, reviews, scientific review, etc.; to define conditions for operators with different properties;<br>Be able to constructive educational and social interaction and cooperation in the group; propose to consider a problem, to reason its importance;accept criticism and to criticize; work in a team; recognize the role of taken course in the implementation of individual learning paths. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-3.<br>PC-4.<br>PC-5.<br>PC-10.<br>PC-13.<br>PC-16.<br>PC-20.<br>PC-22. | Elements of Computability Theory. Algebraic system. The theory of algorithms. Introduction to model theory. Introduction to classical geometry.<br>Knowledge(Elements of Computability Theory):as a result of studying module the student will acqure basic knowledge in the field of computable functions and computably enumerable sets, will learn to define computable functions and sets; will know the bases of computably enumerable sets and the recursion theorems, Turing machine and gallop operator, methods of construction computably enumerable sets.<br>Skill: Having successfully mastered the curriculum of the module students should understand methods of the computation theory.<br>Knowledge(Algebraic systems): as a result student must know concepts about of Group's homomorphisms and isomorphisms, rings and subrings, algorithm to find a finite number of polynomials for the construction of the Gröbner basis.<br>Skill: to be able to work with concepts groups, subgroups, rings, subrings, a homomorphism of rings and its kernels.<br>Knowledge (The theory of algorithms): to have non-formal understanding of algorithm, simple functions, primitive recursive and superposition operators, class of primitive recursive functions, primitive recursive predicates.<br>Skill: to distinguish Cantor and Gödel numberings, the notion of Turing machine, to know to construct Functions computable by Turing machine, computability of primitive recursive functions.<br>Knowledge(Introduction to model theory): as the result of studying students should know elements of model theory, interpretation and model, submodels, elimination of quantifiers and examples of categorical theories.<br>Skill: to know basic concepts of models theory, first order theory, to define homomorphism of the models, isomorphism and automorphism of the models, groups of automorphisms and relation between them.<br>Knowledge (Introduction to classical geometry): to distinguish and have presentation about Euclidean geometry, Affine geometry, Projective geometry, to research real projective plane, RP2, construct coordinate charts for RP2 (and for CP1).<br>Skill: to have presentation about various types of geometry: affine geometry, projective, elliptic, hyperbolic geometry and their possible models. | |

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| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-23. | Stochastic Differential Equations. Stochastic financial mathematics. Stochastic processes.Non-parametric statistic and learning theory. The theory of random matrices.<br>Knowledge: Basic concepts and the most important fundamental results of the general theory of random processes; Fundamentals of the theory of martingales and semimartingales; Definitions of a stochastic differential equation and its solution; Conditions for the existence and uniqueness of solutions of stochastic differential equations; Definitions of the diffusion process; The direct and inverse Kolmogorov equations; Connection of diffusion processes with the Cauchy problem for partial differential equations of parabolic type; Connection of diffusion processes with solutions of stochastic differential equations.<br>Skills: to be able to analyze and compare the methods of obtaining solutions of stochastic differential equations and similar methods of obtaining solutions of the corresponding nonrandom equations; to be able to analyze the results obtained by various alternative methods and draw appropriate conclusions;<br>Knowledge: to understand the fundamentals, basic properties and use of classical and modern nonparametric statistical methods for data analysis.<br>Skills: to be able to identify appropriate nonparametric methods for analyzing data; perform a variety of nonparametric statistical analyses; to gain a working proficiency in the use of statistical software for data management and performing basic nonparametric statistical analyses<br>Knowledge (The theory of random matrices): some of the most important mathematical techniques used in random matrix theory and have an understanding of how these are relevant in various areas of mathematics, physics, engineering and probability.<br>Skills: to be able to define and comprehend the notions of spectral statistics for various matrix ensembles. To compute typical examples of spectral statistics. To recognize and compute with a few common matrix ensembles | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11. | Qualitative theory of differential equations.Periodic and conditionally periodic solutions of differential equations. The theory of generalized Lyapunov exponents. Asymptotic methods for solving singularly perturbed equations. Integral and integro-differential equations. Theoretical and computational questions of the equations of mathematical physics. Modern methods for solving boundary value problems of partial differential equations. The motion stability theory. Methods of Teaching Mathematics.<br>Knowledge (Qualitative theory of differential equations): Generalized upper and lower functions of a linear system of differential equations. Generalized upper and lower central indices of a linear system of differential equations. Estimates of the solutions of a nonlinear system of differential equations by applying generalized central indicators. Application of generalized central indicators to the theory of stability of a nonlinear system of differential equations.<br>Knowledge (The theory of generalized Lyapunov exponents): Generalized Lyapunov exponent for solutions of a linear system of differential equations. Normal fundamental system of solutions. Generalized Lyapunov exponents of a linear system of differential equations. Generalized regular linear system of differential equations. Existence of generalized | |

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| PC-12.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-24. | exponents of solutions of a nonlinear system of differential equations. Stability and generalized Lyapunov exponents of nonlinear system of differential equations. Signs of stability, asymptotic stability, and exponential stability of solutions of nonlinear system of differential equations obtained by applying generalized Lyapunov exponents.<br>Knowledge (Asymptotic methods for solving singularly perturbed equations):the basic concepts of the theory of singular perturbations; Qualitative asymptotic properties of solutions of initial and boundary value problems for singularly perturbed equations; Asymptotic methods for solving singularly perturbed ordinary differential and integro-differential equations; The qualitative behavior of solutions of singularly perturbed boundary-value problems with initial nets at the point of discontinuity, where the solution jumps; Methods for proving the estimates of the remainder term of the asymptotics. The basic concepts of the theory of integral equations of Fredholm and Volterra; Methods for solving linear integral equations of Fredholm and Volterra; Fredholm's theorem.<br>Skills: to be able to solve problems associated with singular perturbations; the application of the method of boundary functions for constructing the asymptotics of the solution of singularly perturbed initial and boundary value problems; to apply the theoretical knowledge obtained for solving applied problems.<br>Knowledge (Integral and integro-differential equations):Be able to solve problems associated with integral and integro-differential equations; to prove the main theorems on the properties of integral and integro-differential equations; to construct the resolvent of the integral equations of Fredholm and Volterra; to use the basic results of the theory of integral and integro-differential equations in practical activity. | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br><br>PC-2.<br>PC-3.<br>PC-9.<br>PC-11.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15. | General theory of extreme problems. Mathematical programming. Optimal control.The boundary problems of control theory. Practical solving of optimization problems and counterexamples in optimal control theory. Optimization problems for the distributed parameter systems and the differentiation theory.<br>Knowledge (General theory of extreme problems): the general theory of extreme problems in Banach space; The main determinations. Examples. Feasible controls. Optimal control. Functional limitation. The lower bound. Minimizing sequences. Sequence convergence to the set. Absolute minimum.<br>Skills: to be able to solve problems of optimal control; the application of the method of optimal control and differentiation of nonlinear operators; differentiation of nonlinear functionals; existence and uniqueness theorems of solution of the Cauchy problem for differential equation in Banach space at control; iteration process of Newton-Kantorovich.<br>Weierstrass theorem in Banach space.<br>Knowledge (The boundary problems of control theory): the basic concepts of Integral equations. Solvability and construction of solution of the equations. Approximation solution of Fredholm integral equation of the first kind. Integral equation with parameter. Controllability theory and optimal speed. Controllability and optimal speed of linear system. Controllability and optimal speed of nonlinear system.The boundary value problem theory of ordinary differential equations. Constructive theory of boundary value problems. Immersion principle.<br>Skills: to be able to solve Integral equations; to know the application of the method of boundary value problem theory of | |

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| PC-24. | ordinary differential equations; to apply the theoretical knowledge obtained for solving applied problems. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-2.<br>PC-3.<br>PC-5.<br>PC-6.<br>PC-7.<br>PC-10.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-16.<br>PC-17.<br>PC-18.<br>PC -19.<br>PC -20.<br>PC-22. | Big data, Actuarial mathematics, Mathematical models in biology and medicine, SAS Technologies in Applied Data Analysis.<br>Knowledge: Big Data as a discipline for complex data sets through quantitative (statistics, computer science) and qualitative (topology, geometry) methods. Extracting patterns and interpreting their significance in applications are greatly facilitated through rigorous qualitative methods that have been developed by topologists, geometers and theoretical physicists. Topological methods providing a powerful interface between statistics and machine learning.<br>The theoretical foundations of financial mathematics, the actuarial models in life insurance and the application of these models; mortality tables, the life expectancy and similar demographic quantities; the expected values of life annuities and of life insurance; basic life insurance benefits; the mathematical language of actuaries.<br>By studying Mathematical models in biology and medicine, students genuinely and realistically learn to convert an understanding of the underlying mechanisms of complicated processes in molecular biology, population biology, epidemiology, etc. into a predictive science using both discrete- and continuous-time models. As believed in a broad scientific community, “Biology is becoming Mathematics’ new Physics”. While Physics has developed its own solid mathematical background throughout the centuries, more technologies and tools are required to study Biology and Ecology as a new wave of problems, as it is acquiring. The course “Mathematical models in Biology and Medicine” provides a sound knowledge and appreciation of the ideas and concepts related to modelling biological and ecological systems using differential equations. Students will work with both so-called mechanistic and phenomenological models, focusing on population biology that can be analyzed using deterministic discrete- and continuous-time spatial- and non-spatial models, and demonstrates how mathematical techniques such as linear stability analysis, phase planes, singular perturbation and travelling waves, can provide important information about the behavior of complex models.<br>At the end of the SAS Technologies in Applied Data Analysis, the students will know basic ideas and concepts such as macros, SQL, SAS/STAT statistical analysis methods library: dispersion analysis, linear regression, logistic regression, the generalized linear models, Tobit models, the survival analysis, clustering. Bayesian analysis; interactive programming language for processing IML matrix data: matrix, linear algebra and numerical methods in IML; integration with SAS/BASE, C++; explanation SAS/BASE programming technology aspects (syntax, semantics, rules, ways to work with it); fundamental bases in SAS programming technology: SAS/BASE, macros, SQL, SAS/STAT, SAS/IML, integration with SAS/BASE.<br>Skill:To apply mathematical modeling using pure math concepts from set-theory, analysis, linear algebra, probability and geometry/topology; Exploring Finance and Economics – Stock market data exploration; Modeling Data Using Graphs.<br>The ability to become a licensed actuary in Kazakhstan; to take of the life contingencies segments of actuarial professional examinations, i.e. MLC exam, to become a licensed actuary in almost any other country, including the USA. The ability to become knowledgeable members of an insurance market. To give students good exposure to both financial calculators and software programs such as Microsoft Excel. | **3. Interdisciplinarydisciplines (2 credits) For mathematicians** |

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| | The ability to construct a model for complex systems based on known raw data and qualitative behavior and it is essential for those who want to study and predict the way nature evolves. Reading results are done after the modelling and it is important, because misinterpretation might have a big price in fields as Epidemiology and Medicine. The course gives basics while focusing on understanding the concepts by students and on encouraging them to explore a broad range of ways to study biological phenomena for the good of all parts of nature.<br>To be able to demonstrate knowledge and comprehension on SAS programming basic ideas and concepts such as macros, SQL, SAS/STAT statistical analysis methods library: dispersion analysis, linear regression, logistic regression, the generalized linear models, Tobit models, the survival analysis, clustering. Bayesian analysis; interactive programming language for processing IML matrix data: matrix, linear algebra and numerical methods in IML; integration with SAS/BASE, C++; explanation SAS/BASE programming technology aspects (syntax, semantics, rules, ways to work with it); demonstrate and understand the most important and fundamental bases in SAS programming technology: SAS/BASE, macros, SQL, SAS/STAT, SAS/IML, integration with SAS/BASE. To provide math skills to create an algorithm for SAS program with strong analytical skills. | |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-1.<br>PC-3.<br>PC-5.<br>PC-6.<br>PC-7.<br>PC-10.<br>PC-13.<br>PC-15.<br>PC-16.<br>PC-17.<br>PC-18.<br>PC-22. | Mathematical demography,Economic-mathematical models<br>Knowledge:By studying this discipline, students genuinely and realistically learn to convert an understanding of the underlying mechanisms of complicated processes in molecular biology, population biology, epidemiology, etc. into a predictive science using both discrete- and continuous-time models. As believed in a broad scientific community, mathematical techniques such as linear stability analysis, phase planes, singular perturbation and travelling waves, can provide important information about the behavior of complex models.<br>Skill: The ability to construct a model for complex systems based on known raw data and qualitative behavior and it is essential for those who want to study and predict the way that nature evolves. Reading results is done after the modelling and it is important, because misinterpretation might have a big price in fields as Epidemiology and Medicine. The course gives basics while focusing on understanding the concepts by students and on encouraging them to explore a broad range of ways to study biological phenomena for the good of all parts of nature.<br>To be able to demonstrate acquired knowledge (of a new view to the linear operators) and its understanding; to show an overall structure of the study field and the relations between its elements (operator, functional, transformation, kernel, etc.);classify classes of symbols and operators; to discuss applications of the theory;<br>To be able to include new knowledge in the context of basic mathematical knowledge, to apply it to PDEs; to analyze properties of the objects of the mathematical physics; to use methods of the Nonharmonic Analysis; to reveal the differences and similarity of the integral and differential equations;<br>To be able to synthesize, interpret and evaluate the learning outcomes of discipline, modules, midterm exam content; to analyze dynamics of scientific problems decision of the course (scientific reviews of specific issues researches); to make analysis of learning outcomes of the course, generalize them through scientific essays, presentations, reviews, scientific | **3.**<br>Interdisciplinarydisciplines<br>(2credits)<br>For actuaries |

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| | review, etc.; to define conditions to have operators with different properties;<br>To be able to constructive educational and social interaction and cooperation in the group; to propose to consider a problem, to reason its importance; to accept criticism and to criticize; work in a team; recognize the role of taken course in the implementation of individual learning paths. | |
| CC-2.<br>CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-8.<br>CC-9.<br>CC-10.<br><br>PC-1.<br>PC-2.<br>PC-3.<br>PC-4.<br>PC-5.<br>PC-6.<br>PC-7.<br>PC-8.<br>PC-10.<br>PC-12.<br>PC-13.<br>PC-14.<br>PC-15.<br>PC-16.<br>PC-17.<br>PC -19.<br>PC -20.<br>PC-21. | In the educational Practice the following practical skills and competencies are formed:<br>- the ability to recognize the importance of theoretical knowledge in applied aspects of problems;<br>- the ability to work with information from various sources including network resources of the Internet<br>- the ability to solve professional mathematical problems;<br>- the ability to maintain programming skills;<br>- the ability to demonstrate general scientific knowledge of the natural sciences, mathematics and computer science;<br>- the ability to acquire new scientific and professional knowledge, using modern educational and information technologies;<br>- the ability to understand and apply modern mathematical apparatus in research and application;<br>- the ability in the research and production team to solve the tasks of professional activity;<br>- the ability to critically rethink the accumulated experience, change, if it is necessary, the type and nature of their professional activities. | **4. Educational practice** |
| | In the practice training the following practical skills and competencies are considered:<br>- the ability to master the culture of thinking, the ability to give reasoned and clear oral and written language;<br>- the ability to realize the social importance of their future profession, to have a high motivation to carry out their professional activities;<br>- the ability to work with information in global computer networks;<br>- the ability to work in a team and use regulatory legal documents in their activities;<br>- the ability to use professional skills in the scientific and cognitive activities, as well as in the social sphere, in working with information and computer technologies;<br>- the ability to work with information from various sources, including network resources of the Internet, to solve professional and social problems;<br>- the ability to demonstrate general scientific knowledge of the natural sciences, mathematics and computer science;<br>- the ability to acquire new scientific and professional knowledge using modern educational and information technologies;<br>- the ability to understand and apply a modern mathematical apparatus in research and application;<br>- the ability to solve the tasks of professional activity in the research and production teams;<br>- the ability to critically rethink the accumulated experience, change, if necessary, the type and nature of their professional activities;<br>- the ability to carry out a targeted search for information on the latest scientific and technological achievements in the Internet and other sources;<br>- the ability to collect, process and interpret the data of modern scientific research necessary for drawing conclusions on relevant scientific, professional, social and ethical issues;<br>- the ability to carry out scientific research on the problems of the theory of choice and decision-making using methods of | **Practice Training** |

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|---|---|---|
| | probability theory, mathematical statistics, and system analysis;<br>- the ability to determine the relevance of scientific problems, formulate new tasks, propose methods for their solution;<br>- the ability, on the basis of a meaningful analysis of the essence of practical problems, to formalize a practical problem, substantiate, select and implement a mathematical model for its solution. | |
| | As a result of the pedagogical Practice that takes place at secondary schools, gymnasiums, and lyceums, students gain initial experience of practical pedagogical activity by teaching Mathematics-related subjects. During the Practice, students shall fulfill requirements and gain experience as follows:<br>• understand psychological, pedagogical and other aspects of the teaching process;<br>• get acquainted with modern methods of teaching;<br>• improve their pedagogical knowledge and teaching skills;<br>• learn specific aspects of the operation and methodological activity of secondary education organizations. | **Pedagogical Practice** |
| | As a result of the pre-diploma Practice that takes place at relevant enterprises, institutions, and organizations, students apply in practice professional skills obtained during the theoretical study of mathematical modules and laboratory work. During the Practice, students shall gain experiences as follows:<br>• improve their knowledge within general and specialized modules;<br>• carry out theoretical and applied research in the selected research paper;<br>• learn to design, plan and perform experimental scientific work;<br>• acquire skills of operating and maintaining different types of computer equipment;<br>• collect and process experimental results for use in their diploma projects. | **Pre-diploma Practice** |
| CC-3.<br>CC-4.<br>CC-5.<br>CC-6.<br>CC-7.<br>CC-10.<br>PC-3.<br>PC-10. | Knowledge of state policy and fundamental achievements of the Republic of Kazakhstan in the field of physical culture and sports.<br>Knowledge of the theoretical, methodological, hygienic and organizational foundations of physical culture and sports.<br>The ability to use in practical life skills, ensuring the preservation and strengthening of health, development and improvement of psycho-physical abilities and qualities.<br>Ownership experience in the use of means of physical culture and sport for disease prevention, mental well-being, development and improvement of qualities and personality traits. | **5.** Additional Types ofLearning |

# EDUCATIONAL PROGRAM

**5В0606100 – МАТЕМАТИКА МАМАНДЫҒЫ БОЙЫНША НЕГІЗГІ ОҚУ ЖОСПАРЫ**
**ОСНОВНОЙ УЧЕБНЫЙ ПЛАН ПО СПЕЦИАЛЬНОСТИ 5В060100 – МАТЕМАТИКА**
**CORE CURRICULUM FOR THE SPECIALITY5В060100 – MATHEMATICS**

**Академиялық дәрежесі:** 5В060100-Математика мамандығы бойынша жаратылыстану бакалавры
**Академическая степень:** Бакалавр естествознания по специальности 5В060100-Математика
**Academic degree:** Bachelor of Natural Sciences on a specialty 5В060100-Mathematics

| **Коды<br>Код<br>Code** | **Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities** | **Кредит саны<br>Кредиты<br>Credits** | **Семестры/Семестры/Semesters** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** |
| | | | **Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab** | | | | | | | |
| **ЖАЛПЫ БІЛІМ БЕРЕТІН ПӘНДЕР (ЖББП)<br>ОБЩЕОБРАЗОВАТЕЛЬНЫЕ ДИСЦИПЛИНЫ (ООД)<br>GENERAL EDUCATION DISCIPLINES (GED)** | | **22** | | | | | | | | |
| **МІНДЕТТІКОМПОНЕНТ (МК)<br>ОБЯЗАТЕЛЬНЫЙКОМПОНЕНТ (ОК)<br>OBLIGATORYCOMPONENT (OC)** | | **18** | | | | | | | | |
| | **Әлеуметтік-гуманитарлықмодуль/ Социально-гуманитарныймодуль/ Social and humanitarian module** | **6** | | | | | | | | |
| **SIK1101** | Қазақстанның қазіргі заман тарихы (Мемлекеттік емтихан)/ Современная история Казахстана (Государственный экзамен)/ Modern history of Kazakhstan (State Examination) | 3 | 2+1+0 | | | | | | | |
| **Fil 2102** | Философия/ Философия/ Philosophy | 3 | | | | 2+1+0 | | | | |
| | **Инструменталды модуль/ Инструментальный модуль/ Instrumentalmodule** | **12** | | | | | | | | |
| **IYa 1103** | Шетел тілі/ Иностранный язык / Foreign Language | 6 | 0+3+0 | 0+3+0 | | | | | | |
| **K(R)Ya 1104** | Қазақ (орыс) тілі/ Казахский (русский) язык/ Kazakh (Russian) Language | 6 | 0+3+0 | 0+3+0 | | | | | | |
| | **Барлығы міндетті компонент бойынша<br>Итого по обязательному компоненту<br>Total on obligatory component** | **18** | **9** | **6** | **0** | **3** | **0** | **0** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)** | | **4** | | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **КОМПОНЕНТ ПО ВЫБОРУ (КВ)/ ELECTIVECOMPONENT (EC)** | | | | | | | | | | |
| | **Мәдени-коммуникативтікмодуль/ Культурно-коммуникативныймодуль/ Cultural and communicative module** | **4** | | | | | | | | |
| **KRYaK 3105** | Сөз мәдениеті және тілдік қарым-қатынас/ Культура речи и языковая коммуникация/ Culture of Speech and Language Communication | 2 | | | | | 1+1+0 | | | |
| **PMK 3106** | Тұлғааралық қарым-қатынас коммуникацияның психологиясы/Психология межличностной коммуникации/ Psychology of interpersonal communication | 2 | | | | | 1+1+0 | | | |
| | **Қоғамдық-саясимодуль/ Общественно-политическиймодуль/ Social and political module** | **4** | | | | | | | | |
| **TPP 3107** | Теориялық және қолданбалы саясаттану/ Теоретическая и прикладная политология/ Theoretical and Applied Political Science | 2 | | | | | 1+1+0 | | | |
| **OPS 3108** | Жалпы және қолданбалы әлеуметтану/ Общая и прикладная социология/ General and Applied Sociology | 2 | | | | | 1+1+0 | | | |
| | **Экологиялық модуль/Экологический модуль/EcologyModule** | | | | | | | | | |
| **EUR3109** | Экология және орнықты даму/ Экология и устойчивое развитие/ Ecology and Sustainable Development | 2 | | | | | 1+1+0 | | | |
| **BGCh3110** | Адам тіршілігінің қауіпсіздігі/ Безопасность жизнедеятельности человека/HumanLifeSafety | 2 | | | | | 1+1+0 | | | |
| | **Модуль« Қазіргі қоғамның әлеуметтік-саяси және тарихи негіздері/Социально-политические и исторические основы современного общества/Socio-political and historical foundations of modern society»** | **4** | | | | | | | | |
| **DVFIS 4111** | Рухани жаңғыру және тарихи сананың қалыптасуы/ Духовное возрождение и формирование исторического сознания/ Spiritual Revival and the Formation of Historical Consciousness | 2 | | | | | | | 1+1+0 | |
| **KP4112** | Қазақстандыққұқық/Казахстанскоеправо/Kazakhstan Law | 2 | | | | | | | 1+1+0 | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **OE4113** | Экономиканегіздері/ Основыэкономики/The Fundamentals of Economics | 2 | | | | | | | 1+1+0 | |
| | **Тарихи-мәдени модуль/ Историко-культурный модуль/Historyandculturemodule** | **4** | | | | | | | | |
| **AFS4114** | Әл-Фараби және қазіргі заман/Аль-Фараби и современность/Al-Farabi and modernity | 2 | | | | | | | 1+1+0 | |
| **KR4115** | Мәдениетжәнедін/Культураирелигия/Culture and religion | 2 | | | | | | | 1+1+0 | |
| **MPMIM4116** | Математиканы оқыту әдістемесі, математика тарихы/ Методика преподавания математики, история математики/ Methods of teaching mathematics, the history of mathematics | 2 | | | | | | | 1+1+0 | |
| | **Таңдау компоненті бойынша барлығы/Компонент по выбору, итого/Total of elective component** | **4** | **0** | **0** | **0** | **0** | **2** | **0** | **2** | **0** |
| | **Жалпы білім беретін пәндер бойынша барлығы/ Итогопо общеобразовательным дисциплинам Total of generaleducationdisciplines** | **22** | **9** | **6** | **0** | **3** | **2** | **0** | **2** | **0** |
| **БАЗАЛЫҚ ПӘНДЕР (БП) /БАЗОВЫЕ ДИСЦИПЛИНЫ (БД)/COREDISCIPLINES(CD)** | | **72** | | | | | | | | |
| **МІНДЕТТІ КОМПОНЕНТ (МК)/ОБЯЗАТЕЛЬНЫЙ КОМПОНЕНТ (ОК)/OBLIGATORYCOMPONENT (OC)** | | **24** | | | | | | | | |
| | **Кәсіби тілдер және АКТ/Профессиональные языки и ИКТ/Professional languages and ICT** | **6** | | | | | | | | |
| **PK (R) Ya 2201** | Кәсіби бағдарлы қазақ(орыс) тілі\ Профессионально-ориентированный казахский(русский) язык Professionally-Oriented Kazakh (Russian)Language | 2 | | | 0+2+0 | | | | | |
| **POIYa2202** | Кәсіби-бағдарлы шетел тілі/Профессионально-ориентированный иностранный язык/Professionally focused foreign language | 2 | | | 0+2+0 | | | | | |
| **IKT 1103** | Ақпараттық-коммуникациялық технологиялар (ағыл.)/ Информационно-коммуникационные технологии (англ.)/ Information and Communication Technologies (in English) | 2 | 1+0+1 | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | **Математикалық пәндер/Математическиедисциплины/Mathematical subjects** | **18** | | | | | | | | |
| **MA1204** | Математикалық анализ 1 **(ОЖСБ)/**Математическийанализ1**(ВОУД)**/Mathematical analysis 1**(EEEA)** | 4 | 2+2+0 | | | | | | | |
| **MA1205** | Математикалық анализ 2 /Математический анализ 2 /Mathematicalanalysis 2 | 4 | | 2+2+0 | | | | | | |
| **LA1206** | Сызықтықалгебра/ Линейная алгебра Linear algebra | 3 | | 2+1+0 | | | | | | |
| **AG1207** | Аналитикалық геометрия/Аналитическая геометрия/Analyticalgeometry | 3 | | 2+1+0 | | | | | | |
| **DU 2208** | Қалыптыдифференциалдықтеңдеулер**(ОЖСБ)**/ Обыкновенныедифференциальные уравнения **(ВОУД)**/Ordinary Differential equations**(EEEA)** | 4 | | | | 2+2+0 | | | | |
| | **Барлығы міндетті компонент бойынша/ Итого по обязательномукомпоненту/ Total of obligatory component** | **24** | **6** | **10** | **4** | **4** | **0** | **0** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)/ КОМПОНЕНТ ПО ВЫБОРУ (КВ)/ELECTIVECOMPONENT (EC)** | | **48** | | | | | | | | |
| **Білім беру бағдарламасының базалық пәндері/Базовые дисциплины образовательной программы/Main disciplines of the educational program** | | | | | | | | | | |
| | **Математикалық пәндер/Математические дисциплины/Mathematicaldisciplines** | **39** | | | | | | | | |
| **OA1209** | Алгебранегіздері/ Основы алгебры/ The Basics of Algebra | 3 | 2+1+0 | | | | | | | |
| **DM1210** | Дискретті математика/ Дискретная математика/ Discrete mathematics | 3 | | 2+1+0 | | | | | | |
| **MA2211** | Көп өлшемді талдау/ Многомерный анализ Multivariable Calculus | 4 | | | 2+2+0 | | | | | |
| **ML2212** | Математикалық логика / Математическая логика Mathematicallogic | 3 | | | 2+1+0 | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **DG2213** | Дифференциалдық геометрия/ Дифференциальная геометрия/ Differential geometry | 3 | | | 2+1+0 | | | | | |
| **VIMO 2214** | Вариациялық қисаптар және тиімділеу әдістері<br>Вариационное исчисление и методы оптимизации<br>Variation calculus and Methods of optimization | 3 | | | | 2+1+0 | | | | |
| **MM2215** | Математикалық моделдеу<br>Математическое моделирование<br>Mathematicalmodeling | 3 | | | | 2+1+0 | | | | |
| **VA2216** | Векторлық талдау /Векторныйанализ<br>Vector Analysis | 3 | | | | 2+1+0 | | | | |
| **OT2217** | Жалпы топология/ Общая топология<br>Generaltopology | 3 | | | | 2+1+0 | | | | |
| **KA3218** | Комплекс талдау/ Комплексный анализ<br>ComplexAnalysis | 3 | | | | | 2+1+0 | | | |
| **DUShP 3219** | Дербес туындылы дифференциалдық теңдеулер<br>Дифференциальные уравнения в частных производных<br>PartialDifferentialEquations | 4 | | | | | | 2+2+0 | | |
| **ShM3220** | Сандық әдістер/ Численныеметоды<br>Numerical methods | 4 | | | | | | | 2+0+2 | |
| | **STEM модулі/STEM-модуль/STEM Module** | **9** | | | | | | | | |
| **P2221** | Программалау/ Программирование/Programming | 3 | | | 2+1+0 | | | | | |
| **F3222** | Физика/ Физика/Physics | 3 | | | | | 2+1+0 | | | |
| **TM 3223** | Теориялық механика/ Теоретическая механика/Theoretical Mechanics | 3 | | | | | | 2+0+1 | | |
| | **Таңдау компоненті бойынша барлығы /<br>Итого компонент по выбору /<br>Total of elective component** | **48** | **3** | **3** | **13** | **12** | **6** | **7** | **4** | |
| | **Базалық пәндер бойынша барлығы /<br>Итого по базовым дисциплинам /<br>Total on core disciplines** | **72** | **9** | **13** | **17** | **16** | **6** | **7** | **4** | |
| **КӘСІПТЕНДІРУ ПӘНДЕРІ (КП) / ПРОФИЛИРУЮЩИЕ ДИСЦИПЛИНЫ (ПД) / MAJOR DISCIPLINES (MD)** | | **35** | | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **МІНДЕТТІ КОМПОНЕНТ (МК) / ОБЯЗАТЕЛЬНЫЙ КОМПОНЕНТ (ОК) / OBLIGATORYCOMPONENT (OC)** | | **8** | | | | | | | | |
| **TVMS 2301** | Ықтималдықтартеориясыжәне математикалық статистика **(ОЖСБ)/**Теория вероятностей и математическая статистика**(ВОУД)/**Probability Theory and Mathematical statistics**(EEEA)** | 4 | | | | | 2+2+0 | | | |
| **FA3302** | Функционалдық анализ **(ОЖСБ)/**Функциональный анализ **(ВОУД)/**Functional Analysis**(EEEA)** | 4 | | | | | | 2+2+0 | | |
| | **Барлығы міндетті компонент бойынша/Итого по обязательномукомпоненту/Total on obligatory component** | **8** | **0** | **0** | **0** | **0** | **4** | **4** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)<br>КОМПОНЕНТ ПО ВЫБОРУ (КВ) / ELECTIVECOMPONENT (EC)** | | **25** | | | | | | | | |
| **EC3303** | Subject 1* from Elective Course of Majors | 3 | | | | | 2+1+0 | | | |
| **EC3304** | Subject 2* from Elective Course of Majors | 3 | | | | | 2+1+0 | | | |
| **EC3305** | Subject 3* from Elective Course of Majors | 3 | | | | | | 2+1+0 | | |
| **EC3306** | Subject 4* from Elective Course of Majors | 3 | | | | | | 2+1+0 | | |
| **EC3307** | Subject 5* from Elective Course of Majors | 2 | | | | | | 1+1+0 | | |
| **EC4308** | Subject 6* from Elective Course of Majors | 3 | | | | | | | 2+1+0 | |
| **EC4309** | Subject 7* from Elective Course of Majors | 3 | | | | | | | 2+1+0 | |
| **EC4310** | Subject 8* from Elective Course of Majors | 3 | | | | | | | 2+1+0 | |
| **EC4311** | Subject 9* from Elective Course of Majors | 2 | | | | | | | 1+1+0 | |
| | **Таңдау компоненті бойынша барлығы / Итого компонент по выбору /Total on elective component** | **25** | | | | | **6** | **8** | **11** | |
| **ПӘНАРАЛЫҚ МОДУЛЬ, МЕЖДИСЦИПЛИНАРНЫЙ МОДУЛЬ, INTERDISCIPLINARYMODULE** | | **2** | | | | | | | | |
| **BD 3312** | Үлкен мәліметтер/ Большие данные/ Bigdata | 2 | | | | | | 1+1+0 | | |
| **MMBM 3313** | Биология және медицинадағы математикалық моделдеу<br>Математическое моделирование в биологии и медицине | 2 | | | | | | 1+1+0 | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | Mathematical models in biology and medicine | | | | | | | | | |
| **AM3314** | Актуарлық математика/ Актуарная математика<br>Actuarialmathematics | 2 | | | | | | 1+1+0 | | |
| **TSASPAD 3315** | Деректерді қолданбалы талдаудағы SAS технологиясы<br>Технологии SAS в прикладном анализе данных<br>SAS Technologies in Applied Data Analysis | 2 | | | | | | 1+1+0 | | |
| | **Пәнаралық модуль бойынша барлығы / Итого по междисциплинарный модуль /<br>Total of interdisciplinary module** | **2** | | | | | | **2** | | |
| | **Кәсіптендіру пәндері бойынша барлығы / Итого по профилирующим дисциплинам / Total on majordisciplines** | **35** | | | | | **10** | **14** | **11** | |
| | **Теориялық оқыту бойынша барлығы<br>Всего по теоретическому обучению /<br>Total of theoretical studies** | **129** | **18** | **19** | **17** | **19** | **18** | **21** | **17** | |
| | **Дене шынықтыру модулі / Модуль физической культуры / PhysicalTrainingModule** | | | | | | | | | |
| **FK** | Дене шынықтыру /Физическая культура /Physical Training | **8** | 0+0+2 | 0+0+2 | 0+0+2 | 0+0+2 | | | | |
| | **Кәсіптік практика модулі/Модуль профессиональной практики/Professional practicemodule** | **10** | | | | | | | | |
| **UP** | Оқу практикасы/Учебная практика/Educational Internship | 2 | | 2<br>(1нед) | | | | | | |
| **PrP** | Өндірістік практика/ Производственная практика/ PracticeTraining | 2 | | | | 1<br>(2нед) | | 1<br>(2нед) | | |
| **PP** | Педагогикалық практика /<br>Педагогическая практика<br>Educational Practice | 4 | | | | | | | | 4(5 нед weeks) |
| **PdP** | Диплом алды практика/<br>Преддипломная практика/<br>Pre-Graduation Internship | 2 | | | | | | | | 2 (5 нед weeks) |
| | **Қосымша оқу түрлері бойынша барлығы / Итого по** | **18** | **2** | **4** | **2** | **3** | **0** | **1** | **0** | **6** |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | **дополнительным видам обучения / Total on additional types of training** | | | | | | | | | |
| **ҚОРЫТЫНДЫ АТТЕСТАЦИЯ/ИТОГОВАЯ АТТЕСТАЦИЯ/FINALATTESTATION** | | **3** | | | | | | | | |
| GES | Мамандық бойынша мемлекеттік емтихан / Государственный экзамен по специальности / State exam on the specialty | 1 | | | | | | | | 1 (5 нед/weeks) |
| NZDR | Диплом жұмысын (жобасын) жазу және қорғау / Написание и защита дипломной работы (проекта) / Writing and Presentation of Diploma Work (Project) | 2 | | | | | | | | 2 (4 нед/ weeks) |
| **БАРЛЫҒЫ / ИТОГО /TOTAL** | | **150** | **20** | **23** | **19** | **22** | **18** | **22** | **17** | **9** |

| *MAJOR Elective Courses<br>**Note:** Student selects nine subject for 25 credits from the following list: Subject 1* – Subject 9* | |
|---|---|
| 1. Fourier series<br>2. Applied functional analysis<br>3. Spectral theory of linear operators<br>4. Number Theory<br>5. Approximation Theory<br>6. Pseudo-differential Operators on compact Lie groups<br>7. Hyperbolic equations with distributional data and coefficients<br>8. Nonharmonic Analysis<br>9. Elements of the theory of computation<br>10. Algebraic system<br>11. The theory of algorithms<br>12. Introduction to models<br>13. Introduction to classical geometry<br>14. Stochastic Differential Equations<br>15. Stochastic financial mathematics<br>16. Stochastic processes<br>17. Non-parametric statistic and learning theory<br>18. The theory of random matrices | 19. Qualitative theory of differential equations<br>20. Periodic and conditionally periodic solutions of differential equations<br>21. The theory of generalized Lyapunov exponents<br>22. Asymptotic methods for solving singularly perturbed equations<br>23. Integral and integro-differential equations<br>24. Theoretical and computational questions of the equations of mathematical physics<br>25. Modern methods for solving boundary value problems of partial differential equations<br>26. The motion stability theory<br>27. Methods of Teaching Mathematics<br>28. General theory of extreme problems<br>29. Mathematical programming<br>30. Optimal control<br>31. The boundary problems of control theory<br>32. Practical solving of optimization problems and counterexamples in optimal control theory<br>33. Optimization problems for the distributed parameter systems and the differentiation theory<br>34. Boundary value problems of mathematical physics<br>35. Introduction to the inverse problems theory of mathematical physics<br>36. Special functions in problems of mathematical physics |

**Академиялықдәрежесі:** 5В060100 - математикамамандығыбойыншажаратылыстанубакалавры(мамандандандырылуы Актуарлыматематика)
**Академическая степень:** Бакалавр естествознания по специальности 5В060100 - Математика (для специализации Актуарная математика)
**Academic degree:** Bachelor of Natural Sciences on a specialty 5В060100 – Mathematics (for specialization Actuarial Mathematics)

| **Коды<br>Код<br>Code** | **Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities** | **Кредит саны<br>Кредиты<br>Credits** | **Семестры/Семестры/Semesters** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** |
| | | | **Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab** | | | | | | | |
| **ЖАЛПЫ БІЛІМ БЕРЕТІН ПӘНДЕР (ЖББП)<br>ОБЩЕОБРАЗОВАТЕЛЬНЫЕ ДИСЦИПЛИНЫ (ООД)<br>GENERAL EDUCATION DISCIPLINES (GED)** | | **22** | | | | | | | | |
| **МІНДЕТТІКОМПОНЕНТ (МК)<br>ОБЯЗАТЕЛЬНЫЙКОМПОНЕНТ (ОК)<br>OBLIGATORYCOMPONENT (OC)** | | **18** | | | | | | | | |
| | **Әлеуметтік-гуманитарлықмодуль/ Социально-гуманитарныймодуль/ Social and humanitarian module** | **6** | | | | | | | | |
| **SIK1101** | Қазақстанның қазіргі заман тарихы (Мемлекеттік емтихан)/ Современная история Казахстана (Государственный экзамен)/ Modern history of Kazakhstan (State Examination) | 3 | 2+1+0 | | | | | | | |
| **Fil 2102** | Философия/ Философия/ Philosophy | 3 | | | | 2+1+0 | | | | |
| | **Инструменталды модуль/ Инструментальный модуль/ Instrumentalmodule** | **12** | | | | | | | | |
| **IYa 1103** | Шетелтілі/ Иностранный язык / ForeignLanguage | 6 | 0+3+0 | 0+3+0 | | | | | | |
| **K(R)Ya 1104** | Қазақ (орыс) тілі/ Казахский (русский) язык/ Kazakh (Russian) Language | 6 | 0+3+0 | 0+3+0 | | | | | | |
| | **Барлығы міндетті компонент бойынша<br>Итого по обязательному компоненту<br>Total of obligatory component** | **18** | **9** | **6** | **0** | **3** | **0** | **0** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)<br>КОМПОНЕНТ ПО ВЫБОРУ (КВ)** | | **4** | | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **ELECTIVECOMPONENT (EC)** | | | | | | | | | | |
| | **Мәдени-коммуникативтікмодуль/ Культурно-коммуникативныймодуль/ Cultural and communicative module** | **4** | | | | | | | | |
| **KRYaK 3105** | Сөз мәдениеті және тілдік қарым-қатынас/ Культура речи и языковая коммуникация/ Culture of Speech and LanguageCommunication | 2 | | | | | 1+1+0 | | | |
| **PMK 3106** | Тұлғааралық қарым-қатынас коммуникацияның психологиясы/Психологиямежличностнойкоммуникации/ Psychology of interpersonal communication | 2 | | | | | 1+1+0 | | | |
| | **Қоғамдық-саясимодуль/ Общественно-политическиймодуль/ Social and political module** | **4** | | | | | | | | |
| **TPP 3107** | Теориялықжәнеқолданбалысаясаттану/ Теоретическаяиприкладнаяполитология/ Theoretical and Applied Political Science | 2 | | | | | 1+1+0 | | | |
| **OPS 3108** | Жалпыжәнеқолданбалыәлеуметтану/ Общаяиприкладнаясоциология/ General and Applied Sociology | 2 | | | | | 1+1+0 | | | |
| | **Экологиялық модуль/Экологический модуль/EcologyModule** | | | | | | | | | |
| **EUR3109** | Экологияжәнеорнықты даму/ Экологияиустойчивоеразвитие/ Ecology and Sustainable Development | 2 | | | | | 1+1+0 | | | |
| **BGCh3110** | Адам тіршілігінің қауіпсіздігі/ Безопасность жизнедеятельности человека/HumanLifeSafety | 2 | | | | | 1+1+0 | | | |
| | **Модуль« Қазіргі қоғамның әлеуметтік-саяси және тарихи негіздері/Социально-политические и исторические основы современного общества/Socio-political and historical foundations of modern society»** | **4** | | | | | | | | |
| **DVFIS 4111** | Рухани жаңғыру және тарихи сананың қалыптасуы/ Духовное возрождение и формирование исторического сознания/ Spiritual Revival and the Formation of Historical | 2 | | | | | | | 1+1+0 | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | Consciousness | | | | | | | | | |
| **KP4112** | Қазақстандыққұқық/Казахстанскоеправо/Kazakhstan Law | 2 | | | | | | | 1+1+0 | |
| **OE4113** | Экономиканегіздері/ Основыэкономики/Fundamentals of Economics | 2 | | | | | | | 1+1+0 | |
| | **Тарихи-мәдени модуль/ Историко-культурный модуль/Historyandculturemodule** | **4** | | | | | | | | |
| **AFS4114** | Әл-Фараби және қазіргі заман/Аль-Фараби и современностьAl-Farabi and modernity | 2 | | | | | | | 1+1+0 | |
| **KR4115** | Мәдениетжәнедін/Культураирелигия/Culture and religion | 2 | | | | | | | 1+1+0 | |
| **MPMIM4116** | Математиканы оқыту әдістемесі, математика тарихы/ Методика преподавания математики, история математики/ Methods of teaching mathematics, the history of mathematics | 2 | | | | | | | 1+1+0 | |
| | **Таңдау компоненті бойынша барлығы/Компонент по выбору, итого/Total of elective component** | **4** | **0** | **0** | **0** | **0** | **2** | **0** | **2** | **0** |
| | **Жалпы білім беретін пәндер бойынша барлығы/ Итогопо общеобразовательным дисциплинам Total of generaleducationdisciplines** | **22** | **9** | **6** | **0** | **3** | **2** | **0** | **2** | **0** |
| **БАЗАЛЫҚ ПӘНДЕР (БП) /БАЗОВЫЕ ДИСЦИПЛИНЫ (БД)/COREDISCIPLINES(CD)** | | **72** | | | | | | | | |
| **МІНДЕТТІ КОМПОНЕНТ (МК)/ОБЯЗАТЕЛЬНЫЙ КОМПОНЕНТ (ОК)/OBLIGATORYCOMPONENT (OC)** | | **24** | | | | | | | | |
| | **Кәсіби тілдер және АКТ/Профессиональные языки и ИКТ/Professional languages and ICT** | **6** | | | | | | | | |
| **PK (R) Ya 2201** | Кәсіби бағдарлы қазақ(орыс) тілі\ Профессионально-ориентированный казахский(русский) язык Professionally-Oriented Kazakh (Russian)Language | 2 | | | 0+2+0 | | | | | |
| **POIYa2202** | Кәсіби-бағдарлы шетел тілі/Профессионально-ориентированный иностранный язык/The professional focused foreign language | 2 | | | 0+2+0 | | | | | |
| **IKT 1103** | Ақпараттық-коммуникациялық технологиялар (ағыл.)/ Информационно-коммуникационные | 2 | 1+0+1 | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | технологии (англ.)/ Information and Communication Technologies (in English) | | | | | | | | | |
| | **Математикалық пәндер/Математическиедисциплины/Mathematical subjects** | **18** | | | | | | | | |
| **MA1204** | Математикалық анализ 1 **(ОЖСБ)/**Математическийанализ1**(ВОУД)**/Mathematical analysis 1**(EEEA)** | 4 | 2+2+0 | | | | | | | |
| **MA1205** | Математикалық анализ 2 /Математический анализ 2 /Mathematicalanalysis 2 | 4 | | 2+2+0 | | | | | | |
| **LA1206** | Сызықтықалгебра/ Линейная алгебра<br>Linear algebra | 3 | | 2+1+0 | | | | | | |
| **AG1207** | Аналитикалық геометрия/Аналитическая геометрия/Analyticalgeometry | 3 | | 2+1+0 | | | | | | |
| **DU 2208** | Қалыптыдифференциалдықтеңдеулер**(ОЖСБ)**/ Обыкновенныедифференциальные уравнения **(ВОУД)**/Ordinary Differential equations**(EEEA)** | 4 | | | | 2+2+0 | | | | |
| | **Барлығы міндетті компонент бойынша/<br>Итого по обязательномукомпоненту/<br>Total of obligatory component** | **24** | **6** | **10** | **4** | **4** | **0** | **0** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)/ КОМПОНЕНТ ПО ВЫБОРУ (КВ)/ELECTIVECOMPONENT (EC)** | | **48** | | | | | | | | |
| **Білім беру бағдарламасының базалық пәндері/Базовые дисциплины образовательной программы/Main disciplines of the educational program** | | | | | | | | | | |
| | **Математикалық пәндер/Математические дисциплины/Mathematicaldisciplines** | **39** | | | | | | | | |
| **OA1209** | Алгебранегіздері/ Основы алгебры/ Basics of Algebra | 3 | 2+1+0 | | | | | | | |
| **OFM1210** | Қаржылық математика негіздері<br>Основыфинансовой математики<br>Fundamentals of financial mathematics | 3 | | 2+1+0 | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **MA2211** | Көп өлшемді талдау/ Многомерный анализ<br>Multivariable Calculus | 3 | | | 2+2+0 | | | | | |
| **DMML1212** | Дискретті математика және математикалық логика<br>Дискретная математика и математическая логика<br>Discrete mathematicsand Mathematical logic | 4 | | 2+1+0 | | | | | | |
| **TMIL 2213** | Өлшем және Лебег интегралы теориясы<br>Теория меры и интеграла Лебега<br>Measure and Lebegues Integration theory | 3 | | | 2+1+0 | | | | | |
| **P2214** | ПрограммированиеC#/ Программирование на C#<br>ProgramminginC# | 3 | | | | 2+1+0 | | | | |
| **MM2215** | Математикалық моделдеу<br>Математическое моделирование<br>Mathematicalmodeling | 3 | | | | 2+1+0 | | | | |
| **TSP2216** | Кездейсоқ үрдістер теориясы<br>Теорияслучайныхпроцессов<br>The theory of random processes | 3 | | | | 2+1+0 | | | | |
| **APP2217** | Актуарлық принциптер және оның қолданыстары-1<br>Актуарные принципы и их применение-1<br>Actuarial principles and their applications-1 | 3 | | | | 2+1+0 | | | | |
| **KA3218** | Комплекс талдау/ Комплексный анализ<br>ComplexAnalysis | 3 | | | | | 2+1+0 | | | |
| **DUShP 3219** | Дербес туындылы дифференциалдық теңдеулер<br>Дифференциальные уравнения в частных производных<br>PartialDifferentialEquations | 4 | | | | | | 2+2+0 | | |
| **ShM3220** | Сандық әдістер/ Численныеметоды<br>Numerical methods | 4 | | | | | | | 2+0+2 | |
| | **STEM модулі/STEM-модуль/STEM Module** | **9** | | | | | | | | |
| **P 2221** | Программалау/ Программирование<br>Programming | 3 | | | 2+1+0 | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **TSZh 3222** | Өмірді сақтандыру теориясы<br>Теориястрахованияжизни<br>Theoryoflifecontingencies | 3 | | | | | 2+1+0 | | | |
| **SUBD 3223** | Дерекқорды басқаружүйесі<br>Системауправления базами данных<br>Database management system | 3 | | | | | | 2+0+1 | | |
| | **Таңдау компоненті бойынша барлығы /<br>Итого компонент по выбору /<br>Total of elective component** | **48** | **3** | **3** | **13** | **12** | **6** | **7** | **4** | |
| | **Базалық пәндер бойынша барлығы /<br>Итого по базовым дисциплинам /<br>Total of core disciplines** | **72** | **9** | **13** | **17** | **16** | **6** | **7** | **4** | |
| **КӘСІПТЕНДІРУ ПӘНДЕРІ (КП) / ПРОФИЛИРУЮЩИЕ ДИСЦИПЛИНЫ (ПД) / MAJOR DISCIPLINES (MD)** | | **35** | | | | | | | | |
| **МІНДЕТТІ КОМПОНЕНТ (МК) / ОБЯЗАТЕЛЬНЫЙ КОМПОНЕНТ (ОК) / OBLIGATORYCOMPONENT (OC)** | | **8** | | | | | | | | |
| **TVMS 2301** | Ықтималдықтартеориясыжәне математикалық статистика **(ОЖСБ)/**Теория вероятностей и математическая статистика**(ВОУД)/**Probability Theory and Mathematical statistics**(EEEA)** | 4 | | | | | 2+2+0 | | | |
| **FA3302** | Функционалдық анализ **(ОЖСБ)/**Функциональный анализ **(ВОУД)/**Functional Analysis**(EEEA)** | 4 | | | | | | 2+2+0 | | |
| | **Барлығы міндетті компонент бойынша/Итого по обязательномукомпоненту/Total of obligatory component** | **8** | **0** | **0** | **0** | **0** | **4** | **4** | **0** | **0** |
| **ТАҢДАУ БОЙЫНША КОМПОНЕНТ (ТК)<br>КОМПОНЕНТ ПО ВЫБОРУ (КВ) /ELECTIVECOMPONENT (EC)** | | **25** | | | | | | | | |
| **EC3303** | Subject 1** from Elective Course of Majors | 3 | | | | | 2+1+0 | | | |
| **EC3304** | Subject 2**from Elective Course of Majors | 3 | | | | | 2+1+0 | | | |
| **EC3305** | Subject 3** from Elective Course of Majors | 3 | | | | | | 2+1+0 | | |
| **EC3306** | Subject 4** from Elective Course of Majors | 3 | | | | | | 1+1+0 | | |
| **EC3307** | Subject 5** from Elective Course of Majors | 3 | | | | | | 2+1+ | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| **EC4308** | Subject 6** from Elective Course of Majors | 2 | | | | | | | 2+1+0 | |
| **EC4309** | Subject 7** from Elective Course of Majors | 3 | | | | | | | 2+1+0 | |
| **EC4310** | Subject 8** from Elective Course of Majors | 3 | | | | | | | 2+1+0 | |
| **EC4311** | Subject 9** from Elective Course of Majors | 3 | | | | | | | 1+1+0 | |
| | **Таңдау компоненті бойынша барлығы / Итого компонент по выбору /<br>Total of elective component** | **25** | | | | | **6** | **8** | **11** | |
| **ПӘНАРАЛЫҚ МОДУЛЬ, МЕЖДИСЦИПЛИНАРНЫЙ МОДУЛЬ, INTERDISCIPLINARYMODULE** | | **2** | | | | | | | | |
| **BD 3312** | Үлкен мәліметтер/ Большие данные/ Bigdata | 2 | | | | | | 1+1+0 | | |
| **MMBM 3313** | Биология және медицинадағы математикалық моделдеу<br>Математическое моделирование в биологии и медицине<br>Mathematical models in biology and medicine | 2 | | | | | | 1+1+0 | | |
| **MD3314** | Математикалық демография / Математическая демография<br>Mathematical demography | 2 | | | | | | 1+1+0 | | |
| **EMM 3315** | Экономикадағы математикалықмоделдер<br>Экономико-математические модели<br>Economic-mathematicalmodels | 2 | | | | | | 1+1+0 | | |
| | **Пәнаралық модуль бойынша барлығы / Итого по междисциплинарный модуль /<br>Total of interdisciplinary module** | **2** | | | | | | **2** | | |
| | **Кәсіптендіру пәндері бойынша барлығы / Итого по профилирующим дисциплинам / Total of majordisciplines** | **35** | | | | | **10** | **14** | **11** | |
| | **Теориялық оқыту бойынша барлығы<br>Всего по теоретическому обучению /<br>Total of theoretical studies** | **129** | **18** | **19** | **17** | **19** | **18** | **21** | **17** | |
| | **Дене шынықтыру модулі / Модуль физической культуры / PhysicalTrainingModule** | | | | | | | | | |
| **FK** | Дене шынықтыру /Физическая культура /PhysicalTraining | **8** | 0+0+2 | 0+0+2 | 0+0+2 | 0+0+2 | | | | |
| | **Кәсіптік практика модулі/Модуль профессиональной** | **10** | | | | | | | | |

| Коды<br>Код<br>Code | Пән атаулары/оқу жұмысының түрлері<br>Наименования дисциплин видов учебной работы<br>Names of disciplines/other educational activities | Кредит саны<br>Кредиты<br>Credits | Семестры/Семестры/Semesters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V | VI | VII | VIII |
| | | | Дәр+ практ+ лаб/ Лек+практ+лаб/lec+ practice+ lab | | | | | | | |
| | **практики/Professional practicemodule** | | | | | | | | | |
| **UP** | Оқу практикасы/Учебная практика/EducationalInternship | 2 | | 2 (1нед) | | | | | | |
| **PrP** | Өндірістік практика/ Производственная практика/ PracticeTraining | 2 | | | | 1 (2нед) | | 1 (2нед) | | |
| **PP** | Педагогикалық практика /<br>Педагогическая практика<br>Educational Practices | 4 | | | | | | | | 4(5 нед weeks) |
| **PdP** | Диплом алды практика/<br>Преддипломная практика/<br>Pre-Graduation Internship | 2 | | | | | | | | 2 (5 нед weeks) |
| | **Қосымша оқу түрлері бойынша барлығы / Итого по дополнительным видам обучения / Total on additional types of training** | **18** | **2** | **4** | **2** | **3** | **0** | **1** | **0** | **6** |
| **ҚОРЫТЫНДЫ АТТЕСТАЦИЯ/ИТОГОВАЯ АТТЕСТАЦИЯ/FINALATTESTATION** | | **3** | | | | | | | | |
| GES | Мамандық бойынша мемлекеттік емтихан/ Государственный экзамен по специальности / State exam in the specialty | 1 | | | | | | | | 1 (5 нед/weeks) |
| NZDR | Диплом жұмысын (жобасын) жазу және қорғау / Написание и защита дипломной работы (проекта) /<br>Writing and Presentation of Diploma Work (Project) | 2 | | | | | | | | 2 (4 нед/ weeks) |
| **БАРЛЫҒЫ / ИТОГО /TOTAL** | | **150** | **20** | **23** | **19** | **22** | **18** | **22** | **17** | **9** |

****MAJOR Elective Courses**

**Note:** Student selects nine subject for 25 credits from the following list: Subject 1** – Subject 9**

| | |
|---|---|
| 1. Actuarial principles and their applications-2<br>2. Stochastic processes<br>3. Non-parametric statistic and learning theory<br>4. The theory of random operations<br>5. Multidimensional Statistical Analysis<br>6. Time series statistics | 7. Financial Statistics<br>8. Statistics of random processes<br>9. Mathematical models of investment<br>10. Applied Statistics<br>11. Variation calculus and Methods of optimization |

| | |
|---|---|

**Note**: Additional to above education institutions can introduce their own special courses.

# LEARNING UNITS OF SUBJECTS

## 1. GENERAL EDUCATION
## THE MODERN HISTORY OF KAZAKHSTAN

**Learning Units:**

1. Kazakhstan on the way to Independence: the phase of development and nation-building ideas
   1.1. Socio-economic situation in Kazakhstan - preconditions struggle for independence.
   1.2. The origins of the national movement of the Kazakh people.
   1.3. The historical origins of the formation of the Soviet Kazakhstan: challenges indigenization.
   1.4. Formation of the Soviet totalitarian Kazakhstan: character, actions and consequences.
   1.5. The exploits and the loss of Kazakhstan in the fight against fascist aggression.
2. The contradictions and consequences of the Soviet reforms in Kazakhstan in the second half of the XX century.
   2.1. Apogee «cult of personality» and the influence of the «thaw» in the socio-political sphere.
   2.2. Socio-economic and spiritual «stagnation» Ecological problems of Kazakhstan.
   2.3. Attempts to "reconstruction" Soviet Kazakhstan.
   2.4. State strategy and socio-economic development of independent Kazakhstan.
   2.5. Formation of government of the Republic of Kazakhstan.
   2.6. Kazakhstani model of economic development.
   2.7. Social reforms and changes in the field of education.
   2.8. Ethnodemographic processes and strengthening of interethnic consent.
3. Democratic and spiritual renewal of independent Kazakhstan.
   3.1. Social and political prospects.
   3.2. The youth policy in the Republic of Kazakhstan and the path of spiritual renewal.
   3.3. Policy formation of a new historical consciousness and outlook of the people of the Great Steppe.
4. The value of the Leader of the nation program "People in the stream of history" for the formation of a new historical consciousness.
5. The significance of the celebration of 550 anniversary of the Kazakh Khanate for the formation of a new social consciousness.
6. «Mangilik El» - Kazakhstan national idea of the XXI century.
7. Kazakhstan - a country recognized by the modern world.

## KAZAKH (RUSSIAN) LANGUAGE
**Learning Units:**

1. Introductory course: language and speech. The main functions of language.
   1.1. Language and its basic functions. Speech: types and forms of speech. General characteristics of the forms and types of speech.
   1.2. Text as the leading unit of verbal communication. The main features of the text. Methods of communication proposalsin the text.
   1.3. Functional-semantic types of speech. Understanding the types of monologue speech.
   1.4. Functional styles of speech. General characteristics of functional speech styles.
   1.5. Conversational style. Art style. Journalistic style. Official-business style.
   1.6. Style and language features. The main genres of documentation. Preparation of documents: autobiography, resume, declarations, powers of attorney, receipts, reports and others.

1.7. Scientific style and its features. Stylistic features of scientific style. Lexical and grammatical means o fscientific style.

2. Structural-semantic division of scientific text.

2.1. Types of scientific information, incorporated in the text.

2.2. Definition: general characteristics. Introduction of the term.

2.3. Features more information text (summarizing, concretizing illustrating opening, the substitute).

2.4. Communicative situation scientific field of communication.

3. The culture of professional speech. Scientificdiscussion

3.1. Oral scientific speech. Information genres: abstract, message, lecture, report. The structure of oral monologue. Performing with elements dialogization: the question of the author - the answer to it, dialogized monologue - interaction with the audience, inclusion of students in the monologue.

3.2. Convincing genres in scientific and journalistic style. Discussion. Dispute. Controversy. The objectives of the discussion of communication. Voice actions involved in the discussion dealing.

**FOREIGN LANGUAGE**

**LearningUnits:**

1. Higher education in Kazakhstan. The system of education in Great Britain and in the USA. Myuniversity. Myfuturespecialty.
2. Environmentalproblems.
3. Electricity. Non-traditional sources of energy.
4. Electronics. Television.
5. Computers.
6. New technological achievements in new materials production.
7. Made in Space. Transport for tomorrow.
8. A New Era for Aircraft.
9. Watertransport.
10. Technologicalandscientificachievements.
11. Optical technology and laser application.
12. Superconductivity.
13. TheInternationalSpaceStation.

**PHILOSOPHY**

**LearningUnits:**

1. Thesubjectofphilosophy.
2. Subject matter, purpose and function of philosophy.
3. Historyofphilosophy
4. The philosophy of the ancient world.
5. The philosophy of the Middle Ages of the East and the West
6. RenaissancePhilosophy
7. The philosophy of the New Age
8. The philosophy of the European Enlightenment of the XVIII century.
9. ClassicalGermanPhilosophy.
10. The philosophy of the end of the eighteenth century - beginning of the XXI century.
11. Kazakhphilosophy.
12. Basics of philosophical understanding of the world.

13. Being as the central category of ontology.
14. Development principle: dialectics and synergy.
15. Possibilities and boundaries of knowledge. The specificity of scientific knowledge.
16. Philosophy in the search and development.
17. Philosophicalanthropology.
18. Socialphilosophy.
19. Philosophical understanding of today's global challenges.

**METHODS OF TEACHING MATHEMATICS, THE HISTORY OF MATHEMATICS**

1. Analysis, goals and objectives of teaching mathematics in high school
2. Develop and overall characteristics of method of scientific knowledge
3. Exploring enhance the cognitive activity of students
4. Analysis of the main trends in the development of mathematics education
5. Drafting and decision versions of examinations and tests in mathematics in 3-4courses
6. Mathematics lessons. Drafting outline mathematics lessons, conduct and analysis
7. Production and use of appropriate tables, charts and workbooks for math lesson
8. Mathematics classroom. Visual aids in mathematics.
9. Characterizing the basic purpose and content of teaching mathematics at 1-2 courses, 3-4 courses.
10. Reading the explanatory notes to the programs in mathematics for high school
11. Introduction to the program, textbooks and manuals for teachers of mathematics in 1-4 courses
12. Application of student centered methods of lesson
13. Planning and abstract lesson to build mathematical concepts in 1-3 courses
14. Different ways to search for solution to problems
15. Developing synopsis lesson on the proposed topics, making suggestions for the lesson. Analyzing of lesson on the proposed sheme.

**2. BASIC DISCIPLINES**

**PROFESSIONALLY-ORIENTED KAZAKH (RUSSIAN) LANGUAGE**

**LearningUnits:**

1. Introduction
   1.1. Introduction to the subject area on the professional Kazakh (Russian) language.
   1.2. Foundations for mastery of subject-language material.
   1.3. Basic categorical and conceptual apparatus in his professional Kazakh (Russian) language.
   1.4. Professional terminology in Kazakh (Russian) language.
   1.5. Feature content domain majoring in Kazakh (Russian) language.
2. Simulationofrandomlaws.
   2.1. Simulationofrandomnumbers.
   2.2. Simulationofrandomevents.
   2.3. Simulation of continuous random variables.
   2.4. Simulationofrandomvectors.
   2.5. Modeling of random processes and flow requirements.
   2.6. Identification of the random laws.
3. Simulation models of information processes.
   3.1. Organizationsimulation.
   3.2. Simulation of queuing systems and Petri nets.
   3.3. Physicalmodeling.
   3.4. Simulation modeling of economic and organizational systems.
   3.5. Simulation modeling of management information systems.

**THE PROFESSION FOCUSED FOREIGN LANGUAGE**
**Learning Units:**

1. Introduction.
    1.1. Introduction to the subject area of specialty in the professional foreign language.
    1.2. Professional foreign language disciplinary phenomenon, serving all areas of human activity.
    1.3. Terminology, Lexicology of foreign languages. History of project management development.
2. Project Life Cycle and Organization project.
    2.1. Summaryofprojectmanagement.
    2.2. Caseclassificationprojects.
    2.3. ProjectLifeCycle.
    2.4. Group management processes: initiation, planning, monitoring and management, execution, completion.
3. ProjectIntegrationManagement.
    3.1. The stages of project planning.
    3.2. Structural hierarchical decomposition of the work.
    3.3. Control the timing and cost of the project.
    3.4. ProjectQualityManagement.
    3.5. Management of human resources and communications.
4. Risk Management and Project Procurement.
    4.1. Identification of risks, risk response planning, project risk management.
    4.2. ProjectProcurementManagement.
    4.3. Documentation, completion of the project.
    4.4. Trends in the development of project management theory.
    4.5. The use of special terminology, vocabulary of the English language in the project management of information systems in science, technology and business.

**INFORMATION AND COMMUNICATION TECHNOLOGIES**
**Learning Units:**
1. The role of ICTs in key sectors of society. ICT Standards.
2. Introduction into computer systems. Architecture of computer systems.
3. Software. OS.
4. Human-computerinteraction.
5. Databasesystems.
6. Dataanalysis. Datamanagement.
7. NetworksandTelecommunications.
8. Cybersecurity.
9. Internettechnologies.
10. CloudandMobiletechnologies.
11. Multimediatechnologies.
12. Smarttechnology.
13. E-technology. E-business. E-learning. E-government.
14. Information technology in professional sphere. Industrial ICT.
15. ICT DevelopmentProspects

**MATHEMATICAL ANALYSIS 1**
**Learning Units:**
1.The Set Theory. Set Operations. Properties of set operations. The System of Real Numbers. Properties of real numbers.Principle of Mathematical Induction. The bounded above (or below)

sets of numbers. A theorem on the existence and uniqueness of the upper and lower bounds of a nonempty numerical set.
2. Countable and uncountable sets. Cardinality of the set. Properties of set operations. Mapping of sets.
3.Definition of sequence of real numbers. Limits of a sequence. Convergent sequences and their properties. Arithmetic operations on the sequences. Limited, unlimited, infinitely small and infinitely large sequences. Basic properties of infinitely small sequences. The notion of a monotone sequence. Convergence theorem for bounded and monotone sequence. The number e.
4.Fundamental sequences. Cauchy's criterion for convergence of the sequence. Subsequences. Limit points, the upper and lower limits of the sequence. Bolzano-Weierstrass theorem.
5. The concept of variable quantity and function. Limit of a function by Heine and Cauchy.One-sided limits.
6. Cauchy's criterion for the existence of the limit of a function. Arithmetic operations on functions having a limit. Infinitely small and infinitely large functions.
7.Comparison of functions. The definition of a monotone function. The notion of an inverse function. The simplest elementary functions. 1st and 2nd remarkable limits.
8.The continuity of functions at point and their properties.The continuity of functions on a set and their properties: Theorem (Bolzano-Weierstrass) on the intermediate value. The first theorem of Weierstrass. The second theorem of Weierstrass.
9. Continuity of a complex function. Continuity of the basic elementary functions. Properties of monotone functions: the existence of an inverse function, the existence of one-sided limits that are monotonic on a segment, functions. A necessary and sufficient condition for the continuity of a monotone function, the continuity of the inverse function. Uniform continuity. Cantor's theorem. Criterion for uniform continuity of a function on an interval. Points of discontinuity and their classification. On points of discontinuity of a monotone function.Cantor's Theorem.
10. The derivative function. Geometric and physical meaning of the derivative. One-sided derivatives. Differentiable functions, differential. The relationship between differentiability and existence of a derivative, and also between differentiability and continuity at a point. Properties of differentiable functions.
11. Invariance of the form of the first differential. Table of Derivatives of the Basic Elementary Functions. Derivative of a complex function. The derivative of the inverse function, the derivative of the function given parametrically and the derivative of implicitly function. Derivatives of higher orders. Higher-order differentials. The Leibniz formula.
12. Increasing and decreasing functions.Fermat's Theorem. Rolle's Theorem. Lagrange's Theorem. Cauchy's Theorem. L'Hospital's Rule.
13. Taylor's formula. The Maclaurin formula. Expansion by the Maclaurin formula of some elementary functions. Different forms of the remainder term of Taylor formula.
14. Extremum theory, necessary and sufficient conditions for a local extremum of a function. Increment and decrease of the function. The concept of convexity. Sufficient conditions for convexity. Monotonicity conditions for a differentiable function.
15. Inequalities of Jensen, Holder, Minkowski. Inflection points of the function. A necessary condition for curve inflection. Sufficient conditions of inflection. Asymptotes of the graph.

**MATHEMATICAL ANALYSIS 2**

1. The definition of the upper and lower Darboux sums, their basic properties. Upper and lower Darboux integrals. Riemann integral sums. Integral as the limit of Riemann sums. Conditions for the existence of a definite integral. Criterion of integrability. Classes of integrable functions.
2.Integral with variable upper limit and its properties. The Newton-Leibniz formula. Change of the variable and integrating by parts in a definite integral. Estimates of integrals. Integrating the inequality. The first mean value theorem. Second mean value theorem. The remainder term of Taylor formula in integral form.

3. The length of the arc curve. The concept of a simple curve, a parametrizable curve and a rectifiable curve. Properties of rectifiable curves. Criterion of rectifiability of a curve. Calculation of arc length of a curve. Differential arc. The notion of the boundary of the set and a plane figure. The area of a plane figure. Area of curvilinear trapezoid and curvilinear sector. Examples of computing areas. Volume of the body. Some classes of cubed bodies.
4. Approximate calculation of a definite integral. Basic principles of constructing formulas for the approximate calculation of a definite integral. The simplest quadrature formulas (rectangles, trapezoids, Simpson's formula).
5. Concepts of numerical series, convergence and the sum of numerical series. Basic definitions. Properties of convergent series. Cauchy's criterion for convergence of series. The necessary and sufficient condition for the convergence of the series with nonnegative terms: comparison test, Cauchy's test, d'Alembert's test, Raabe's test, Gauss test. Cauchy's integral test for the convergence of a numerical series with nonnegative terms. Logarithmic test.
6. Arbitrary numerical series. Types of convergence. Alternating numerical series. The concept of absolute and conditional convergence of a series. Dirichlet's test and Abel's test for convergence of alternating series. Abel's transformation. Alternating numerical series, Leibniz test.
7. Operations on convergent series. Associativity of convergent numerical series. Commutativity: The rearrangement of the members of an absolutely convergent series (Cauchy's theorem), the rearrangement of the members of a conditionally convergent series (Riemann's theorem). Arithmetic operations on convergent series.
8. Improper Integrals. Improper integrals of 1 and 2 types. The Cauchy criterion for the convergence of improper integrals. The change of variables under the sign of the improper integral and the formula for integration by parts. Improper integrals of nonnegative functions; tests of their convergence. Absolute and conditional convergence of improper integrals. Convergence theorems of Dirichlet and Abel. The main value of the improper integral.
9. Functional sequences and series. Concepts of the functional sequence and functional series; Their convergence at a point and on a set.
10.Uniform convergence on a set. The Cauchy's criterion for uniform convergence of a functional sequence and a functional series.
11. Sufficient conditions for uniform convergence of functional sequence and functional series: Weierstrass's theorem, Dirichlet's theorem, Abel's theorem and Dini theorem on the uniform convergence of functional series.
12.Termwise passage to the limit. The continuity of the sum of the series. Theorems on term by term integration and differentiation of functional sequences and functional series.
13. Power series. Expansion of a function in power series. The power series and the domain of its convergence. Abel's theorem. The radius of convergence, tCauchy-Hadamard formula. Continuity of the sum of a power series.
14. Theorems on term-by-term integration and termwise differentiation of a power series. Expansion of a function in a power series. Taylor's series. Expansion of some elementary functions in Taylor series.
15.Weierstrass's theorem on the uniform approximation of a continuous function by polynomials and trigonometric polynomials.

**LINEAR ALGEBRA**

**Learning Units:**

1. Vectors and linear operations with them. The Linear dependence of vectors. Cartesian system of coordinates. Changing the coordinates at the replacement of a basis.
2. Linear (vector) space. Dimension and basis of a linear space. Linearly independent vectors. Linear hull.
3. Bilinear and quadratic forms. Polylinear images. Bilinear forms. The law of changing the matrix of a bilinear forms. Symmetric and skew-symmetric forms. Quadratic forms.

4. Transformation of the coordinates at a transition to a new basis. Transition matrix. Theorem on an existence of the fundamental system of solutions.
5. Linear transformations (operators).The coordinate representation of linear transformations. The sum of linear transformations
6. Invariant subspaces, eigenvectors, and eigenvalues of a linear transformation. Eigen-subspace of a linear transformation. Theorems about Eigenvalues and Eigenvectors.
7. The image and kernel of linear operators. Linear mappings. Linear functional.
8. Affine transformations and their properties. Orthogonal transformations of the plane. An invariant set of the transformation.
9. Euclidean space. Basic metric concepts.
10. Orthogonal basis and procedure of orthogonalization. Orthogonal complements and orthogonal projections in Euclidean space. The coordinate representation of a scalar product. Isomorphism of Euclidean vector spaces.
11. Complex vector space. Hermitian vector spaces. Hermitian forms. Metric relationships. Orthogonality. Unitary matrices. Normalized vector spaces.
12. Orthonormal basis and orthogonal matrices. Symplectic spaces.
13. Transformations (operators) in a Euclidean space. Self-adjointoperators. Orthogonal transformations. On polar decomposition.
14. Unitary space. Linear operators in a unitary space. Properties of unitary operators.
15. Quadratic forms. Definite quadratic forms (quadratic forms of fixed sign).The criterion of Sylvester for definiteness of a quadratic form. Reducing an equation of a curve of the second order to canonic type. Polynomials and their roots. The Euclid algorithm (the algorithm of sequential dividing).

**ANALYTICAL GEOMETRY**

**Learning Units:**

1. Introduction. A vector, as a directed segment, as an equivalence class, its length, collinear vectors, equal, opposite vectors; Actions on vectors and their properties; Criterion for the collinearity of vectors. Projection of a vector.
2. Linear dependence and independence of vectors. The geometric meaning of linear dependence.
3. Affine coordinates on a straight line, on a plane and in space. Cartesian coordinates. Polar, cylindrical and spherical coordinate systems. The simplest problems of analytic geometry: the division of a segment in this respect, the distance between two points.
4. Right-hand and left-hand triples of vectors. The vector product of two vectors and its properties. Geometrical meaning. Criterion of collinearity. The computational formula of a vector product. Mixed product of three vectors and its properties. Geometrical meaning. The criterion of coplanarity of three vectors. The computational formula of a mixed product.
5. Equations of a straight line in a plane: vector, parametric, canonical, equation of a straight line passing through two points, through an angular coefficient, in segments. The theorem on the general equation of a straight line. The normal vector. Relative position of two straight lines in a plane and the angle between them. Distance from a point to a line. The normal equation.
6. Equations of a plane in space: vector, parametric, canonical, equation of a straight line passing through three points, in segments. The theorem on the general equation of a plane. The normal vector. Relative position of two planes and the angle between them. The normal equation. Distance from a point to a plane.
7. Equations of a straight line in space: vector, parametric, canonical. The general equation of a straight line. Relative position of two straight lines in space and the angle between them. Relative position of a straight line and a plane in space.
8. Ellipse and its canonical equation. Eccentricity of ellipse. The theorem about directrix of ellipse.

9. Hyperbola and its canonical equation. Eccentricity and Asymptotes of hyperbola. The theorem about directrix of hyperbola.
10. Parabola and its canonical equation. The equation of the ellipse, hyperbola and parabola in the polar coordinate. Transformation of a Cartesian coordinate system on a plane. Rotation and parallel transfer.
11. General equation of a curve second degree. Bringing it to the canonical form. Invariants. Central and noncentral curves. Classification of curves of the second order.
12. Ellipsoid; hyperboloids: hyperboloid of one sheet; hyperboloid of two sheets; cone; Elliptic and hyperbolic paraboloids; Cylinders. Cross-sections of surfaces by coordinate planes. Sketches of surfaces.
13. Definition of motions and affine transformations. Transformation of vectors by affine transformation of a plane and space.
14. Basic properties of affine transformations. Similarity transformations. Homothetic.
15. The movements are straight, plane and space.

**ORDINARY DIFFERENTIAL EQUATIONS**

**Learning Units:**

1. Basic concepts of differential equations. Examples of physical and mechanical problems leading to differential equations. The concepts of phase space, phase velocity fields, direction fields and the integral curve.
2. Simplest equations of the first order integrable in quadratures. The existence and uniqueness theorem for the solution of the Cauchy problem. General method of introducing a parameter. Singular solutions and methods for finding them.
3. Normal systems of differential equations. The existence and uniqueness theorem for the solution of the Cauchy problem for a normal system. Differential equations of higher order. Reduction to the normal system. The existence and uniqueness theorem for the solution of the Cauchy problem for higher order differential equations.
4. Linear homogeneous systems of differential equations. Properties of solutions.Wronskian. Linear dependence and independence of vector functions.Liouville formula. A fundamental system of solutions. The fundamental matrix. The structure of the general solution of a linear homogeneous system.
5. Linear nonhomogeneous systems of differential equations. The structure of the general solution. Solution of an inhomogeneous system of linear equations (the method of variation of arbitrary constants, the Cauchy method).
6. Matrix exponent. Matrix method of integrating a linear homogeneous system with constant coefficients. Calculation of the matrix exponent based on reduction of matrices to the Jordan form. Fundamental system of solutions of a linear homogeneous system with constant coefficients. Solution of a nonhomogeneous system with a special form right-hand side.
7. Linear homogeneous equations of the nth order and their properties. Linear dependence and independence of functions. A fundamental system of solutions and its existence.Wronskian. Liouville formula. The general solution of the homogeneous equation.
8. Structure of the general solution of a linear nonhomogeneous differential equation of the nth order. Methods for constructing a particular solution of a nonhomogeneous equation. The Cauchy method.
9. Linear homogeneous equations of the nth order with constant coefficients. Euler's method. Linear nonhomogeneous equations of the nth order with constant coefficients and with a quasipolynomial right-hand side.
10. Boundary value problem for a nonhomogeneous second-order differential equation. The Cauchy function, the boundary functions, and their explicit representations. Green’s function and its properties. Representation of Green's function using Cauchy function and boundary functions. Integral formula for the solution of the boundary value problem. The Sturm-Liouville problem. Integration of linear differential equations by means of series.

11. The concepts of the integral, the first integral, and the general integral of normal systems. Symmetric form of normal systems. The theorem on the number of independent integrals. The existence of a complete system of first integrals for solving the system. Continuous dependence of the solution on the initial data and parameters. The differentiability of the solution with respect to the parameters. Equations in variations. The small parameter method.
12. Autonomous systems. Properties of solutions. Phase trajectories of the linear autonomous system of two equations in the neighborhood of equilibrium points: node, saddle, focus and center. The concept of a limit cycle.
13. Lyapunov stability and asymptotic stability. Asymptotic stability of the zero solution of linear autonomous systems and nth order equations. Lyapunov theorem on stability in the first approximation.
14. Linear homogeneous partial differential equations of the first order and their connection with the system of ordinary differential equations. Equation of characteristics. The structure of the general solution. The Cauchy problem.
15. Quasilinear partial differential equations of the first order. Characteristics and integral surfaces. Cauchy problem.

**3. MAJORS**
**THEORY OF PROBABILITY AND MATHEMATICAL STATISTICS**
**Learning Units:**
1. Introduction. Probabilistic space as a mathematical model of a random experiment. Statistical stability. Discrete probability space. Events and operations on events. Probability of the event. The classical definition of probability. Conditional probabilities. Full-probability and Bayes's formulas. Independent events and trials. TheBernoullischeme.
2. Common space of elementary events. Probabilistic model of the experiment with an infinite number of successes. Algebras and sigma algebras. Probability (axioms and basic properties). General probability space. Equivalence of the axiom of countable additivity and continuity axioms. Borel's sigma of the algebra on $R$ and $R^n$.
3. Random variables. Definition of a random variable. The distribution function of a random variable and its properties. Types of the distribution function and random variables. Examples of discrete and (absolutely) continuous random variables.
4. Multidimensional (vector) random variables. Joint distributions of random variables. A multidimensional normal random variable. Independence of Random Variables. Functions of random variables. Composition formulas.
5. Numerical characteristics of random variables. Expected value. Mathematical expectations of discrete and continuous random variables. The mathematical expectation of the product of independent random variables.
6. Numerical characteristics of random variables (continued) moments. Variance. Variance of the sum of random variables. Covariance. Correlation coefficient. The covariance matrix of a random vector. Inequalities of Cauchy-Bounjakowsky (Schwartz), Markov and Chebyshev.
7. Limit theorems. Different types of convergence of sequences of random variables and the relation between them. Convergence in probability and the law of large numbers (L.L.N.) in the form of Chebyshev. Consequences (Stability of the frequencies of events as a consequence of the law of large numbers, etc.).
8. Characteristic functions. The definition and properties of the characteristic function. The inversion formula. The uniqueness theorem and some of its applications. Continuity theorems. The method of characteristic functions of the proof of limit theorems. The law of large numbers

in the form of Khinchin. The central limit theorem for a sequence of independent identically distributed random variables. Investigation (LimittheoremofMoivre-Laplace).

9. Characteristic functions (continuation). The central limit theorem for a sequence of independent differently distributed random variables. Multidimensional characteristic function. Multidimensional normal distribution. Some important properties of Gaussian (normal) random variables.

10. Basic concepts of sampling theory. Probably a statistical model. Problems of mathematical statistics. The concept of sampling. Variation series of the sample. Empirical distribution function. Selective moments. Mathematical expectation and variance of sample mean and sample variance. Asymptoticbehaviorofsamplemoments.

11. Point estimates. Definitions and examples. Unbiased estimates with minimal variance (optimal estimates). Inequality of Rao-Kramer and effective estimates. Methods for finding estimates: Maximum likelihood estimates; Method of moments.

12. Sufficient statistics and optimal estimates. Sufficient estimates. Criterion of factorization. Rao-Blackwell-Kolmogorov theorem. Complete sufficient statistics. Examples of the application of sufficient statistics.

13. Interval estimation. Confidence interval and confidence. Building a confidence interval using central statistics. Confidence intervals for normal distribution parameters (different cases: confidence interval for an unknown mathematical expectation for a known variance, etc.).

14. Testing of statistical hypotheses. The concept of a statistical hypothesis and a statistical criterion. Criteria for agreement and their main characteristics. Testing the hypothesis of the type of distribution: Kolmogorov's consent criterion; Chi-square agreement of C. Pearson.

15. Parametric hypotheses. General concepts of parametric hypotheses: The concept of a parametric hypothesis; Criteria for testing hypotheses; the general principle of choosing the critical region of the criterion. The choice of two simple hypotheses. The Neumann-Pearson criterion.

**FUNCTIONAL ANALYSIS**

**Learning Units:**

1. Spaces. Vector space. Normed spaces. Metric spaces. Topological concepts of metric spaces. Definition of a topological space

2. Banach spaces. The main theorem in complete metric spaces: the principle of nested spheres; Contraction mapping principle and its application; Theorem of Baire categories and its application.

3. Inner product space and Hilbert space. Bases in Hilbert spaces.

4. Compactness. Compact sets. Precompact set. The fundamental theorem of compactness in metric spaces. Criterion for precompactness of a set in a metric space.Arzel's theorem.

5. Linear operators and linear functionals. Normed linear space of bounded linear operators. Convergence of a sequence of operators: uniform and pointwise convergence of a sequence of operators.

6. Uniform boundedness theorem - Banach-Steinhaus theorem. The Inverse operators.

7. Open mapping theorem. Closed linear operators.Banach's theorem about closed graph. An example of closed but not continuous operator.

8. Hahn-Banach theorem on the extension of linear functionals. The corollaries of Hahn-Banach theorem.

9. Dual (conjugate) spaces. Riesz representation theorem of a continuous linear functional on a Hilbert space.

10. The second dual spaces. Reflexive spaces. Strong convergence, weak convergence of elements.
11. Elements of the theory of distributions. Spaces of smooth functions and distributions. The derivative distributions. The simplest applications of distributions.
12. Adjoint, self-adjoint (symmetric) operators.
13. Compact operators. Compactness of the Fredholm operator with square-integrable kernel.
14. The elements of spectral theory in linear operator in normed spaces. The spectral theory in finite dimensional normed spaces. The Eigenvector and eigenvalues of the operator. The resolvent set and the spectrum of a bounded linear operator. The spectral radius of a linear operator.
15. Spectral properties of compact linear operators. Hilbert-Schmidt theorem

## 4. ELECTIVE COURSE (BASIC DISCIPLINES)

### MULTIVARIABLE CALCULUS

**Learning Units:**

1. Arithmetical space $R^n$. Neighborhoods of points, limit points and interior points. Connected, disconnected, bounded, unbounded sets. Closed and open sets.Rectangular space coordinates. Vectors in three-dimensional space. Inner product (dot or scalar product). Vector product (cross product). Lines and Planes in space. Surfaces. Higher dimensions.

2. The concept of a function of several variables. Level curves and level surfaces. Limit of a several variables function. Continuity of a function of several variables at a point.Vector functions of a real variable. Algebra of vector functions. Space curves and tangent vectors. Arc length as a parameter. Simple geometry of curves. Torsion and Frenet-Serret formulas. Applications to curvilinear motions. Curvilinear motion in polar coordinates. Cylindrical and spherical coordinates. Scalar and vector fields. Vector lines. Algebra of vector fields.
3. Partial derivatives of a function of several variables at a point. A sufficient condition for the function to be differentiable at a point. Arithmetic properties of differentiable functions.
4. The theorem on the differentiability of a composite function. Equation of the tangent plane. Differential of a function of several variables at a point. Invariance of the form of the first differential.
5. The gradient of a function at a point and the directional derivative. Directional derivative of a scalar field. Gradient of a scalar field. Higher order partial derivatives and differentials of functions of several variables. A theorem on the equality of mixed partials.
6. Taylor polynomial. The concept of an implicit function. A theorem on the existence and continuity of an implicit function defined by a single equation.
7. An implicit function. The concept of a system of implicit functions defined by a system of equations. Conditions for their existence and differentiability.
8. The Jacobi Matrix. Local extremum of functions of several variables. A theorem on the extremum of an implicit function defined by an equation and a system of equations.
9. Conditional extremum of a function of several variables. The Lagrange function and the Lagrange multipliers for the conditional extremum problem.
10. One variable uniform tendency of a function of two variables to a limit with respect to another variable. Cauchy criterion of uniform convergence of a function to the limit function.
11. Proper integrals depending on a parameter. Improper integrals of the first type depending on the parameter. Improper integrals of the second type depending on the parameter.
12. Euler's integrals. Gamma function. Beta function. Stirling formula. Multiple integrals depending on parameters.

13. The upper and lower Darboux sums of a function defined on the parallelepiped. Their properties. Riemann integral of a function defined on the parallelepiped. E-integrability criterion. The integral as a limit of Riemann sums. The sets of measure 0 and 0 volume, their properties. Double integral. Reduction of the double integral to the repeated integrals. Change of variables in the double integral. Double integral in polar coordinates.
14. The properties of multiple integrals. The multiple integral over an arbitrary region. Fubini's theorem on reduction of the multiple integral to iterated integrals. Calculation of double, triple integrals. Jacobian transformation. Calculation of the area of a plane figure by using double integral. Geometric applications of the double integral.
15. Triple integrals and their properties. Change of variables in triple integrals. Spherical and cylindrical coordinate system.Improper multiple integrals. Geometric and physical applications of multiple integrals.

**VECTOR ANALYSIS**
**Learning Units:**
1. Definition of a line integral of the first type. Reduction of a line integral to an ordinary definite integral. Calculation of line integrals by using reduction of line integrals to ordinary definite integrals. Conditions for the existence of linear integrals.
2. Definition of a line integral of the second type. Existence and computation of a line integral of the second type.
3. Conditions for line integrals to be independent of path of integration. Calculation of areas by using line integrals.Equivalent paths. Properties of line integrals. The Fundamental Theorem of line integrals.
4. Green's Theorem in the plane. The circulation of the vector field. Applications of line integrals.
5. Definition oaSurface in$R^n$. The normal and tangent plane to the surface. Parametric representation of surfaces. Definition of surface integrals of the first type, it's physical meaning. The reduction of surface integrals to ordinary double integrals. Conditions for the existence of surface integrals.
6. Mechanical applications of surface integrals of the first type. Definition of a surface integral of the second type. Calculation of volume of a solid by using a surface integral.
7. Stokes' theorem.
8. Ostrogradsky's formula.
9. Bilinear form and its coordinate representation. The scalar product and the general bilinear form. Nondegeneracy of a bilinear form. The correspondence between vector and form.
10. Curvilinear coordinates and metric. Orthogonal systems of curvilinear coordinates and unit vectors. Cartesian, cylindrical and spherical coordinates.
11. The differential of the form and the gradient, curl, divergence. Gradient of a function and its coordinate representation. Divergence of a vector field. Curl of a vector field. Hamilton operator. Other properties of the divergence and the curl.
12. Differential of the function and gradient. Gradient in cylindrical and spherical coordinates. The flux of the vector through the surface.
13. Divergence and its coordinate representation. Differential of the flux and the divergence of the field.
14. Divergence in cylindrical and spherical coordinates. Rotor of a vector field and its coordinate representation. Basic integral formulas of analysis in vector form.
15. Solenoidal and potential fields.

**COMPLEX ANALYSIS**
**Learning Units:**

1. Complex plane.Complex numbers and their implementation. Different forms of recording complex numbers. Definition. Algebraic structure. Polar representation. The topology of the complex plane. Compactification of the complex plane.
2. Complex differentiability. The geometric meaning of derivative.R-differentiability. C-differentiability. Cauchy-Riemann conditions. Directional derivative. Holomorphic functions and conformal mappings. Various interpretations of holomorphic functions. The geometric meaning of the complex derivative. Holomorphy and conformality of mappings of the extended complex plane.
3. Integral and antiderivative. Definition of the integral along the way. Properties of the integral along the way. Goursat lemma. Antiderivative. Antiderivative along the way.
4. Cauchy's theorem.Cauchy's theorem about homotopy. Cauchy's theorem for multiply connected domains. Cauchy integral formula.
5. Taylor power series.Decomposition of a holomorphic function in a Taylor series. Cauchy inequalities. Liouville theorem. The set of points of convergence of power series. Holomorphicity of sum of power series. Infinite differentiability of holomorphic functions. Taylor series coefficients. Cauchy integral formula for derivatives. Morera theorem. Three equivalent definitions of holomorphic functions. Decomposition of a holomorphic function in a neighborhood of zero. Uniqueness theorem. The Weierstrass theorem on series of holomorphic functions. An approximation of holomorphic functions by polynomials.
6. Laurent series and singular points.Decomposition of a holomorphic function in a Laurent series. Convergence of series in integer powers of z - a. Cauchy inequalities for the Laurent coefficients. Remark on the Laurent series and Fourier series. Isolated singular points. Description of removable singular points. Description of poles. Sokhotskii theorem. $a = \infty$ as an isolated singular point. Entire functions with a pole at infinity. Meromorphic functions with a pole at infinity.
7. Residues. Cauchy residue theorem. Residue in terms of the Laurent series theorem. Formulae for calculating of residues. The residue at $a = \infty$. Theorem on the total sum of residues. Jordan lemma.
8. Analytic continuation. Statement of the problem. Analytic continuation of the G- function. Analytic continuation of the logarithm.
9. Weierstrass theory. Statement of the problem. Elements and their analytic continuations. Properties of direct analytical continuation. Continuation of canonical elements along the path. Equivalence of analytic continuation in the chain and along the way. Theorem on Extension along homotopic paths.
10. Analytic functions.Definitions. Example: the analytic function $\sqrt{z}$. Example: the analytic function ln z. Operations on analytic functions. Isolated singularities of analytic functions. Classification of isolated singular points. Examples of analytic functions and their singular points.
11. Riemann surfaces.Riemann surface of the function $w = \sqrt{z}$. Riemann surface of the function $w = \ln z$. Riemann surface of the function $w = \arcsin z$. Riemann surface of an analytic function.
12.The argument principle.Logarithmic residue. The argument principle. Rouche's theorem.
13.Principle of conservation of area and the reversibility of holomorphic functions.Principle of conservation of area.The local reversibility of holomorphic functions. Hurwitz's theorem.
14.Maximum modulus principle and its consequences.Maximum modulus principle. Schwarz lemma.
15.Compactness principle. Sequence of holomorphic functions.Compactness principle.Montel's theorem. Continuous functionals on families of holomorphic functions.

**BASICS OF ALGEBRA**
**Learning Units:**

1. Sets. Operations on sets. Venn diagrams. Power set. Binary relations. Special binary relations. Set cardinality.
2. Permutations and combinations. The standard permutation entry. The cycle structure of the permutation. The sign of the permutation.
3. Matrices. Operations with matrices. An addition of matrices, multiplication of a matrix on a number, multiplication of matrices. Classification of matrices.
4. Systems of linear equations. Linear combinations. Linear independence. Basis. Linear hull. Dimension.
5. Determinants of the second and the third orders. Determinants of the n-th order. Finding minors and cofactors of a matrix.
6. Properties of determinants. Decomposition of the determinant by the elements of a column or row. Determinants of the special matrices. Computation of the inverse matrix. Finding solutions of a system of linear equations by the method of the inverse matrix. The space of solutions.
7. Rank of a matrix. A criterion for compatibility of a system of linear equations (Theorem of Kronecker-Capelli). Square matrices. Classes of equivalent matrices.
8. Sets with algebraic operations. Binary operations. Semigroups and monoids. Generalized associativity.
9. Groups. Definition and examples. Cyclic groups.
10. Rings. Definition and general properties of rings. The ring of integers modulo n.
11. Fields. Definition and general properties of fields. Characteristics of the fields. Quotient field of a ring.
12. Fields of complex numbers. Auxiliary construction. The plane of complex numbers. Geometric interpretation of operations with complex numbers.
13. Exponentiation and extraction of the root of complex numbers. The uniqueness theorem. The elementary geometry of complex numbers.
14. Polynomial ring. Polynomials of one variable. Polynomials in many variables. The algorithm of a division with the remainder.
15. Decomposition in the polynomial ring. Elementary properties of divisibility. Euclidean rings. A unique factorization domain. Irreducible polynomials.

**MATHEMATICAL LOGIC**

**Learning Units:**

1. Statements. Mathematical operations on statements. Equivalent transformations.
2. Functions of algebra of logic.
3. Formulas. Implementation of functions by formulas. The laws of algebra of logic. The duality principle.
4. Expansions of Boolean functions with respect to variables. The perfect disjunctive (conjunctive) normal form
5. Completeness and isolation.
6. The most important closed classes. The completeness theorem. The presentation of the results of Fasting.
7. Predicators.
8. Operations on predicators.The quantifier of the community and the quantifier of existence.
9. Formulas of the logic of predicates. Equivalent formulas of the logic of predicates.
10. Models. Language of the theory of models.
11. Solvability of the algebra of logic
12. Derivation from hypotheses
13. Formalized language. The language of propositional calculus, axioms, inference rules.
14. The metatheory of the propositional calculus. Calculus of predicates.
15. Metatheory of the predicate calculus

## DIFFERENTIAL GEOMETRY

**Learning Units:**

1. Frene curves in $\mathbb{R}^n$. Plane curves and space curves.
2. Relations between the curvature and the torsion. The Frenet equations and the fundamental theorem of the local theory of curves.
3. The global theory of curves.
4. Surface elements and the first fundamental form. The Gauss map and the curvature of surfaces.
5. Surfaces of revolution and ruled surfaces.Minimal surfaces.
6. Intrinsic Geometry of Surfaces. The covariant derivative. Parallel displacement and geodesics.
7. Gaussian equation and the Theorema Egregium. The fundamental theorem of the local theory of surfaces
8. Gaussian curvature in special parameters. The Gauss-Bonnet Theorem. Selected topics in the global theory of surfaces.
9. The notion of a manifold. The tangent space. The Riemannian connection.
10. The Curvature Tensor. Tensors. The sectional curvature.
11. Ricci tensor and the Einstein tensor.
12. Spaces of Constant Curvature
13. Hyperbolic space.
14. Geodesics and Jacobi fields. The space form problem.
15. Three-dimensional Euclidean and spherical space forms

## GENERAL TOPOLOGY

**Learning Units:**

1. Sets, operations on sets, maps between sets, the cardinality of a set the comparison of cardinalities
2. The comparison of cardinalities, infinite sets, the Bernstein theorem
3. Countable sets, the countability of a product of countable sets, the countability of the set of algebraic numbers
4. Uncountable sets, the Cantor theorem on the uncountability of the continuum, the Cantor theorem that all numbers are transcendental
5. Orders on sets, well-ordered sets, notion of ordinals, the comparison of cardinalities
6. Topology on a set, open and closed subsets
7. Bases of topology, metric spaces, subspaces
8. Continuous maps, homeomorphisms
9. Connectedness, path connectedness
10. Separations axioms
11. The embeddings od space into the cube or into the Hilbert cube (Tikhonov theorem)
12. Countability axioms, compactness.
13. Compactness in mathematical analysis, the compactness of the interval, properties of compact spaces.
14. Stone-Weierstrass theorem.
15. The compactness of a product of compact spaces.

## DISCRETE MATHEMATICS

**Learning Units:**

1. Sets and operations on them. Power sets.
2. Relations and operations on them. Special binary relations. Order relations.
3. The relation of equivalence. A theorem on partitioning. Function.
4. The Dirichlet Principle. Rules of the account. The formula of inclusion-exclusion.

5. Permutation. The placement and combination. The number of injections, subjecti and bicci on finite sets.
6. The method of mathematical induction. Recursive relations. The Number Of Fibonacci.
7. Generating functions and their properties. Whole numbers that are comparable by module *m* The Chinese remainder theorem.
8. Multiplicative function. Theorems of Euler and Fermat.
9. Chain fractions. The solution of equations in integers.
10. The definition of the graph. A multigraph. Isomorphism of graphs. Additional graphs. The subgraphs. Operations over graphs.
11. Metric characteristics of a graph. The degree of each vertex counts.
12. Chain. Cycles. The connectivity of the graph. Trees and forests.
13. Bipartite graphs. Algorithm of width search. Matrices associated with graphs.
14. Planar graphs. The Theorem of Pontryagin-Kuratowski. Coloring of graphs.
15. Eulerian graphs. Hamiltonian graphs.

**VARIATION CALCULUS AND METHODS OF OPTIMIZATION**

**Learning Units:**

1. Brachistochrone problem.
2. The simplest problem.
3. Necessary conditions for a weak local minimum.
4. Lagrange's lemma. Euler equation.
5. Dubois - Raymond lemma.
6. Bolz problem.
7 Weierstrass necessary condition.
8. Methods optimization. Problem statement.
9. Weierstrass' theorem.
10. Convex sets.
11. Convex functions.
12. Theorem about global minimum. Criterion of optimization.
13. The prescription ways of the convex sets.
14. Separability of the convex sets.
15. Convex cones.

**PROGRAMMING**

**Learning Units:**

Part I. Basics of C++

1. Basic structure of C++ program. Compile, link and run processes. Variables and constants.
2. Using arrays and strings.
3. Operators and statements. Execution flow control.
4. Function, pointer and reference.
5. C++ input/output streams.

Part II Object oriented programming

6. Class and object. Inheritance
7. Polymorphism. Operator overloading.
8. Macros and templates.
1. Part III Standard Template Library
9. Using Standard Template Library (STL).
10. Using strings and dynamic arrays in STL.
11. Using lists, sets and maps in STL.
12. Functors and lambda expressions.

13. STL algorithms. Stack and queue implementation.
14. Smart pointers in C++.
15. Exceptions in C++.

**MATHEMATICAL MODELING**

**Learning Units:**

1. Introduction. Cognition and modeling. Natural science and mathematics. The equation of the fall of the body as an example of a mathematical model. Principles of constructing mathematical models. Classification of mathematical models.
2. Mechanical oscillations. Derivation of the equation of oscillation of a pendulum. Solution of the pendulum oscillation equation. Energy of oscillation of the pendulum. Pendulum oscillation in the presence of friction.
3. Electrical oscillations. Electrical circuit. The energy of the circuit. Contour with resistance.
4. Basis of the dynamical systems theory. Evolution processes and differential equations. The phase plane. Stability of the equilibrium state. Limiting cycle.
5. Mathematical models of chemical processes. Equations of chemical kinetics. Monomolecular reaction. Bimolecular reaction. The Volterra-Lotka system.
6. Mathematical models in biology. Models of Malthus and Verhulst. The model of "biological competition". Model "ecological niche". The predator-prey model.
7. Dynamic models of the economy. The model of "economic competition". Model "economic niche". The "free market" model. The "monopolized market" model. Model of inflation.
8. Models of transfer processes. Heat transfer equation. Statement of boundary value problems. The diffusion equation. Equation of electrical conductivity. Equation of migration.
9. Models of oscillatory processes. Equation of oscillation of a string. Running waves. Energy of oscillation of a string. Electric oscillations. Equations of acoustics.
10. Models of stationary processes. Stationary fluid flow. Electrostatic field. Potential of point charge. Potential of the charged wire.
11. Variational principles of physics. The principle of least action and the equations of classical mechanics. The problem of brachistochrone. The principle of Fermat of geometrical optics.
12. Statistical modeling. Calculation of the number "pi". The Monte Carlo method and its applications.
13. Models of quantum mechanics. Problems of quantum mechanics. Wave function. Schrodinger equation. Motion of a particle in an external field. Potential barrier.
14. Ill-posed problems and mathematical models. The notion of well-posedness. An example of Hadamard. Euler's problem of an elastic rod. The Benard problem.
15. Inverse problems of mathematical physics. The concept of the inverse problem of mathematical physics. Time inverse problem. Boundary inverse problems. Coefficient inverse problems.

**PHYSICS**

**Learning Units:**

1. Mechanics
   1.1. Physics and measurement. Kinematics. Basic formulations and laws of body movement. Motion in one and several dimensions. Distance, velocity, acceleration and their relations
   1.2. Circular motion and other applications of Newton’s Laws
2. Dynamics
   2.1. Energy of a system. Conservation of energy
   2.2. Linear momentum and collisions. Rotation of a rigid object about a fixed axis. Angular momentum.

2.3. Static equilibrium and elasticity. Universal gravitation.
2.4. Oscillations and mechanical waves
2.5. Oscillatory motion. Wave motion.
2.6. Sound waves. Superposition and standing waves.

3. Molecular physics and thermodynamics
3.1. Temperature. The first law of thermodynamics.
3.2. The kinetic theory of gases. Heat engines, entropy and the second law of thermodynamics.

4. Electricity and magnetism
4.1. Electric field. Gauss's law. Electric potential.
4.2. Capacitance and dielectrics. Current and resistance.
4.3. Direct current circuits.
4.4. Magnetic field. Sources of magnetic field.
4.5. Faraday's law. Inductance.
4.6. Alternating current circuits. Electromagnetic waves.

5. Optics
5.1. Wave equation for the electromagnetic field
5.2. Properties of light waves
5.3. Diffraction of waves

6. Quantum physics
6.1. Thermal radiation. Experimental substantiation of basic ideas of quantum theory.
6.2. Elements of quantum physics.

**THEORETICAL MECHANICS**

**Learning Units:**

1. Kinematics.

1.1 The subject of theoretical mechanics. The models of material bodies studied in theoretical mechanics: material point (point mass), absolutely solid body, the system of material points. Basic concepts and laws of mechanics. Kinematics of a point. Problems of kinematics. Methods of the point motion setting.

1.2 Velocity and acceleration. Decomposing of velocity and acceleration in the radial and transverse components. Decomposing of accelerate at the axes of the natural trihedral.

1.3 Mechanical system. The number of the freedom degrees of the system and a rigid body. Basic movements of a rigid body. Translational motion of a rigid body. Acceleration and velocity in the translational motion.

1.4 Rotational motion of a rigid body around a fixed axis. Angular velocity and the angular acceleration of a rigid body.

1.5 Plane-parallel motion of a rigid body. Velocities of the points of a plane figure. Instantaneous centre of velocity.

1.6 Acceleration of the points of a plane figure. Instantaneous centre of acceleration.

1.7 Compound motion of a point. Basic concepts. Full and relative derivatives of the vector. Addition of velocities. Theorem on the addition of accelerations (Coriolis theorem).

1.8 Compound motion of a solid body. Addition of the translational velocities. Addition of the instant angular velocities. Addition of the instant angular and translational velocities. Reduction of the system of sliding vectors.

2. Statics.

2.1 The concept of force and mass. Types of forces. Basic definitions and axioms of statics. Problems of geometric statics. Constraints. Constraint reactions. Axiom of the constraints.

2.2 Centre of gravity and centre of mass. Methods for finding the coordinates of the centre of gravity and the centre of mass.

2.3 Equilibrium conditions of arbitrary spatial system of forces.

2.4 Special cases of the equilibrium conditions (convergent system of forces, parallel forces, plane system of forces).

3. Dynamics of the point mass and the system.

3.1 The Newton laws. Direct and inverse problems of dynamics. Motion equations.

3.2 Basic dynamic variables. Properties of internal forces of the system.

3.3 Theorem of change of linear momentum of a point mass and mechanical system. Theorem on the motion of the centre of mass.

3.4 Angular momentum theorem of a point mass and the mechanical system.

3.5 Work of force. Force field. Potential force field.

3.6 Work-Energy theorem for the mass point and the system. Conservation of energy.

3.7 Rectilinear motion of the material point. Harmonic vibrations of the point. Parameters of vibrations. Vibrations in a resistant medium.

3.8 Forced vibrations in a medium without resistance and in a resistant medium. Resonance.

4. Dynamics of the solid body.

4.1 Mass geometry. Inertia moments. Theorem of Guigens-Shteiner.

4.2 Inertia moments relative to the axes of the beam, coming from the point.

4.3 Rotation of a rigid body around a fixed axis. Motion equations. Dynamic and static reactions.

4.4 General problem of the heavy solid body with one fixed point. Special cases: the case of Euler-Puanso, the case of Lagrange-Puasson, the case of Kovalevskaya.

5 Bases of analytical mechanics.

5.1 The notion of holonomic and nonholonomic systems. Actual and virtual displacement of the point. Conditions imposed by reactions on the variations of coordinates.

5.2 Virtual work of forces. Ideal constraints. Principle of virtual work.

5.3 D'Alambert's principle for the point mass and mechanical system.

5.4 General dynamic equation.

5.5 Generalized coordinates. Generalized forces.

Equations of motion in generalized coordinates (Lagrange equations of 2-nd type).

**PARTIAL DIFFERENTIAL EQUATIONS**

**Learning Units:**

1. Introduction.

1.1. Basic notions of the theory of Partial Differential Equations (PDE). The main equations of mathematical physics (EMP). Physical problems leading to EMP.

1.2. Definition of Cauchy problem and boundary problem for EMP. Initial and boundary conditions. Correctness of setting a problem. Examples.

1.3. Classification and reducing to canonical presentation of PDE of the second order. Classification and reducing to canonical presentation of PDE of the second order with many variables.

2. Equations of hyperbolic type.

2.1. Problem definition. Wave equation. Physical interpretation. Dirichlet's initial-boundary problem. Neumann's initial-boundary problem. Cauchy initial problem for wave equation for $n=1$. D'Alembert's formula. Non-homogeneous equation. Duhamel's principle. Presentation of solution of initial-value problem for non-homogeneous equation. Uniqueness.

2.2. Method of separation of variables for Cauchy problem for homogeneous heat equation. Method of separation of variables for non-homogeneous heat equation.

2.3. Cauchy problem for wave equation in $R^n$, $n=2, 3$. Cauchy and Goursat's generalized task. Delayed potential. Fourier's method for the wave equation and the heat conductivity equation in the Cartesian system of coordinates. A problem of Storm-Liouville. Solution of the non-homogeneous equation

2.4. Fourier's method in polar and spherical coordinates. Special functions of mathematical physics.

3. Equations of elliptic type.

3.1. Problem definition. Green's formulas. Laplace and Poisson equations. Physical interpretation.

3.2. Laplace equation in spherical and cylindrical co-ordinates. Harmonic functions. Analytic functions. Cauchy-Riemann condition. Fundamental solution of the equation of Laplace.

3.3. Poisson equations. Solving Poisson equations in $R^n$, $n=2, 3$. Basic properties of harmonic functions. Integral of a normal derivative.

3.4. Boundary problems for Laplace equation. Dirichlet's problem. Neumann's problem. Solution of Dirichlet's problem for Laplace Equation on the ball using separation of variables. Mean value formulas for Laplace Equation. Converse to mean value property.

3.5. Properties of harmonic functions. Strong maximum principle. Uniqueness. Local estimates for harmonic functions. Liouville's theorem. Representation formula. Harnack's inequality.

4. Equations of parabolic type.

4.1. Problem definition. Heat equation. Physical interpretation. Cauchy initial problem. Dirichlet's initial-boundary problem. Neumann's initial-boundary problem. Fundamental solution of heat equation.

4.2. Method of separation of variables for heat equation. Solution of initial-value problem. Solution of non-homogeneous problem. Presentation of solution of initial-value problem for non-homogeneous equation.

4.3. Mean value formula. Weak maximum principle for heat equation. Strong maximum principle for heat equation. Uniqueness.

**NUMERICAL METHODS**

**Learning Units:**

1. On the definition of inverse and ill-posed problems. Classification of ill-posed problems.
2. Initial boundary value problem for the Laplace equation. Direct and inverse problems. The concept of a generalized solution of the direct problem.
3. Well-posedness of the direct problem. Estimates of solutions to the auxiliary and direct problems
4. Uniqueness and existence of the generalized solution to direct problem. Estimate of the trace of solution to direct problem
5. Formulation of the conjugate problem. The concept of a generalized solution to the conjugate problem.
6. Reduction of the inverse problem for the Laplace equation to an operator equation. Boundedness of the operator $A$. Gradient methods for solving the inverse problem.
7. The proof of the convergence by functional of the solution to the inverse problem.
8. Ill-posed problem to the heat conduction equation. Direct and inverse problems. The concept of a generalized solution of the direct problem.
9. Well-posedness of the direct problem. Estimate of solutions to the direct problem
10. Uniqueness and existence of the generalized solution to the direct problem for heat conduction equation
11. Formulation of the conjugate problem. The concept of a generalized solution to the conjugate problem.
12. Reduction of the inverse problem for the heat conduction equation to an operator equation. Boundedness of the operator $A$.
13. Research conditional stability.
14. The proof of the convergence by the functional of the solution to the inverse problem

15. Gradient methods for numerical solving the inverse problem.

**FUNDAMENTALSFINANCIALMATHEMATICS**

Introduction. Accumulation Function. Simple Interest. Compound Interest. Present Value and Discount Factor.
Nominal Interest Rate. Constant and Varying Force of Interest
Net Present Value. Rate of Return
Dollar-weighted Rate of Return. Time-weighted Rate of Return.
Annuity Immediate. Annuity Due. Equations of Value. Perpetuities.
Unknown Time and Unknown Interest Rate. Continuous Annuities.
Varying Annuities. Arithmetic Increasing and Decreasing Annuities.
Amortized Loan. Amortization Schedule.
Sinking Fund Loans. Yield Rate.
Price of a Bond. Book Value of a Bond. Bond Amortization Schedule.
Callable Bond.
Investment Duration. Modified Duration
Bond Convexity.
Life Contingency.
Review Session.

**DISCRETE MATHEMATICSAND MATHEMATICAL LOGIC**

**Learning Units:**

1. Statements. Mathematical operations on statements. Equivalent transformations. Functions of the algebra of logic.
2. Formulas. Implementation of functions by formulas. The laws of algebra of logic. The duality principle.
3. Expansions of Boolean functions with respect to variables. The perfect disjunctive (conjunctive) normal form
4. Completeness and isolation.
5. The most important closed classes. The completeness theorem. The presentation of the results of Fasting. Predicators.
6. Operations on predicators.The quantifier of the community and the quantifier of existence.
7. Formulas of the logic of predicates. Equivalent formulas of the logic of predicates. Operations on predicators.The quantifier of the community and the quantifier of existence.
8. Formulas of the logic of predicates. Equivalent formulas of the logic of predicates.
9. Identities of the algebra of sets. Operations on sets. Power sets. Relations and operations on them. Special binary relations. Order relations.
10. The relation of equivalence. A theorem on partitioning. Function.
11. Dirichlet Principle. Rules of account. The formula of inclusion-exclusion.Permutation. The placement and combination. The number of injections, subjecti and bicci on finite sets.
12. The method of mathematical induction. Recursive relations. The Number Of Fibonacci.
13. Generating functions and their properties. Whole numbers that are comparable by module *m*. Chinese remainder theorem.
14. Multiplicative function. Theorems of Euler and Fermat.Multiplicative function. Generating functions and their properties.
15. The definition of the graph. A multigraph. Isomorphism of graphs. Additional graphs. The subgraphs. Operations over graphs.

**MEASURE AND LEBEGUES INTEGRATION THEORY**

**Learning Units:**

1. Topology of Euclidean spaces R. Interior, exterior and boundary point of the set. Limit

(accumulation) point. Open and closed sets. Rectangles and cubes. The structure of open and closed bounded sets in $R$ and$R^d$.
2. Measure theory. The exterior (outer) measure. Properties of the exterior measure: monotonicity, countable sub-additivity. Measurable sets and the Lebesgue measure. Properties of Lebesgue measure. Sigma-algebras and Borelsets.Construction of a non-measurable set.
3. Measurable functions. Borel and Lebesgue measurable functions and their properties.Nonmeasurable functions. Approximation by simple functions.
4. The convergences almost everywhere and in measure. The theorems of Lebesgue, Egoroff, Luzin and Riesz.
5. Lebesgue Integration theory. Lebesgue integral of a measurable and bounded function on $R$and$R^d$. The main properties of the Lebesgue integral: The theorem on average. Corollary. Additivity of the integral. The monotony of the Lebesgue integral. Comparison of the Lebesgue and Riemann integrals. Lebesgue's theorem on taking limits under the integral sign.Lebesgue integral of a nonnegative measurable function.
6. Fatou lemma. Theorem of Bepo-Levy. Integrable functions of arbitrary sign.Carathéodory's extension theorem to the algebra generated on its σ- algebra.
7. Functions of bounded variation, presenting them as a sum of monotone.
8. Lebesgue-Stieltjes measure. Lebesgue-Stieltjes integral and the Riemann-Stieltjes.Lebesgue theorem on the differentiability almost everywhere monotone function. The derivative of the integral over the upper limit. Lemma F.Rissa. The derivative of the indefinite Lebesgue integral.
9. Absolutely continuous functions. Cantor-Lebesgue function. Absolute continuity of the indefinite integral of a summable function. Lebesgue theorem about restoring an absolutely continuous function from its derivative. The formula for integration by parts in the Lebesgue integral.
10. Space L1. Integral Holder's inequality and Minkowski.
11. Radon-Nikodym theorem. The product measures. Fubini's Theorem. Applications

**PROGRAMMING IN** C#
**Learning Units:**
1. Introducing.NET and C#.
2. Lecture 2. C# Types and Operators.Method Issues.
3. Class and Interface Issues.
4. Arrays. Strings. Regex.
5. Miscellaneous Issues.
6. C# Properties and Indexes. Operator Overloading. User-DefinedConversions/Casts.
7. C# Enums and Structures. C# Attributes.
8. Exception Handling. C# Delegates and Events.
9.Multi-Threading. Reflection.
10.File I/O.
11. Add-on Serialization.
12. C# Collection Classes.
13. ADO.NET.
14.LINQ.
15. Generics.

**THE THEORY OF RANDOM PROCESSES**
**Learning Units:**
1. Introduction. The subject of random processes and its applications. Index set. Discrete-time and continuous-time processes. State space. Discrete and real-valued processes. Sample function. Increment.
2. Poisson point processes. Homogeneous and inhomogeneous Poisson processes: properties and

theorems. Spatial Poisson processes.
3. General point processes. Operations on point processes: operational time, thinning, translation, superposition. Multivariate point processes.
4. Markov chains. Markov property. Transient evolution. Reducibility. Periodicity. Ergodicity. Steady-state analysis. Limiting distributions.
5. Reversible Markov chains. Birth–death processes. Markov chains with rewards.
6. Continuous-time Markov processes. Kolmogorov differential equations. Monotonicity of Markov processes. Nonhomogeneous Markov processes.
7. General birth-death processes. Mixed Poisson processes.
8. Renewal processes. Renewal function. Delayed renewal processes. Renewal equation. Excess life.
9. A general approach to random walks. Lattice random walk. Ladder epochs. Wiener-Hopf factorization.
10. Martingales in discrete and continuous time. Filtration. Stopping Time. Submartingales. Supermartingales.
11. Doob's inequality. Convergence for martingales. Doob-Mayer decomposition. Kolmogorov's extension theorem.
12. Branching processes. Basic properties. Branching random walk.
13. Compound Poisson process.
14. Brownian motion. Wiener processes. First passage time. Barriers. Brownian bridge. Brownian excursion process.
15. Levy processes. An introduction to diffusion processes.

**THEORY OF LIFE CONTINGENCIES**

**Learning Units:**

Introduction to Life Contingencies and Life Tables. Survival Probability.
The Law of Mortality and the Construction of Mortality Tables.
Stationary Population.
Expectation of Life. Multiple Decrement Models
Introduction to Life Annuities.
Commutation Functions. Insurance Payable at the Moment of Death.
Varying Life Annuities. Increasing Life Annuities.
Annual Premiums and Unearned Premium Reserves for a Life Annuity.
Introduction to Life Insurance. Types of Life Insurance. Commutation Functions and Basic Identities for Life Insurance.
Insurance Payable at the Moment of Death. Varying Life Insurance.
Life Insurance Annual Premiums and Reserves.
Joint-Life Actuarial Functions. Types of Joint-Life Insurance Policies.
Last-Survivor Problems. Reversionary Annuity.
Pension Plan.
Pension Applications.

**DATABASE MANAGEMENT SYSTEM**

**Learning Units:**

1 Introduction to Databases and Database Systems
2 Theoretical-graphical data models
3 Basic notions of a relational model
4 Relational Algebra operations
5 Additional Relational Algebra operations. Relational calculus
6 SQL: data definition language, data manipulation language
7 SQL: data query language

8 Database Development
9 Modeling of DB based on normalization principles
10 Infological modeling
11 Principles of integrity supporting in relational data model
12 Physical DB models
13 Distributed data processing
14 Transaction models
15 Overview of Object-Oriented Databases

**ACTUARIAL PRINCIPLES AND THEIR APPLICATIONS-1**

**Learning Units:**

1. Applications of theory of interest
2. Loans: Amortization, Amortization Schedules, Sinking Fund. The outstanding loan balance.
3. TI BAII Calculator Professional
4. Bonds. Price of Bonds. Book value of bonds. Callable bonds. Bond Amortization. Modified Duration of Bonds.
5. Life Annuities. Different Forms of LifeAnnuities. Pricing of Annuities
6. Life Insurance: Product Design, Marketing, Underwriting
7. Individual Life Insurance. Calculation Premiums with Asset Share.
8. Actuarial Valuation of Life Annuities. Valuation of Reserves: Net Level Premium, Gross Premium methods.
9. Life Insurance: Minimum Required Capital. Risk-Based Capital.
10. The Economics of Insurance.Utility Theory. Insurance and utility. Optimal insurance.
11. Property and Casualty Insurance: Overview, Ratemaking. Loss Cost (LC) and Loss Ratio (LR) Methods.
12.Insurance Reserve and Loss Reserving in Property and Casualty Insurance
13. Loss Reserving in Property and Casualty Insurance Loss reserve estimation methods: Bornhuetter-Ferguson, Frequency-severity technique.
14. Loss Reserving in Property and Casualty Insurance.
Mack's Method.
15. Review Session

**ACTUARIAL PRINCIPLES AND THEIR APPLICATIONS-2**

**Learning Units:**

1. Life Insurance: Profitability Measurement and Analysis. Profitability measures. Pricing model.
2. The method of bounded fluctuations. Buhlmann's method.
3. Group Insurance. Overview of Group Insurance. Group Life Insurance Benefits. Group Disability Income Benefits.
4. Group Insurance. Underwriting large groups. Underwriting small groups. Application of credibility in group insurance. Underwriting and Pricing
5. Group Health Insurance. Development of health insurance plan (covered diseases, general conditions, covered medical services). Overview of Managed Care Plans (HMO, EPO, POS, PPO), Claim cost estimation methods: Aggregate Method, Benefit Cost Method, Budgetary Method, Community Rating Method).
6. Group Health Insurance. Impact of managed care on health costs, projecting multiple option claim costs. Gross premiums for group insurance (overview of components). Types of health insurance reserves and liabilities. Overview of Methods of Claim Reserves Estimation (Factor Method, Claim Runout/Lag Chart, Tabular Method, Average Claim Size Method, Loss Ratio Method).
7. Review Session

8. Reinsurance. Characteristics of Reinsurance Risks. Categories of Reinsurance Contracts.
9. Pensions. Overall objectives in designing a retirement program. Defined Benefit pension plan (DB)
10. Pensions.
Defined Contribution pension plan (DC). Principles of social security. Multi-tier pension plans
11. Investment Management. Financial planning process. Expected return and standard deviation.
Efficient frontier of risky assets. The Markowitz Portfolio Selection Model.
12. Investment Management
The Markowitz Portfolio Selection Model.
13. How to Promote Life Insurance Products – Insurance Company Perspective
14. Principles of Social Security.
15. Review Session.

**4. ELECTIVE COURSES (MAJORS)**

**1. Fourier series**

1. Orthonormal systems and general Fourier series.
2. Orthonormal systems.
3. The concept of a general Fourier series.
4. Closed and complete orthonormal systems.
5. Closure of the trigonometric system and its consequences.
6. Uniform approximation of a continuous function by trigonometric polynomials.
7. Proof of closure of the trigonometric system.
8. Consequences of the closure of the trigonometric system.
9. Conditions for the uniform convergence and term-by-term differentiation of the trigonometric Fourier series.
10. Introductory remarks.
11. Conditions for the absolute and uniform convergence of the trigonometric Fourier series.
12. The conditions for term-by-term differentiation of the trigonometric Fourier series.
13. Module of continuity of function.
14. Hölder classes.
15. The expression for the partial sum of the trigonometric Fourier series.
16. The principle of localization.
17. The uniform convergence of the trigonometric Fourier series for the function of the Holder class.
18. On the convergence of the trigonometric Fourier series of a piecewise Holder function.
19. Summability of the trigonometric Fourier series of a continuous function by method of arithmetic means.
20. Multiple trigonometric Fourier series.
21. The concepts of a multiple trigonometric Fourier series and its rectangular and spherical partial sums.
22. Modulus of continuity and Holder classes for a function of n variables.
23. Conditions for the absolute convergence of a multiple trigonometric Fourier series.
24. Fourier transformation.
25. Representation of a function by the Fourier integral.
26. Auxiliary statements.
27. The main theorem.
28. The inversion formula.
29. Examples.

30. Some properties of the Fourier transform.
31. Multiple Fourier Integral.

**2. Applied functional analysis**
**Learning Units:**
1. Inner product spaces and the Cauchy-Schwarz inequality.
2. Normed spaces and bounded linear operators.
3. Metric spaces, convergence and density, different convergence notions for sequences of functions.
4. Topological notions in metric spaces (open and closed sets, continuity, and compactness, equivalence of norms and metrics, completeness)
5. Banach and Hilbert spaces, convergence of series in Banach and Hilbert spaces.
6.L1[a;b]- and L2[a;b]-spaces.
7. Hilbert Space Fundamentals (best approximations, orthogonal projections, Riesz-Frechet theorem, maximal orthonormal systems, abstract and concrete Fourier expansions)
8. Sobolev spaces and the variational approach to Poisson's problem in dimension one
9. Integral operators, Hilbert-Schmidt operators, Volterra operators, Neumann series with applications to integral equations, adjoints of Hilbert space operators, compact Hilbert space operators
10. Spectral theory of compact self-adjoint operators
11 Applications to boundary value problems in dimension one

**3. Spectral theory of linear operators**
**Learning Units:**
1. Introduction to the linear operators. Definitions.
2. Ordinary differential equations. Main properties. Fundamental solutions.
3. Partial differential equations.
4. Boundary value problems. Dirichlet and Neumann boundary conditions.
5. Regular boundary conditions. Introduction to the results of Naimark.
6. Spectral problems for ordinary differential equation with regular boundary conditions.
7. The system of eigenfunctions as a basis of the Hilbert space.
8. Different types of function systems. Basisness. Completeness. Minimality. Totality.
9. The first and second eigenvalues. Connection with Physics. Interdisciplinary interpretations.
10. Pseudo-differential operators.
11. The spectral theory of self-adjoint pseudo-differential operators. Introduction to Agranovich's results.
12. The spectral theory of differential operators on compact Lie groups.

**4.Number Theory**
**Learning Units:**
1.Brief overview of natural numbers, integers, primes, the Euclidean algorithm for integers. The fundamental theorem of arithmetic. Applications of unique factorization in Z.
2.Modular arithmetic. Euler's totient function
3.Fermat's little theorem. Fermat's sum of two squares theorem. The Chinese remainder theorem
4. The Gaussian integers and their applications to the arithmetic of the integers
5-6. Diophantine equations. Pell’s equation
7. Review session
8. Diophantine approximation and continued fractions
9-10. Quadratic reciprocity and Gauss sums
11. Riemann zeta function

12-14.Ring of integers. Norm, trace and discriminant

15. Review session

**5. Approximation Theory**

**Learning Units:**

1.Interpolation. Basic concepts.Linear problem of approximation theory.Lagrangian interpolation.Estimation of the error of the Lagrange interpolation formula. Inequalities of Lebesgue.Residual plan in the Cauchy form for the Lagrange interpolation formula.The Haar theory of interpolation in $\mathbb{R}^N$.

2. Estimation of the remainder of the interpolation. Polynomials of Chebyshev.Evaluation of the remainder term. Polynomials of Chebyshev.Basic properties of Chebyshev polynomials (expressed by equalities).Extremal properties of Chebyshev polynomials.

3. Polynomials of Chebyshev (continuation). Interpolation (applications).Theory of V.A. Markov.Extremal interpolation on the class $W^{n+1}$.Interpolation in a complex area.The simplest applications of the Lagrange interpolation formula.

4. Quadrature processes and interpolation with derivatives.Quadrature formulas.Quadrature processes and their convergence.Interpolation with derivatives.

5. Fourier series, Feier sums.First information about Fourier series.The Feier sums.

6. Approximation of continuous functions by Fourier sums. The sums of Valle Poussin.

Approximation by Fourier and Feier sums in $\mathrm{C}_{2\pi}$.The sums of Valle Poussin.Properties of the sums of Valle Poussin.

7. Best approximations in linear normed spaces.Auxiliary information from the theory of linear normed spaces.Characteristics of linear normed spaces.Basic spaces.

8. Jackson's theorem.Approximation to $L_2(a,b)$.Bernstein's inequality.Modulus of oscillation, modulus of continuity.Jackson's theorem in в$L^2_{2\pi}$.The reverse theorem.

**6. Pseudo-differential Operators on compact Lie groups**

**Learning Units:**

1. Motivation. Basic properties of the Fourier transform.

2. Tempered distributions. Fourier transform of tempered distributions. Operations with distributions. Approximating by smooth functions.

3. Distributions. Localization of $L^p$ –spaces and distributions. Convolution of distributions.

4. Mollifies. Properties of mollifications. Lebesgue's differentiation theorem.

5. Amplitude representation of pseudo-differential operators. Kernel representation of pseudo-differential operators.

6. Boundedness of Pseudo-differential Operators on $L^2$.

7. Calculus of pseudo-differential operators. Composition formulae.

8. Applications to partial differential equations. Freezing principle for PDEs.

9. Distributions and Fourier transform on the torus and lattices.

10. Toroidal symbols.

11. Groups. Topological groups. Representations of topological groups.

12. Peter–Weyl decomposition of representations.

13. Fourier series on compact Lie groups.

14. Function spaces on the unitary dual. Spaces on the group. Spaces on the dual. Symbols of operators. Full symbols.

15. Taylor expansion on Lie groups. Symbolic calculus. Difference operators.

**7. Hyperbolic equations with distributional data and coefficients**

**Learning Units:**

1. Motivation. Examples of physical phenomena where discontinuous or singular entities are involved.

2. Introduction to the basic notations.
3. Parameter Dependent Quasi-Symmetriser. The Quasi-Symmetriser: General Theory.
4. Parameter Dependent Quasi-Symmetriser. The Quasi-Symmetriser of the Matrix Aε.
5. Case 1: Well-Posedness for Gevrey Initial Data. Gevrey-Moderate Families.
6. Case 1: Well-Posedness for Gevrey Initial Data. Energy Estimate and Well-Posedness.
7. Case 2: Well-Posedness for Smooth Initial Data. Gevrey Regularization of Smooth Functions with Compact Support.
8. Case 2: Well-Posedness for Smooth Initial Data. Energy Estimates and Well-Posedness.
9. Case 3: Well-Posedness for Distributional Initial Data.
10. Consistency with the Classical Well-Posedness Results.
11. Introduction. Fourier analysis for the Landau Hamiltonian.
12. Wave equation for Landau Hamiltonian. Classical well-posedness.
13. Wave equation for Landau Hamiltonian with irregular electromagnetic field. Existence of the very weak solutions.
14. Wave equation for Landau Hamiltonian with irregular electromagnetic field. Uniqueness and consistency of very weak solutions.
15. Inhomogeneous equation case. Landau Hamiltonian in R^2d.

**8. Nonharmonic Analysis**

**Learning Units:**

1. Introduction. Examples of model operators and boundary conditions
2. Global distributions generated by the boundary value problem
3.L-Fourier transforms. L-Convolutions
4.Plancherel formula, Sobolev spaces H(s, L), and their Fourier images
5. Spaces lp(L) and lp(L*)
6. Schwartz' kernel theorem.
7. L-Quantization and full symbols.
8. Difference operators. Symbolic calculus. I.
9. Symbolic calculus. II. Properties of integral kernels.
10. Sobolev embedding theorem. Conditions for L2-boundedness.
11. Motivation. Examples of manifolds with boundary.
12. Global symbols: L-symbols and L-Fourier multipliers on compact manifolds with boundary.
13. Schatten classes and nuclearity on manifolds with boundary.
14. Review on the Analysis without WZ condition. Part 1. Schwartz' kernel theorem.
15. Review on the Analysis without WZ condition. Part 2. Symbolic calculus.

**9. Elements of Computability Theory**

**Learning Units:**

One-one reducibility and many-one reducibility.
Creative set. Complete set.
One-one equivalence and recursive isomorphism.
One-one completeness and many-one completeness.
Cylinder. Productiveness. Simple set. Immune set.
Truth-table reducibility and many-one reducibility.
Bounded truth-table reducibility.
Turing reducibility and truth-table reducibility.
Post’s problem. Hypersimple sets; Dekker’s theorem.
Enumeration reducibility. Recursive operators.
Incomplete sets. Friedberg’s solution.

**10. Algebraic system**

**Learning Units:**
Sets and the Cartesian product. Equivalent relation and a factor set. Groups and subgroups. Adjacent classes. Normalized subgroup. Factor group. Lagrange theorem and its corollary.
The order of the element, subgroup. Cyclic groups. Group's homomorphisms and isomorphisms. Rings. Subrings. A homomorphism of rings and their kernels. Ideals of commutative rings. The ring of integers modulo n. Canonical homomorphism. Simple and maximal ideals. A theorem on the maximal ideal, which is a prime ideal. Ring of the main idols. Nilpotent elements and zero divisors. Zorn's Lemma. The theorem on finding the maximal element. Nil-radical. A theorem about the nilradical of a ring which is equal to the intersection of all prime ideals of the ring. The nil-radicals of a ring of polynomials with n-variables. Primitive polynomials. The Gauss lemma on primitive polynomials. Division algorithm for polynomials of n-ring variable. Operations on Ideals. The Jacobson radical and its properties. Mutually prime ideals. Monomials and their ordering. Lemma of Dickson. Lexical order and its types. Gröbner basis. Algorithm to find the finite number of polynomials for the construction of the Gröbnerbasis. The Buchberger algorithm to find the Gröbnerbasis of an ideal. System of polynomial equations of sets. The Hilbert's Zeros Theorem. Commutative Algebra and Algebraic Geometry.

**11. The theory of algorithms**
**Learning Units:**
Non-formal understanding of algorithm. Simple functions. Primitive recursive and superposition operators. Class of primitive recursive functions. Primitive recursive predicates. Cantor and Gödel numberings. Minimization operator. Class of partial recursive, total recursive and recursive functions. The notion of Turing machine. Functions computable by Turing machine. Computability of primitive recursive functions. Programming on Turing machine and useful programs. Enumeration of Turing machines. Theorem about equivalence between partial recursive functions and functions which are computable by Turing machine. Kleene theorem about normal form of partial recursive functions. Church-Turing thesis. The notion of recursive and recursively enumerable sets. Basic operations on recursively enumerable sets. Criteria of recursive sets. Direct and non-repeating recursive enumerations. Criteria of recursively enumerable sets. Projection theorem. Reduction and uniformization theorems. Theorem about graphic. Universal functions. Kleene numberings. Diagonal method of prove. Parameterizations theorem. Recursion theorem. Rice theorem. Myhill's theorem for characterization recursively enumerable predicates. Post numbering. Computable numberings. Reducibility of numberings. Principal numberings. Canonical numberings of the family of finite sets. Criteria of computable numberings. The notion of m-reducibility. Creative and productive sets. Simple sets.

**12. Introduction to model theory**
**Learning Units:**
Sets and operations over the sets. Cartesian product and relations. Operations over the relations. Mapping. Binary relations. Special binary relations. Equivalent classes. Quotient sets. Interpretation and model. Submodels. Notions of terms and formulas. Definability, truth and false formulas. Sentences. Equivalence of formulas. Normal form. Definability on models. First order theory. Homomorphism of the models. Isomorphism and automorphism of the models. Groups of automorphisms and relation between them. Elementarily equivalent models. Local isomorphism and its properties. Elementary submodel. Tarski-Vott theorem of an elementary model. Definitive relations and functions. J. Robinson theorem. Henkin Theory. Filters product and ultra-products. Contradictory and inconsistent models. Gödel's completeness theorem. Non-standard models of arithmetic. Peano Arithmetic. Elimination of quantifiers. Solvable and

insoluble theories. Gödel's theorem on incompleteness. On the undecidability of arithmetic. Theory of categoricity. Types. Type of elements and full types. Examples of categorical theories: the theory of dense orders and independent equivalence relations. The uncountable categoricity of algebraically closed fields. Waught's theorem on the completeness of categorical theories and examples of its application. Ryl'-Nardzevsky theorem and countably categorical theories. Operations over graphs. The theory of probability graphs and its countable categoricity. Properties of probability graphs. Atomic and the complete diagram. Tarski's quantifier elimination algorithm. Levenheim-Skolem's theorem on lowering and increasing capacity. Homogeneous and non-homogeneous models. Universal and simple models.Ehrenfeucht's theorem on theories with a finite number of countable models.Morley's theorem on categoricity. Totally categorical theories. Algebraic and definable closure. Properties of closeness and definability. Lachlan-Baldwin theorem.

**13. Introduction to classical geometry**

**Learning Units:**

Euclidean geometry. Symmetries. Invariants under rigid transformations. Cylinders and tori. Finite subgroups of E(2) and E(3).

Affine geometry. The line at infinity. Affine transformations and their invariants.

Projective geometry. The real projective plane. The Duality Principle. The shape of RP2. Coordinate charts for RP2 (and for CP1). The projective group. Invariance of the cross ratio. The space of conics. Projective properties of the conics. Poles and polars. Elliptic geometry.

Hyperbolic geometry. Models of the hyperbolic plane. Transformations of the hyperbolic plane. Steiner network. The hyperbolic metric. The first results in hyperbolic geometry. Surfaces with hyperbolic structure.

**14. Stochastic Differential Equations**

**Learning Units:**

1. Stochastic integral of a nonrandom function with respect to a process with uncorrelated increments. Processes with uncorrelated and orthogonal increments. Nondifferentiability of processes with uncorrelated increments. A function defined as the variance of a process increment with uncorrelated increments and the relationship of its properties to the properties of the process itself.

2. Stochastic integral of a nonrandom function with respect to a process with uncorrelated increments (continuation)

The stochastic integral $I(f) = \int_a^b f(t)d\xi_t$ , $f\epsilon L^2(dF)$ where $F(t) - F(s) = M|\xi_t - \xi_s|^2$ , $s \leq t$. The case of step functions $f(t)$. Properties of the integral. The general case is $f\epsilon L^2(dF)$. The simplest properties of the integral $I(f)$.

3. Some less elementary properties of the integral $I(f) = \int_a^b f(t)d\xi_t$, $f\epsilon L^2(dF)$.

The case of continuous $f(t)$, $t \in [a, b]$. The case of a continuously differentiable function $f(t)$: the integration by parts formula. The case of permutability by integration with respect to the process and the parameter.

4. The Ito stochastic integral of the random function $f(t, \omega)$ , $t \in [0, T]$ , $\omega \in \Omega$ and $M \int_0^T f^2(t, \omega)dt < \infty$.

The Wiener process $W_t$, $t \geq 0$. One characterization property of the Wiener process. Different variants of the definition of a stochastic integral (a stochastic integral in the Wiener process)

5. Stochastic Ito integral of a random function (continued)

A random function independent of the future (function of class M). The spaces $L^2_{[0,T]\times\Omega}$ , $\mathrm{M}^2 =$

$M \cap L^2_{[0,T]\times\Omega}$. Simple functions in $M^2$. The definition of a stochastic integral for the function $f(t,\omega) \in M^2$. Properties.
6. Stochastic Ito integral of a random function (continued)
The properties of the integral associated with the mathematical expectation of the product and the conditional mathematical expectation of the sigma algebra generated by the Wiener process.
7. The Ito stochastic integral of a random function (continued)
Stochastic integral (general case). Properties of a stochastic integral (general case)
8. Stochastic Ito integral of a random function (continued)
Kolmogorov inequality for martingales with continuous time. Stochastic integral with variable upper limit. The existence of a continuous modification.
9. The stochastic integral $I_t(f) = \int_0^T f(s,\omega)dW_s$, in the case $f \epsilon M$,

$$P\left\{\int_0^t f^2(s,\omega)ds < \infty\right\} = 1.$$

Definition of the integral for simple functions. Properties of the integral. Definition of the integral in the general case (stage I, stage II, stage III). Proof of the intermediate lemma.
10. The stochastic integral (continuation)
Proofs of the properties of a stochastic integral. Stochastic integral with a random (Markov moment) upper limit. Stochastic integral with infinite upper limit.
11. The formula (change of variables) of Ito
Stochastic differential. Ito's theorem (one-dimensional case). Ito's theorem (the multidimensional case). Examples of application of the Ito formula.
12. Stochastic differential equations
Definition of a stochastic differential equation. Determination of the solution of a stochastic differential equation. Existence and uniqueness theorem
13. Stochastic differential equations in cases when the coefficients of the equation depend both on time and space coordinates.
Write the general equation. Conditions on the coefficients. Determination of the solution. The existence and uniqueness theorem for a solution.
14. Markoviness of the solution of a stochastic differential equation.
Inequality for the fourth moment of the difference of the solution. Theorem on the Markov property of the solution. Coincidence of the transfer and diffusion coefficients of the equations in question.
15. Method of differential equations for the determination of distributions from diffusion (Markov) processes.
The conditional mathematical expectation along the trajectories of the process as the solution of the parabolic partial differential equation determined by this process

**15. Stochastic financial mathematics**
**Learning Units:**
1. Basic consepts of the securities market(stocks, bonds, financial market, interest rate, option). Subject of financial mathematics.
2. Probabilistic foundations of financial modeling. Investment strategy(portfolio).Finiteprobabilityspaces.
3. Independence (independence of sets, independents of sigma-algebra, independence of random variables, correlation and independence, law of large numbers, central limit theorem).
4. The Binomial no-arbitrage pricing model. A Binomial model for stockpricedynamics. Information.
5. Conditional expectation (definition of conditional expectation, properties of conditional expectation, examples from the Binomial model)
6. Martingales. Markov processes.

7. Arbitrage pricing. Risk-neutralprobabilitymeasure (Portfolio process, self-financingvalueof a portfolio process). TheMarkovproperty. Binomialmodelpricingandhedging.
8. Pricing in terms of market probabilities: Radon-Nikodymtheorem. Changeofmeasure. Applications of Radon-Nikodym theorem
9. Capital Asset Pricing Model
10. American derivative securities. American Calloptions.
11. Random walk. First passage time. Raflection principle.

**16. Stochastic processes**
**Learning Units:**

1. Gaussian system.

Gaussian random variables, vectors, degenerate and nondegenerate normal (Gaussian) distribution. Gaussian system. Properties. The existence of Gaussian systems with given mean and covariance matrix. Examples.

2. Gaussian system (continued). The structure of the degenerate normal distribution.Orthogonalization process. A theorem on normal correlation and its application.
3. Basic concepts of the theory of stochastic processes. The random process. Trajectory (custom function) of a random process. Finite-dimensional distribution. The properties of symmetry and consistency. Kolmogorov's theorem on finite-dimensional distributions. The main classes of random processes.
4. Poisson process. Poisson process. The trajectory of the Poisson process. Applications to certain biological problems (birth and death processes).
5. Wiener process. A random walk model, which leads (in the limit) to the Wiener process (Brownian motion). Finite-dimensional distribution of the Wiener process. One characterization property of the Wiener process.
   Building Wiener process as a series with random coefficients.
6. Stochastic equivalent processes. Kolmogorov. The concept of stochastic equivalence. Stochastic continuity. A necessary and sufficient condition for the existence of a continuous moditifikatsii. A sufficient condition for the existence of a continuous modification (Kolmogorov).
7. Properties of the trajectories of Wiener process. The law of the iterated logarithm. Local law of the iterated logarithm. Nediffirentsiruemost trajectories.
8. Markov and strong Markov properties of the Wiener process. Markov property. Markov time and the associated sigma-algebra. The principle of reflection for the Wiener process. Wald distribution.
9. Correlation function. Processes with a finite second-order moments. Mean values and correlation functions. Property nonnegative definiteness of the correlation function as a characteristic property of the correlation functions.
10. Continuity and differentiability in the mean square. Continuity in the mean square. The criterion of continuity in the mean square. Differentiable in mean square and the criterion of differentiability in rms. The correlation function of the mean square derivative.
11. Integrability in mean square. The integral in the mean square. Criterion of integrability in the mean square. The ergodic theorem.
12. The best linear forecast in terms of the standard deviation. The Hilbert space of random variables. Linked with a stochastic process sigma-algebra and the space of random variables. The task of the best estimate. The best linear forecast in terms of the standard deviation.

13. Processes with orthogonal increments. Definition. Associated with the variance of the increment function. Stochastic integrals of nonrandom functions of processes with orthogonal increments.
14. Stationary processes. Fixed in the narrow and broad sense of random processes. The correlation function in a wide sense stationary process. Bochner-Khinchin theorem on the representation of the correlation function.
15. The spectral representation of stationary in the broad sense of the process. Theorem on the spectral representation (the general case). Spectral representation (real case).

**17. Non-parametric statistic and learning theory**
**Learning Units:**
1. Hypothesis tests.
2. Goodness-of-fit tests for checking whether an unknown distribution belongs to a given parametric family of distributions, or equals a specific parametric distribution: Chi-Squared test, Kolmogorov-Smirnov test).
3. Univariate density estimation. The Rosenblate density estimator and the basic asymptotic results. Univariate Kernel Density Estimation Example. Bias approximation. Distribution function estimation. Multivariate density estimation. Bandwidth Choice. Minimizing Integrated Squared Error. Minimizing Mean Integrated Squared Error
4. Nonparametric estimation of a regression function: kernel estimation, local polynomial, estimation, spline estimation

**18. The theory of random matrices**
**Learning Units:**
1. Introduction: Applications of random matrix theory and examples of spectral distributions.
2. Elementary notions of matrix theory.
3. Elementary notions of probability and measure theory.
4. The Poisson process and its spacing distribution.
5. The 2 x 2 Gaussian ensembles and their spacing distributions.
6. Spectral correlation functions for the CUE ensemble.
7. Techniques for calculating spectral statistics

**19. Qualitative theory of differential equations**
**Learning Units:**
Autonomous systems of differential equations. Properties of solutions. Autonomous systems of differential equations on the plane. Linear autonomous systems of differential equations on a plane. Special points. Types of singular points and phase portraits. Nondegenerate singular points of a nonlinear system of differential equations and phase portraits. Follow-up function. Cycle. Limiting cycle. Theory of indices. Limit points of trajectories of an autonomous system of differential equations. The notion of Poisson stability. The concept of Lagrange stability.

**20. Periodic and conditionally periodic solutions of differential equations**
**Learning Units:**
The theory of oscillations is of great importance in applied problems. The main types of oscillations are periodic and conditionally periodic oscillations. The theory of such research was created by great mathematicians A. Poincare, A.N. Lyapunov. Russian mathematicians N.N. Bogolyubov, A.A. Andronov, I.G. Petrovsky, N.P. Yerugin, etc. They were received outstanding results. World-famous results belong to Kazakhstan mathematicians K.P. Persidsky, O.A. Zhautykov, V.Kh. Kharasakhal, D.W. Umbetzhanov and others.
The course outlines the theory of periodic and conditionally periodic solutions of differential equations and their applications in problems of mechanics, engineering, and physics. It consists

of two sections: the theory of J. Floquet and the theory of N.N. Bogolyubov and Yu.M. Mitropolsky. On methods of finding periodic solutions. The course prepares for the solution of problems by periodic oscillations.

**21. The theory of generalized Lyapunov exponents**
**Learning Units:**
A generalized Lyapunov exponent for solutions of a linear system of differential equations. A normal fundamental system of solutions. Generalized Lyapunov exponents of a linear system of differential equations. Generalized regular linear system of differential equations. Existence of generalized exponents of solutions of a nonlinear system of differential equations. Stability and generalized Lyapunov exponents of a nonlinear system of differential equations. Signs of stability, asymptotic stability, and exponential stability of solutions of a nonlinear system of differential equations obtained by applying generalized Lyapunov exponents.

**22. Asymptotic methods for solving singularly perturbed equations**
**Learning Units:**
This course is devoted to the investigation of asymptotic behavior and to the construction of an asymptotic expansion of solutions of initial and boundary value problems for singularly perturbed ordinary differential and integro-differential equations and systems. Qualitative asymptotic properties of solutions of initial and boundary value problems for singularly perturbed differential and integro-differential equations are established.
Analytic formulas for solutions of initial and boundary value problems for singularly perturbed linear ordinary differential and integro-differential equations are obtained. Estimates of solutions and closeness between solutions of singularly perturbed and degenerate problems are obtained.
Asymptotic expansions of solutions of initial and boundary value problems for any degree of accuracy with respect to a small parameter are constructed. The results obtained are applicable in applied problems of physics, engineering, chemistry and mechanics: for example, the propagation of heat in thin bodies, the theory of semiconductor devices, the combustion process in the case of an autocatalytic reaction, a medium with low viscosity.

**23. Integral and integro-differential equations**
**Learning Units:**
This course is intended to familiarize students with the basic concepts and theorems of the theory of integral equations of Volterra and Fredholm, integral equations with weak singularities, the main sections of the theory of Fredholmintegro-differential equations. Concepts analogous to the basic concepts of the theory of integral Fredholm equations are introduced, and analogues of Fredholm theorems are proved. For Fredholmintegro-differential equations, the Cauchy problems and boundary value problems, some singularities of these equations, are considered.

**24. Theoretical and computational questions of the equations of mathematical physics.**
**Learning Units:**
Initial-boundary value problems of mathematical physics. Correctness of the statement of problems. Basic equations of mathematical physics of parabolic, hyperbolic and elliptic types. Finite difference schemes of PDE. Explicit and implicit schemes.
Numerical analysis of the initial-boundary value problems for parabolic equations. Convergence and stability. Test function method. Galerkin's method.
The statement of finite-difference problems. Numerical solution of initial-boundary value problems for hyperbolic and elliptic equations.

**25. Modern methods for solving boundary value problems of partial differential equations.**
**Learning Units:**

Generalized functions. Weak derivatives. Averaging functions. The Faedo-Galerkin Method. The Lare-Schauder method. Sobolev's imbedding theorems. Interpolation inequalities. Modern functional methods. Obtaining a priori estimates.
Energy estimates. The transition from the classical formulation to the generalized initial boundary value problems of partial differential equations.
Strong and weak solutions of boundary value problems of mathematical physics. Existence and uniqueness of a weak solution of initial-boundary value problems of partial differential equations.

**26. The motion stability theory**
**Learning Units:**
The motion stability theory is one of the main applied sections of higher mathematics, where the theory of differential equations and theoretical mechanics are organically intertwined. It has wide application in various fields of engineering, physics, biology, etc. The course "The motion stability theory" is a natural continuation of the course of ordinary differential equations and providing the basis for a qualitative study of solutions of differential equations.
A mathematical theory of stability was developed by the greatRussian mathematician A.M. Lyapunov. Prominent successors are M.G. Chetaev, I.G. Malkin, K.P. Persidsky, N.N. Krasovsky, etc. The fundamental results are due to our compatriot K.P. Persidsky and his Kazakh students Yu.G. Zolotarev, M.Ya. Yataev, A.A.Bedelbaev, etc. In the special course, the main theoretical achievements of Kazakhstan mathematicians about uniform stability in the first approximation, the existence of the Lyapunov function, and the characteristic exponents of differential equations are presented. The problems of mechanics, physics, automatization and control are solved. After completing the course, the student acquires the technique of solving stability problems using the second Lyapunov method.

**27. Methods of Teaching Mathematics**
**Learning Units:**
The sources of development of mathematical education are the values of two cultures, accumulated over many centuries of experience in mankind: the mathematical proper and the culture of teaching mathematics. Mathematics instills in everyone who comes into contact with it, a culture of thinking, develops logic. The culture of teaching mathematics includes a diverse in content teaching texts, tasks, methods and ideas, tested by historical experience and consecrated by tradition. The requirements for mathematical education in general terms are as follows: to ensure a strong and conscious mastery by the students the system of mathematical knowledge and skills necessary in solving practical problems. Mathematical education should focus on the development of the individual and master knowledge, which have a common cultural value, worldview.
The course outlines the methodological system of teaching mathematics in secondary school and in the initial courses of the university, which includes the formation of a scientific worldview through applied orientation, inter subject communication, historical approach in teaching. The criteria for the selection of content, the basic didactic principles of instruction, are formulated. The methodology of curriculum design, application of inductive, axiomatic-deductive method, differences in the peculiarities of conducting lecture and practical exercises are disclosed. Methods for conducting experimental work on knowledge assessment are given in the literature.

**28. General theory of extreme problems**
**Learning Units:**
Thepurposeofthesubjectistoacquirewith the general theory of extreme problems in Banach space. Thedisciplineisbasedonsubjects “Functional analysis”, “Differential equations”.

Problem statement. The main determinations. Examples. Feasible controls. Optimal control. Functional limitation. The lower bound. Minimizing sequences. Sequence convergence to the set. Absolute minimum.
The main problems of optimal control.
Differentiation of nonlinear operators. Differentiation of nonlinear functionals.
Existence and uniqueness theorems of solution of the Cauchy problem for differential equation in Banach space at control.
Iteration process of Newton-Kantorovich.
Weierstrass theorem in Banach space.

**29. Mathematical programming**
**Learning Units:**
The purpose of the discipline is to study of the theory and methods of minimization for finite-dimensional problem. The discipline is based on the subjects «Mathematical analysis», «Algebra and geometry», «Variation calculus and methods of optimization».
The basic of the theory and methods of unconditional minimizations. Extreme conditions. Gradient method. Newton method.
The general problem of mathematical programming. Convex programming. Nonlinear programming. Methods of convex programming. Methods of nonlinear programming.
Linear and quadratic programming. Theory of linear programming. Finite methods of linear programming. The iteration methods of linear programming. Quadratic programming.

**30. Optimal control**
**Learning Units:**
The purpose is to study the base of the theory and methods of minimization of extreme problems. The discipline is based on the subjects «Functional analysis», «Differential equations», «Variation calculus and methods of optimization».
Convex analysis in Banach space. Convex sets and convex functionals. Strong convex functionals.
Theorem about global minimum. Optimality condition. Projection of the point on the set.
The properties of the convex sets and convex functionals.
Functional gradient on the set of solutions of ordinary differential equations. Lipshitz condition for functional gradient. Optimality condition.
Minimization methods of functional in Banach space. Gradient method. Gradient projection method.

**31. The boundary problems of control theory**
**Learning Units:**
The purpose of the discipline is to study of controllability and optimal speed for processes described by ordinary differential equations. The discipline is based on the subjects «Variation calculus and methods of optimization», «Optimal control».
Integral equations. Solvability and construction of solution of the equations. Approximation solution of Fredholm integral equation of the first kind. Integral equation with parameter.
Controllability theory and optimal speed. Controllability and optimal speed of linear system. Controllability and optimal speed of nonlinear system.
The boundary value problem theory of ordinary differential equations. Constructive theory of boundary value problems. Immersion principle.

**32. Practical solving of optimization problems and counterexamples in optimal control theory**
**Learning Units:**

The optimization control theory is one of the general directions of the applied mathematics with very large important applications. It gives general methods of solving of the optimal control problems. Particularly, we can use gradient methods or iterative methods for their solution of the necessary conditions of optimality (maximum principle, variational inequalities, some other). However, it is justification that requires some suppositions on the problem parameters. This is difficult, as the rule, to check, if these assumptions are true or not. Therefore, we use usually the optimization methods formally without its argumentation. Hence, the result of using of these methods can be negative.

The aim of this course is the analysis of the easy enough examples of the optimal control problems with non-trivial properties. There are the easiest models of the serious practical optimization problems with the same difficulties. The formal using of the standard optimization methods here leads to serious difficulties. We consider the convergence of the iterative optimization methods, the existence and the uniqueness of the optimal control, the sufficiency of the necessary conditions of optimality, the singular control, the well-posedness of the optimal control problems by Tihonov and Hadamard, the bifurcation of extremals.

Each considered example is analyzed, at first, with using of standard optimization methods. We model solving of these problems by computer. Then we discover a form of serious difficulty. We try to determine the reason for this unsatisfactory result. We determine the class of the optimal control problem, where this concrete difficulty is absent. Finally, the practical recommendations for the analysis of the optimization problem with this form of difficulties are given.

This course increases the chances of finding the optimal control for the applied optimal control problems.

**33. Optimization problems for the distributed parameter systems and the differentiation theory**

**Learning Units:**

The distributed parameters systems are the most important and difficult class of control systems. There are mainly the systems described by the equations of mathematical physics. The aim of this course is to study the optimal control problems for systems with distributed parameters from the positions of the theory of differentiation.

As is known, there is a serious relation between extremum problems and the differentiation procedure. In particular, the necessary condition for an extremum of a function is the equality to zero of the derivative of this function at the point of extremum. Besides, many conditions for the extremum of the classical calculus of variations are obtained by equating to zero the variation of the functional. However, the variation of the functional is naturally related to its Gâteaux derivative. The corresponding necessary conditions for the extremum here is the equality to zero of the derivative of this functional at the point of extremum. If the functional is minimized on a convex set, then the variational inequality is a condition for the extremum, which also includes the derivative of the functional.

The natural extension of these results to optimal control problems, in particular, those related to systems with distributed parameters, leads to the necessity of differentiating the state function with respect to the control system. Thus, we pass from differentiating functionals to differentiating operators of general form. If this dependence is not differentiable, then it is possible to obtain the necessary optimality conditions by using weaker forms of operator derivatives. The methods of practical finding these derivatives are given.

This course allows us to develop optimization methods for a large class of difficult enough practically important problems of mathematical physics.

**34. Boundary value problems of mathematical physics**
**Learning Units:**
1. Generalized functions and actions on generalized functions. Normed spaces and Hilbert spaces.
2. General information about linear functionals and linear bounded operators in Hilbert spaces.
3. Compact sets. Completely continuous operators. Linear equations in Hilbert space.
4. Self-adjoint completely continuous operators. On unbounded operators.
5. Generalized derivatives and averaging. The definition of spaces $W_m^l(\Omega)$, $\overset{0}{W}{}_m^l(\Omega)$ and their basic properties. Embedding theorems for spaces $\overset{0}{W}{}_m^l(\Omega)$ and $W_m^l(\Omega)$.
6. Equations of elliptic type. Statement of boundary value problems. Generalized solutions from $W_2^1(\Omega)$. First (energy) inequality.
7. Investigation of the solvability of the Dirichlet problem in space $W_2^1(\Omega)$ (three Fredholm theorems). Expansion theorems in eigenfunctions of symmetric operators.
8. The second and the third boundary value problems. The second fundamental inequality for elliptic operators. Solvability of Dirichlet problems in space $W_2^2(\Omega)$. Approximate methods for solving boundary value problems.
9. Equations of parabolic type. Statement of initial-boundary value problems and Cauchy problems.
10. The first initial-boundary value problem for the heat equation. The first initial-boundary value problem for parabolic equations of general form.
11. Rothe method for the initial-boundary value problem of a parabolic equation.
12. General information about hyperbolic equations. Statement of boundary value problems. Properties of solutions of the wave equation. Cauchy problem for the wave equation.
13. Mixed tasks. Uniqueness of the solution of existing generalized solutions for the wave equation.
14. Galerkin's method. Smoothness of generalized solutions for the wave equation.

**35. Introduction to the inverse problems theory of mathematical physics**
**Learning Units:**
1. Basic concepts about inverse and ill-posed stated problems.
2. Methods for solving ill-posed problems. Solution of the operator equation of the first kind on compact sets. Method of quasi-solutions. The Tikhonov regularization method.
3. Methods for solving ill-posed problems. Iterative method for solving the operator equation of the first kind.
4. Methods for solving integral equations of the first kind.
5. Inverse problems for ordinary differential equations. Problems of determining the right-hand side of a linear differential equation.
6. Problems of determining the coefficients of a linear differential equation and a system.
7. Inverse problems for linear ordinary differential equations with a parameter.
8. Inverse Sturm-Liouville problem.
9. Equations of parabolic type. Statement of initial-boundary value problems and Cauchy problem.
10. Inverse problems for the heat equation. The problem with the reverse direction of time.
11. The problem of determining the initial temperature distribution by measuring the temperature at a point.

12. Determination of the boundary condition for the heat equation.
13. The problem of determining the heat source for the heat equation.
14. The inverse problem for the Laplace equation.
15. Inverse problems for the equation of oscillations. Determination of the initial position of the string for the equation of oscillations.

**36. Special functions in problems of mathematical physics**
**Learning Units:**

1. Definitions of gamma function. Functional relations for the gamma function. Logarithmic derivative of the gamma function. Definite integrals associated with the gamma function.
2. Legendre polynomials. Definition and generating function. Recurrence relations and the differential equation for Legendre polynomials.
3. Orthogonality of Legendre polynomials. Expansion of functions into series in Legendre polynomials.
4. Application of Legendre polynomials to the solution of boundary value problems.
5. Hermite polynomials. Definition and generating function. Recurrence relations and the differential equation for Hermite polynomials.
6. Orthogonality of Hermite polynomials. Expansion of function into series in Hermite polynomials.
7. Laguerre polynomials. Definition and generating function. Recurrence relations and differential equation for Laguerre polynomials.
8. Orthogonality of Laguerre polynomials. Expansion of function into series in Laguerre polynomials.
9. Cylindrical functions. Bessel functions with positive integer and arbitrary m icon. Bessel functions of the second kind. Expansion in a series of Bessel functions of the second kind with an integer icon.
10. Bessel functions of the third kind. Zeros of cylindrical functions.
11. Application of cylindrical functions to the solution of boundary value problems.
12. Spherical Legendre functions. Representation of spherical functions by series.
13.Recurrence relations.
14. Application of spherical functions to the solution of boundary value problems. Boundary value problems for the Helmholtz equation.
15. Particular solutions of the Helmholtz equation in a spherical coordinate system. Boundary value problems for the Helmholtz equation in the spherical layer.

**MAJOR Elective Courses** for Actuary specialization

**1. Non-parametric statistic and learning theory**
1. Distribution estimators. Empirical c.d.f.'s in i.i.d. cases. Empirical likelihoods.
2. Densuty estimation. Semi-parametric methods.
3. Statistical functional. L-, M-, and R- estimators and rank statistics.
4. Linear functions of order statistics. Sample quantiles.
5. Robustness and efficiency. L-estimators in linear models.
6. Generalized estimating equations
7. Variance estimation.
8. Hypothesis tests in nonparametric models
9. Distribution-Free Confidence Intervals.
10. Nonparametric and Robust Density and Regression Estimation.
11. Nonparametric Smoothing. Multivariate Symmetry. Nonparametric Methods for Multivariate Location Models.

**2. Multidimensional Statistical Analysis**

1. Multidimensional Random Variables. Multivariate Normal and Concentration Ellipsoid
2. Random samples from multivariate normal
3. Classical Linear Regression Model: Gauss-Markov
4. Theorem of Multivariate Normal with Multiple Regression, Coefficients of Partial and Multiple Correlation
5. Multivariate analysis of variance. ANOVA and MANOVA
6. Discriminant Analysis
7. Principal Component Analysis
8. Factor analysis
9. Cluster analysis.

**3. Time series statistics**

1. Stochastic process and its main characteristics
2. Autoregressive-moving average models ARMA (p,q)
3. Linear filtering, causality and smoothing.
4. Recursive methods for computing the best linear predictors: Durbin-Levinson algorithm, innovations algorithms.
5.Spectral representation of simple processes. Herglotz Theorem.
6. Spectral density, the relation to characteristic functions and their inversion in probability. Computing the spectral density for ARMA models.
7. Applying the spectral density to obtain causal invertible models.
8.Stochastic integrals: definition, existence, examples, properties, relation to spectral distributions.
9.Spectral representation of stationary processes by stochastic integrals and applications to prediction in ARMA.
10. Estimation of the mean, the covariance, the partial autocorrelation.
11. Estimation of the parameters and model selection.

**4. Financial Statistics**

1. Technical analysis and electronic trading systems
2. Rate of return on and riskiness of a portfolio; maximization of return per unit of risk
3. Investment and portfolio selection strategy
4. Nonparametric density estimation
5. ARMA processes
6. ARIMA and unit root processes
7. ARCH-GARCH models
8. Deterministic trends
9. Simple and exponential moving averages
10 Forecast evaluation
11 Factor analysis
12 Kalman filter
13 Duration
14. Principal components analysis

**5. Mathematical models of investment**

1. Financial Markets and Financial Assets
2.Portfolio Theory. Markowitz Mean-Variance portfolio.
Construction of optimal portfolios and separation theorem.
3. Capital Asset pricing Model. Sharpe-Lintner model. Security market line. Capital market line.
4.Arbitrage Pricing Theory. Regression model. Factor model.

5. Discrete time stochastic decision models.
6. The Black-Scholes market model. Self-financing trading strategies.
7. The Black-Scholes equation. The market price of risk

**6. Applied statistics**
1. Statistics. Statistics based on order. The sample median and quartiles. Sample moments
2. Survey sampling
3. Sample characteristics as estimates. Asymptotical normality of sample characteristics
4. Estimation of parameters and fitting of probability distributions. Least square estimates of parameters. Maximum likelihood, Method of moments
5. Some statistical distributions: $\chi^2$ −distribution, Student's $t$ −distribution. Fisher's distribution
6. Interval estimates.
7. Testing hypotheses and assessing goodness of fit
8. Tests for the mean. Likelihood ratio test. Pearson's chi-square test
9. Summarizing data
10. Comparing two samples
11. Analysis of variance
12. The analysis of categorical data
13. Linear regression. Hypothesis testing, confidence interval in linear regression models
14. Multiple regression

**3. INTER DISCIPLINARY DISCIPLINE**

**1. Big data**
**Learning Units:**
1. Modeling Data Using Graphs, Euler and Hamilton Circuits, Euler Characteristics.
2. Networks, Modeling Networks via ODE Systems, Examples of Dynamical Systems.
3.Data Spaces with Metric Topology, ContinuousMaps, Connectednessand Connected Components.
4. Data Point Clouds & Topology, Topology, neighborhoods, bases, $T_0$, $T_1$, $T_2$ Axioms. Examples of Topological Spaces & Continuous Maps.
5. Compactness in metric and non-metric topologies, Covering of Point Clouds, Nerve Constructions (Czech, Vietories and Rips).
6. Finite Topological Spaces from Data, Boolean Logic versus Topology of Point Clouds, Sample Spaces and Probability Measures, Random Variables and Histograms
7. Piecewise Linear Functions, Simplicial Complexes, Convex Set Systems, Delaunay Complexes Duality.
8. Data Cloud Curves in Euclidean Space, Curvature and Torsion of space curves.
9. One-dimensional Manifolds, Topology versus Geometry of Closed Curves, Knots and Links.
10.Two-dimensional Regression of Data Clouds, Parametric representation of Surface-Data Clouds, Tangent spaces, Orientation, Examples of Non-Orientable Manifolds.
11. Directional Derivative for Point Clouds, Calculus of Vector fields on Surface-Regressions, Point Cloud, Regression by Hypersurfaces in $\mathbf{R}^N$, Mean and Gaussian Curvature, Surfaces of Constant Curvature
12. Curves on Surfaces Identification, Topology, Connected sums of surfaces, Classification of Compact Orientable Surfaces
13. Intersection of Curves & Self-Intersections, Surface Simplification, Classification of Compact Non-Orientable Surfaces
14. Generic Smooth Functions on Surfaces, Transversally Condition, Level Sets for Morse Functions, Dynamical Systems from Gradient Flow on Surfaces

15. Morse Functions on Surface-Regressions, Dynamical Systems on a Surface, Filtration of a Surface by Morse Functions, Morse Functions on Manifolds and Filtration

**2. Actuarial mathematics**

**Learning Units:**

Introduction. Accumulation Function. Simple Interest. Compound Interest. Present Value and Discount Factor

Annuity immediate, annuity due. Equations of Value. Perpetuities.

Varying Annuities.

Survival Probability. The Law of Mortality and the Construction of Mortality Tables.

Stationary Population. Expectation of Life. Multiple Decrement Models

Life Annuities. Immediate and Deferred Annuity.

Commutation Functions.

Life Annuities payable monthly

Varying Life Annuities.

Annual Premiums and Unearned Premium Reserves for a Life Annuity.

Introduction to Life Insurance. Type's of Life Insurance. Commutation Functions and Basic Identities for Life Insurance.

Insurance Payable at the Moment of Death. Varying Life Insurance.

Life Insurance Annual Premiums and Reserves.

Joint-Life Actuarial Functions. TypesofJoint-Life Insurance Policies. Reversionary Annuity.

Pension Plan. Different Types of Pension Plans.

**3. Mathematical models in biology and medicine**

**Learning Units:**

1. Introduction
2. Continuous-time models for a single species. Steady states and linear stability. Models of predation. Harvesting. Delays.
3. Continuous-time models for interacting species. Predator-prey models. Finite predation. Competitive exclusion. Mutualism (symbiosis).
4. Discrete-time models for a single species. Dynamic behavior. Further investigation. Periodic solutions.
5. Discrete-time models for interacting species. Discrete-time age-structured models. A discrete-time predator-prey model.
6. Infectious disease modelling. The SIR model. Incubation periods.
7. Enzyme kinetics. The Law of Mass Action. Michaelis-Menten kinetics. Non-dimensionalization. Singular perturbation investigation. Several enzyme reactions and the pseudo-steady state hypothesis. Allosteric enzymes. Autocatalysis and activator-inhibitor systems.
8. Introduction to spatial variation Derivation of the reaction-diffusion equations. Chemotaxis. Positional Information and Pattern Formation
9. Fisher-Kolmogorov equation: an investigation. Key points. Existence and the phase plane. Relation between the travelling wave speed and initial conditions.
10. Models of epidemics. The SIR model with spatial heterogeneity
11. Pattern formation. Minimum domains for spatial structure. Diffusion-driven instability. Linear analysis.
12. Detailed study of the conditions for a Turing instability. Stability without diffusion. Instability with diffusion. Threshold of a Turing instability.
13. Domain Growth in Biology. Simplest model: 1D solid tumor growth. Model Reduction: Nondimensionalization. Cell death at low nutrient concentration. Revised model: proliferation and necrosis.

14. Age-structures models. Population models with age structure. Von Foerster's equation. Separable solutions for age-structured models. Age-dependent epidemic models. Structured models for proliferating cells.
15. Excitable systems: nerve pulses. Resistance. Capacitance. The Fitzhugh Nagumo equations. Modelling the propagation of nerve signals. The cable model

**4. SAS Technologies in Applied Data Analysis**
**Learning Units:**
1. Introduction. SAS analytic platform, technologies review. SAS U edition. SAS Data sets. SAS libraries. Format and options for Data sets in SAS.
2. SAS/BASE Programming language bases. SAS libraries. Variables attributes in SAS. Date and time. DATA step. Conditional cycles in DATA step. Arrays in DATA step, their features.
3. Data sets options: keep, drop, rename, where. DATA Step features: a) two SET operators; b) two data sets in one SET (append/union). The running sums. Data sets sorts. Group mining in DATA step. Splitting data sets. Queue for variable. Proc Transpose.
4. SAS Macro. Macro substitutions. Macro variables. Macros run order. Debugging macros. Parameters in macros, macro functions. Cycles.
5. SQL usage and implementation features in SAS. PROC SQL main operators. Access to other DBMS. PROC SQL and macro language.
6. SQL & Reporting. SAS formats and their usage. Reports creation on DATA step. Reporting via PROC SQL, PROC PRINT, PROC TABULATE. Tool selection depending on report type. Output delivery system overview. SAS University Edition features.
7. SAS/STAT statistical analysis methods library (MODULE I): dispersion analysis. Examining data distributions, obtaining and interpreting sample statistics using the UNIVARIATE and MEANS procedures, examining data distributions graphically in the UNIVARIATE and SGPLOT procedures, constructing confidence intervals, performing hypothesis simple tests.
8. SAS/STAT statistical analysis methods library (MODULE I): linear regression, producing correlations with the CORR procedure fitting a simple linear regression model with the REG procedure, understanding the concepts of multiple regression, using automated model selection techniques in PROC REG to choose from among several candidate models, interpreting models.
9. SAS/STAT statistical analysis methods library (MODULE I): Logistic regression.
10. SAS/STAT statistical analysis methods library (MODULE II): Analysis of Variance (ANOVA). Target Marketing. Churn Prediction. Credit Scoring, Collection Scoring. Fraud Detection.
11. SAS/STAT statistical analysis methods library (MODULE II): The generalized linear models (Poisson regression, negative binomial regression, etc.)
12. SAS/STAT statistical analysis methods library (MODULE III): Tobit models in SAS/STAT.
13. SAS/STAT statistical analysis methods library (MODULE III): The SAS/STAT survival analysis.
14. Interactive programming language for processing IML matrix data. Introduction to IML. Integration with SAS/BASE, C++
15. SAS/IML SAS/IML Linear algebra and Numerical methods. Practical cases, working on a projects.

**5. Mathematical demography** (for actuaries)
**Learning Units:**
1. The theory of population. Population and historical growth rate. Population dynamics.
Discussion Session: The theory of population. Population and historical growth rate. Population dynamics.
2. Components of population change: births, deaths, and migration. The demographic balancing equation. International statistics. Analysis of the population of Kazakhstan by regions.

3. Demographic indicators. Regression coefficients of demographic indicators. Population data sources. The influence of surrounding environment on demographic indicators in Kazakhstan. Demographic indicators of development
4. Mathematical demography. Lexis diagram. Force and probability of mortality, construction of mortality tables.
5. Methods of measuring mortality rates: age-specific mortality rates. Period life tables, life expectancy calculation using the data for Kazakhstan. Comparison of data trends among foreign countries.
6. Methods of measuring human fertility. Fertility rates by age of mother and order of birth. Total fertility rate, period and cohort indicators.
7. Indicators of cohort study. Birth cohorts and birth probability by cohorts.
8. Definition and methods of measuring migration. Internal and external migration and the registration procedure. Migration flows and migration balance.
9. Age-specific migration rates. Migration data for Kazakhstan.
10. Demographic methods for estimating population size.
11. The relationships between population size, age structure and fertility, mortality, migration levels. Coefficient of population reproduction.
12. Stationary and stable populations. Stable populationmodels.
13. Economic factors and population movements. The impact of various factors on demographic processes.
14. Demographic projections. Forecasting methods and principles of forecasting
15. Possible scenarios for future changes in births, deaths, and migration.

**6. Economic-mathematical models** (for actuaries)
**Learning Units:**
1. Scaled random walks.
2. Brownian motion.
3. Quadratic variation.
4. Markov property.
5. Reflection principle.
6. Black-Scholes-Merton equation.
7. The first passage time distribution.
8. Multivariable stochastic calculus.
9. Brownian bridge.
10. Risk-neutral pricing.
11. Affine-yield models.
12. Heath-Jarrow-Morton model.
13. Forward LIBOR model.
14. Poisson process.
15. Compound Poisson process.
16. Stochastic calculus for jump processes.
17. Dividend-paying stocks.
18. Change of measure.
19. Pricing a European call in a jump model.
20. Martingale representation theorem.

# CATALOGUE OF DISCIPLINES

# 5B060100 –MATHEMATICS

## GENERALEDUCATIONDISCIPLINES (GED)
## OBLIGATORYCOMPONENT (OC)

| Код \ Code<br>**SIK1101** | **Modern history of Kazakhstan (*State Examination*)** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | no |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | To give students objective historical knowledge about the main stages of modern history of Kazakhstan; direct students' attention to the problems of formation and development of independent statehood in Kazakhstan, spiritual culture, continuity of ethnogenesis. | | |
| Abstract of discipline | The study of Modern History of Kazakhstan has a distinctive role in the education curriculum as it challenges students to consider the great social, technological, economic, political and moral transformations from the late eighteenth century to the present. It requires students to analyse the causes, progress and effects of these transformations and finally, to make judgments about them.<br>Modern History of Kazakhstan is especially relevant to the lives of students, as the events and issues that form its content are, in many cases, still current. The fluent communication of thoughts and ideas gleaned from the critical analysis of primary and secondary sources is a sought after skill. The ability to deconstruct texts and narratives, pose intelligent questions, test hypotheses and make critical use of information technologies is essential to live and work in the twenty-first century. | | |

| Code**Fil2102** | Philosophy | | |
|---|---|---|---|
| Prerequisite | Modern historyofKazakhstan | Postrequisite | History and philosophy of science |
| Credits | 3 | Semesters | 4 |
| Aim of discipline | Mastering the philosophical legacy, gaining acquaintance with the main theoretical issues of philosophy, having students worked out a philosophical way of thinking and comprehending as well as the skill to think logically and creatively and to defend their own position logically, convincingly. | | |
| Abstract of discipline | The course "Philosophy" is the basic and generally compulsory for all bachelor's specialties. In the process of studying it, students will get knowledge about the stages of the development of philosophy, about the specifics of | | |

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| | Kazakh philosophical thought, get acquainted with the main problems, concepts and categories of philosophy.<br>The role of philosophy in the training system of a modern specialist is determined by the object of its study, which is a person and his relationship with nature and society. It forms the worldview, moral and meaningful orientations of a person. |

| Code**K(R)Ya 1102** | **Kazakh (Russian) language** | | |
|---|---|---|---|
| Prerequisite | Knowledge and skills acquired by the student on the completion of the school program on the sudject | Postrequisite | Professionally-Oriented Kazakh (Russian)Language |
| Credits | 6 | Semesters | 1, 2 |
| Aim of discipline | The aim of the course is to develop students' skills in reading, speaking, listening, and writing in a Kazakh (Russian) language as a part of the university program. | | |
| Abstract of discipline | Tasks:<br>• expansion of lexical minimum of common words and phrases;<br>• acquisition of lexical and terminological minimum in the specialty;<br>• construction of various types of speech activity: conversation, description, information;<br>• reproduction and adaptation to the production of simple pragmatic texts, dialogue and monologue, orally and in writing on topics relevant to the social, consumer and professional fields, according to various kinds of speech activity: speaking, listening, reading, writing. | | |
| Code**IYa1103** | **Foreign Language** | | |
| Prerequisite | Knowl edge and skills acquired by the student on the completion of the school program on the sudject | Postrequisite | Professionally-OrientedForeignLanguage |
| Credits | 6 | Semesters | 1,2 |
| Aim of discipline | Development of oral language proficiency and language of professional communication for using foreign language in day to day situations and professional spheres. | | |
| Abstract of discipline | The course is the integrative part of continuing foreign language education cycle and is aimed at further development | | |

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| | of receptive( reading, listening)productive(speaking, writing) skills, intercultural and interpersonal competences for using English as the tool of communication |

**GENERALEDUCATIONDISCIPLINES (GED)**
**ELECTIVECOMPONENT (EC)**

| Code**KRYaK 2108** | Culture of Speech and LanguageCommunication | | |
|---|---|---|---|
| Prerequisite | K(R)Ya | Postrequisite | POK(R)Ya |
| Credits | 2 | Semesters | 3 |
| | The course is designed to develop and improve the skills and techniques of effective speech interaction in various communication situations, in the socio-cultural and professional spheres of communication. | | |
| Abstract of discipline | The course is aimed at increasing the level of speech, communicative competence.The main attention is paid to the culture of oral (monological and dialogical) and written speech in Russian. Attention is drawn to the conditions of successful public speaking and skills are formed for effective communication in different conditions of communication. Students have the opportunity to improve the knowledge of the norms of the modern Russian language. | | |

| Code**PMK2109** | Psychology of interpersonal communication | | |
|---|---|---|---|
| Prerequisite | Philosophy | Postrequisite | Introduction to social psychology |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | As a result of studying this course, students will know the basic concepts, principles and procedures for effective communication. They will know the signs and barriers of effective communication. They can establish and maintain constructive communication with different people. They will be able to prevent conflicts, as well as to master the skills of conflict resolution. They will master the skills and skills of business communication, necessary in future professional activities. (Negotiating, business discussions, public speaking). They will analyze and compare various methodological and theoretical approaches to the problem of effective communication. They will learn to manage and organize your communication with different people by evaluating and choosing suitable forms of communication. | | |
| Abstract of discipline | The course contains the methodological foundations and theoretical and applied concepts of the psychology of interpersonal communication. The course introduces students to the psychological and methodological mechanisms underlying effective interpersonal communication. Classical and modern directions of psychology of communication are studied. The course includes such topics as signs and barriers of effective communication, theoretical models of effective communication, conflict psychology, business communication, etc. The course "Psychology of Interpersonal | | |

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| | Communications" provides for the integration of theoretical knowledge and practical skills of students. |

| Code<br>**TPP2110** | **Theoreticaland AppliedPolitical Science** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | Social modification and Political modernization of society |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | - study of politics and its functions, power and power relations, political systems and regimes, trends in world politics;<br>- use of methods of analysis of modern political processes occurring in the world and in the Republic of Kazakhstan;<br>- formation of political consciousness and political culture of students. | | |
| Abstract of discipline | Discipline provides students with current knowledge about the essence of socio-political processes, about methods of scientific and practical activities in the field of politics; Includes the main aspects of political science:<br>Political science as science and studying course. The main stages of development of political knowledge in the history of civilization.Politics within the structure of public life. Power as political phenomenon. Subjects of politics. Modern political systems. Political regimes. Elections and elective systems. State and civil society. Political parties and political systems, social political movements and organizations.<br>Political culture and political ideology. World politics and modern international affairs. Sovereign Kazakhstan within the system of international relations. The main priorities of foreign policy of the Republic of Kazakhstan. Development strategy of Kazakhstan up to 2050. | | |

| Code**OPS2111** | **General andApplied Sociology** | | |
|---|---|---|---|
| Prerequisite | SIK1101 | Postrequisite | KR2119 |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | To form a systematic notion of students about sociology as a science, development of sociological theory and branches of sociology, to teach skills in the application of methods of sociological research and analysis of data in professional and daily life.<br>Course objectives:<br>- to teach the student to understand and explain social interactions, phenomena and processes, social changes in the world on the basis of macro- and microsociological theories;<br>- to interpret the basic sociological concepts and theories with the purpose of studying social processes;<br>- to demonstrate the ability to find available sources of sociological information, generalize and analyze data;<br>- to master the applied methods of sociological research, be able to plan, organize and conduct mini-research on student | | |

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| | projects;<br>- to form skills in the analysis of texts and writing essays, discussions, effective work in a group, presentation of research results. |
| Abstract of discipline | The course presents general questions of theory and history of sociology, methodology and methods of sociological research, special sociological theories. This course is aimed at shaping the sociological imagination of students, basic ideas about the subject and methods of sociological research, topical problems and sociology branches. It offers students the main concepts of sociological theory and effective technologies for studying various spheres of modern society. |

| Code**EUR2116** | **Ecology and Sustainable Development** | | |
|---|---|---|---|
| Prerequisite | Biology, Chemistry, Physics, Mathematics (On the basis of schooling) | Postrequisite | Disciplines in the specialty |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | The purpose of the discipline is to form the ability of students:<br>- to determine the main environmental conditions;<br>- to explain the importance of ecology in the modern world;<br>- to describe the general patterns of environmental factors affecting the activities of living organisms;<br>-to highlight the key environmental factors of the environment;<br>- to assess the ecological state of the environment. | | |
| Abstract of discipline | In studying the course, the following aspects will be considered:<br>The main regularities of the interaction of living organisms with the environment;<br>Mechanisms for the sustainability and functioning of ecosystems and the biosphere;<br>Place and role of ecology in solving modern economic and political problems;<br>Global ecological problems of the present, causes, stages of their formation and consequences;<br>Sustainable development of nature and society, international cooperation in the field of environmental protection. | | |

| Code**BGCh2117** | **Human Life Safety** | | |
|---|---|---|---|
| Prerequisite | Mathematics, Physics and Chemistry | Postrequisite | All socio-humanitarian and natural sciences, provided for by state Standards |

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| Credits | 2 | Semesters | 4 |
| Aim of discipline | To form in students the ability to:<br>- call dangerous and harmful environmental factors in all areas of human activity;<br>- choose the best ways and means of protection against them;<br>- list of natural and man-made disasters;<br>- to identify the threats to life;<br>- highlight the negative factors of the human environment, explain the consequences of their impact;<br>- describe ways to ensure protection;<br>- consider the basic legislation to ensure safety;<br>-objective and creative approach to the discussion of the problems of life safety;<br>- to explore ways to protect against natural hazards, medical and biological, social, man-made;<br>- compare the protective properties of the various means of individual and collective protection;<br>- to distinguish between especially dangerous infections, ways of their distribution;<br>- co take part in rescue and other emergency operations;<br>- to collect historical data on the use of weapons of mass destruction;<br>- to organize the provision of first aid to victims of various emergency situations;<br>- control the actions of self-defense in different emergency situations;<br>- to compare the impact of pollutants into the air, soil and water;<br>- choose effective ways to protect against environmental pollutants;<br>- to take decisions in the selection of a suitable method of protection against hazards;<br>- predict the development of adverse effects and to assess the consequences of their actions. | | |
| Abstract of discipline | The course will cover the following:<br>-consideration of the state and negative factors of habitat;<br>-principles of ensuring the safety of human interaction with the environment,<br>-the consequences of human exposure to traumatic, harmful and damaging factors of the working environment,<br>-the principles of their identification; means and methods of improving security,<br>-the stability of the functioning of economic facilities in emergency situations;<br>-basic principles and methods of protecting the population in emergency situations of natural and technogenic origin,<br>-including in the conditions of military operations;<br>-protection of the population in case of natural disasters, fires, explosions and accidents (radiation, chemical) at production facilities;<br>- the organization and carrying out of rescue operations, the operation of civil defense in emergency situations;<br>-legal, regulatory and technical and organizational basis of life safety. | | |

| Code**DVFIS2112** | **Spiritual Revival and the Formation of Historical Consciousness** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | no |
| Кредиты\Credits | 2 | Semesters | 3 |
| Aim of discipline | To create a system of knowledge that constitutes the notion of historical consciousness, the experience of previous generations in the field of its formation, the preservation of the core of the cultural tradition and spiritual code and the nation's potential for self-development and modernization of ethnic consciousness.<br>Learning outcomes:<br>- The ability to demonstrate knowledge on the history of the people in correlation with the history of other communities at a specific historical and theoretical level.<br>- Understanding the need for spiritual revival and preservation of the historical consciousness of the people as a community united by the oneness of historical destiny, traditions, culture, language, mentality<br>- The search for new solutions and the application of innovative elements of the past in modernizing the public consciousness of the country<br>- A systematic approach to understanding historical consciousness as the spiritual side of the evolution processes of human society<br>- Ability to independently reproduce models of consciousness, explain and interpret mental phenomena, critically perceive and argue them in the context of history, compare progressive historical precedents and identify differences. | | |
| Abstract of discipline | The following aspects are studied in the course:<br>- fundamental problems of consciousness and historical heritage<br>- national meta-values, cultural self-identification, sacral objects.<br>- methods of comparing cultural and historical phenomena concerning the formation and renewal of national identity in the context of different epochs and cardinal changes in the scale of local and global history. | | |

| Code**KP2118** | **Kazakhstan Law** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | no |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | To study the basic concepts and categories of state and law. Legal relations. Lawful behavior and offense. Legal liability. Fundamentals of constitutional law of the Republic of Kazakhstan. Fundamentals of Administrative Law of the Republic of Kazakhstan. Fundamentals of Civil Law of the Republic of Kazakhstan. Fundamentals of the family law of the Republic of Kazakhstan. Fundamentals of the organization and activities of law enforcement. | | |

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| Abstract of discipline | the basic financial rights of the Republic of Kazakhstan. Fundamentals of the tax law of the Republic of Kazakhstan. Fundamentals of the labor law of the Republic of Kazakhstan. Fundamentals of the Criminal Law of the Republic of Kazakhstan. Fundamentals of the environmental law of the Republic of Kazakhstan.<br>The basis of criminal procedural and civil-procedural rights. Fundamental international rights. |

| Code**OE2120** | **Fundamentals of Economics** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | no |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | To give a systematic understanding of the main categories, concepts, laws of the economy. | | |
| Abstract of discipline | The basis of economics is an introductory course in which students are introduced to the basic economic concepts and laws. Students receive initial knowledge in the field of micro- and macroeconomics. This course contributes to improving the student's economic culture, helps to understand the essence of economic transformations in society, the logic and interconnection of phenomena and processes in the life of society, to have the skills and ability to apply the knowledge gained in practical activities. | | |

| Code**AFS2122** | **Al-Farabi and modernity** | | |
|---|---|---|---|
| Prerequisite | Modern historyofKazakhstan | Postrequisite | History and philosophy of science |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | Formation of students' knowledge of the scientific and philosophical heritage of the great Turkic philosopher Abu Nasr al-Farabi in the present context | | |
| Abstract of discipline | The course "Al-Farabi and Modernity" is devoted to the presentation of the basic philosophical and scientific views of Abu Nasr al-Farabi. In the course of studying the course, the peculiarities of al-Farabi's philosophy and its significance for the present are considered, the question of the essence of the scientific and innovative project "Al Farabi university smart city" and its role in the formation of a smart society in Kazakhstan is touched upon. | | |

| Code**KR2123** | **Culture and Religion** | | |
|---|---|---|---|
| Prerequisite | no | Postrequisite | no |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | To familiarize students with the basic concepts and concepts of religion and culture. The teach future young specialists to think creatively and form the necessary ecological-civilized and humane worldview. And also carry out an independent analysis of the assessment of complex and diverse phenomena of the cultural life of different eras. | | |

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| Abstract of discipline | The course will be a general acquaintance with a large volume of theoretical material. In preparation for discipline, an essential role is assigned to the textbook and the collection of problems. |

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|---|---|---|---|
| Code**MPM2124** | **Methods of teaching mathematics, the history of mathematics** | | |
| Prerequisite | no | Postrequisite | no |
| Credits | 2 | Semesters | 7 |
| Aim of discipline | To give overall characteristics of method of scientific knowledge; to analyze of the main trends in the development of mathematics education. | | |
| Abstract of discipline | Mathematics lessons. Drafting outline mathematics lessons, conduct and analysis; Production and use of appropriate tables, charts and workbooks for Maths lesson; Mathematics classroom. Visual aids in mathematics. Reading the explanatory notes to the programs in mathematics for the high school; Different ways to search for solution to problems; Developing synopsis lesson on the proposed topics, making suggestions for the lesson. Analyzing of lesson on the proposed sheme. | | |

**BASIC DISCIPLINES (BD)**
**OBLIGATORY COMPONENT (OC)**

| Code**PK (R) Ya2201** | Professionally-Oriented Kazakh (Russian)Language | | |
|---|---|---|---|
| Prerequisite | Kazakh (Russian)Language | Postrequisite | no |
| Credits | 2 | Semesters | 4 |
| Aim of discipline | Mastering the principles of technical writing, getting skills of construction theoretical calculations, familiarity with the scientific and technical documentation in the subject area of specialty. | | |
| Abstract of discipline | Mastering the lexical and terminological minimum in the specialty. Construction of various types of speech activity: conversation, description, informing. Grammatical forms and constructions in communicative, functional aspects. Reproduction of adapted and production of simple pragmatic texts, dialogical and monologic, in oral and written form, on topics relevant to social and professional spheres, on different types of speech activity: speaking, listening, reading, writing. | | |

| Code **POIYa2202** | Professionally-Oriented Foreign Language | | |
|---|---|---|---|
| Prerequisite | Foreign Language | Postrequisite | |
| Credits | 2 | Semesters | 3 |
| Aim of discipline | The purpose of the module: phonetic, spelling, lexical, grammatical norms of the studied foreign language | | |
| Abstract of discipline | Learning of special terminology, vocabulary in a foreign language, theoretical foundations of project management methodology, project management process groups, drafting documents of the project, the project management directly using the modern tools of software. | | |

| Code**IT 1103** | Information and communication technologies | | |
|---|---|---|---|
| Prerequisite | School course of Computer science, Mathematics, Physics. | Postrequisite | Programming |
| Credits | 2 | Semesters | 1 |
| Aim of discipline | mastering students by professional and personal competences that will give the chance to use the modern information communication technologies in different areas of professional activity, scientific and practical operation, for self-educational and other purposes. | | |
| Abstract of discipline | ICT role in key sectors of development of society. Microsoft Office Windows Cybersafety. Internet technologies. Cloud and mobile technologies. Multimedia technologies. Smart Technology. E-technologies. Electronic business. E- | | |

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| | learning. Electronic government. Information technologies in the professional sphere. |

| Code**MA 1203** | Mathematical analysis 1 | | |
|---|---|---|---|
| Prerequisite | School course of Mathematics | Postrequisite | Mathematical analysis 2 |
| Credits | 4 | Semesters | 1 |
| Aim of discipline | To give students a clear idea about the fundamental concepts of mathematical analysis, methods of differential calculus functions of one real variable and their applications. The objectives of the course included the development of students' logical thinking and mathematical culture to explore other mathematical subjects. Students will be expected to acquire problem solving skills appropriate to the material as well as to solidify analytical skills developed in secondary school. | | |
| Abstract of discipline | The Real Numbers System. Some Set Theory. Sequences of real numbers. Limit of a sequences. Monotonic sequences. Functions and limits. Limit of functions. One-Sided Limits. Infinite limits. Remarkable limits. The continuity of function. Points of discontinuity. Uniform Continuity. The derivative function. One-Sided Derivatives. Differentiation Formulas**.**<br>Differentials. Derivatives of Higher Orders. Rolle's Theorem. Lagrange's theorem. Fermat's theorem. Cauchy's Theorem. L'Hospital's Rule. Taylor's formula. Local Extreme Values. The first derivative test. The second derivative test. Absolute Extreme Values. Concavity and Points of Inflection. Asymptotes. Analysis of function using the derivative, plotting graph of function.Applications of differential calculus. | | |

| Code**MA1205** | Mathematical analysis 2 | | |
|---|---|---|---|
| Prerequisite | Mathematical analysis 1 | Postrequisite | Multivariable Calculus, Complex Analysis, Vector Analysis |
| Credits | 4 | Semesters | 2 |
| Aim of discipline | Formation of mathematical culture of students, student's fundamental preparation in the mathematical analysis field, mastering the classical apparatus of mathematical analysis for using in other areas of mathematical knowledge and natural science disciplines. | | |
| Abstract of discipline | The indefinite integral. Integration of rational expressions. Integration of irrational expressions. The definite integral of Riemann. The length of the curve. Area and volume. Numerical series. Alternating series. Functional sequences and series. Uniform convergence. Power series. The decomposition of functions in power series. | | |

| Code**AG1206** | Linear algebra | | |
|---|---|---|---|
| Prerequisite | Basics of algebra | Postrequisite | Algebraic structures, Functionalanalysis, Numerical methods |

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|---|---|---|---|
| Credits | 3 | Semesters | 2 |
| Aim of discipline | The course is essentially an extension of the course basics of algebra, which is one of the fundamental part of mathematics. The course will cover the main topics on linear algebra. In the course, we formulate basic notions and results, which became classical nowadays and attempt to describe modern trends and achievements. | | |
| Abstract of discipline | Linear (vector) space. Dimension and basis of a linear space. Bilinear and quadratic forms. Bilinear forms. The law of changing the matrix of a bilinear forms. Quadratic forms. Transition matrix. Linear transformations (operators).Invariant subspaces, eigenvectors, and eigenvalues of a linear transformation. The image and kernel of linear operators. Linear mappings. Linear functional. Affine transformations. Euclidean space. Complex vector space. Hermitian vector spaces. Orthonormal basis and orthogonal matrices. Transformations (operators) in a Euclidean space. Unitary space. Criterion of Sylvester for definiteness of a quadratic form. | | |

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|---|---|---|---|
| Code**AG1207** | Analytical geometry | | |
| Prerequisite | School Mathematics | Postrequisite | Linear algebra, Vector Analysis, Differential geometry |
| Credits | 3 | Semesters | 2 |
| Aim of discipline | Having successfully mastered the curriculum of the module, students must know a basis of vector algebra and a method of coordinates, must know a basics of the theory of curves and surfaces of the second order, analytical representations and properties of affine transformations and movements. | | |
| Abstract of discipline | Vector. Linear dependence and independence of vectors. Affine coordinates on a straight line, on a plane and in space. Cartesian coordinates. Polar, cylindrical and spherical coordinate systems.The vectorproduct of two vectors. Mixed product of three vectors. The equations of a straight line in a plane. Equations of a plane in space. Equations of a straight line in space. Curves and surfaces of the second degree. Transformation of vectors. Straight, plane and space movements. | | |

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|---|---|---|---|
| Code**ODU 2208** | Ordinary Differential Equations | | |
| Prerequisite | Mathematical Analysis, Linear Algebra, Analytical Geometry | Postrequisite | PartialDifferentialEquations |
| Кредиты\Credits | 4 | Semesters | 4 |
| Aim of discipline | to provide students with the skills, knowledge and attitudes required to solve differential equations at a level that is necessary for further scientific and professional activity. | | |
| Abstract of discipline | Basic concepts of ordinary differential equations (solution, singular solution, general solution, general integral, | | |

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| | fundamental system of solutions) and existence and uniqueness theorems for solutions of differential equations and systems of differential equations. Linear differential equations of higher orders and linear systems of differential equations. The structure of their decisions. The concept of stability by Lyapunov. Normal, autonomous, symmetric system of ordinary differential equations and a quasilinear partial differential equation of the first order. |

## BASICDISCIPLINES (BD)
## ELECTIVE COMPONENT (EC)

| Code**MA2209** | Basics of Algebra | | |
|---|---|---|---|
| Prerequisite | School Mathematics | Postrequisite | Linear algebra, Complex Analysis, Differential geometry |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | The course is essentially an introduction to the basics of linear algebra, which is one of the basic subjects in mathematics. The goal of this course is an introduction of main mathematical notions based on the concept of linearity and are necessary for training in all fields of mathematics. | | |
| Abstract of discipline | Elementary properties of groups, rings and fields. The field of complex numbers. The Gauss theorem (without proof) and its corollaries. Systems of linear equations. Rings of matrices, groups of non-singular matrices. The row spaces over a field: linear dependence, base and rank of a vector system. Theorems on the rank of matrix. Theory of determinants. Polynomial ring. | | |

| Code**DM1210** | Discrete mathematics | | |
|---|---|---|---|
| Prerequisite | Basics of algebra | Postrequisite | Algebraic structures, Thetheory of algorithms, Elements of Computability Theory, Introduction to model theory |
| Credits | 3 | Semesters | 2 |
| Aim of discipline | Mastery of the tools, including basic concepts and results, the techniques and methods of obtaining the results of discrete mathematics. | | |
| Abstract of discipline | This course examines sets and operations on them, relations and operations on them. Also, we introduce elements of number theory and combinatorics including: rules of the account, Dirichlet principle, inclusion-exclusion, placement and combinations, recursive relations, Chinese remainder theorem, generating functions, multiplicative functions, diophantine equations. It discusses elements of graph theory: first introduces the concepts of graph theory, then discusses the metric characteristics of a graph and specific graphs such as additional self, Hamiltonian, bipartite, Eulerian and planar graphs. | | |

| Code**MA2211** | Multivariable Calculus |
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|---|---|---|---|
| Prerequisite | Mathematical analysis -2 | Postrequisite | Vector analysis |
| Credits | 8 | Semesters | 4 |
| Aim of discipline | to give students a clear idea about the basic concepts of multivariate analysis for solving problems on the topics of the course. This course gives a comprehensive overview of practical techniques of the course. The objectives of the course includes the development of students' logical thinking and mathematical culture to explore other mathematical subjects. | | |
| Abstract of discipline | The course of Multivariate Analysis is the third course of mathematical analysis for students of Mathematics specialty. There is familiarization with the fundamental ideas (functions of several variables, partial derivatives, extrema of function of many variables, conditional extremum) and methods of multivariate analysis (computation of partial derivatives, finding the extremum and conditional extremum of a function of many variables). The emphasis is on proving of basic theorems of Multivariate Differential Calculus as well as on developing computational skills in employing the powerful tools of calculus for solving theoretical and applied problems. | | |

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|---|---|---|---|
| Code**MA2213** | Mathematical logic | | |
| Prerequisite | Basics of algebra, Discrete mathematics | Postrequisite | Algebraic structures, Thetheory of algorithms, Elements of ComputabilityTheory, Introduction to model theory |
| Credits | 3 | Semesters | 3 |
| Цель дисциплины/Aim of discipline | The aim of the course is to master the toolkit, which includes both the basic concepts and results, also the techniques and methods for obtaining the results of mathematical logic. | | |
| Аннотация дисциплины/ Abstract of discipline | In this course, mathematical operations on statements, functions of the algebra of logic and applications of the algebra of statements to electrical engineering and jurisprudence are considered. Also, the theory of the calculus of propositions, the logic of predicates, and the predicate calculus are introduced. The completeness and consistency of the propositional calculus, the independence of the system of axioms of the propositional calculus, Post's theorem on the completeness of functions of the algebra of logic, and the Levenheim-Skolem theorem are proved. | | |

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|---|---|---|---|
| Code**DG2213** | Differential geometry | | |
| Prerequisite | Analytical geometry, Basics of algebra | Postrequisite | GeneralTopology, Introduction to classical geometry |
| Credits | 3 | Semesters | 3 |
| Aim of discipline | The result of studying the module, students should know definitions of the basic concepts of the theory of curves and | | |

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| | surfaces, the basic theorems and formulas of differential geometry. |
| Abstract of discipline | In this course, the theory of curves, the theory of surfaces, the basic concepts of the theory of varieties, external forms are considered. Learning on methods and evident images of classical differential geometry to enter students into area of the basic concepts and ideas of modern differential geometry. The program also includes elements of Riemannian geometry, the beginning of the theory of external differential forms. |

| Code**VIMO 2214** | Variation calculus and Methods of optimization | | |
|---|---|---|---|
| Prerequisite | Mathematical analysis | Postrequisite | Some special courses |
| Credits | 3 | Semesters | 4 |
| Aim of discipline | Creation of the contemporary understanding of information transformation processes in the society; teaching future specialists basic theoretical knowledge and practical skills related to computer systems, system and application software, hardware, development of information system, particularly software for their professional activity. The discipline is basic for the most of the educational program. | | |
| Abstract of discipline | Brachistochrone problem. The simplest problem. Necessary conditions for a weak local minimum.<br>Lagrange's lemma. Euler equation. DuBois - Raymond lemma. Bolz problem. Weierstrass necessary condition.<br>Methods optimization. Problem statement. Weierstrass' theorem. Convexsets. Convexfunctions. Theorem about global minimum. Criterion of optimization. The prescription ways of the convex sets. Separability of the convex sets. Convex cones. | | |

| Code**MM2215** | Mathematical modeling | | |
|---|---|---|---|
| Prerequisite | Multivariable Calculus | Postrequisite | Some special courses |
| Credits | 3 | Semesters | 4 |
| Aim of discipline | Creation of the contemporary understanding of the methods of determinations and analysis of mathematical models of natural and social sciences. | | |
| Abstract of discipline | Cognition and modeling. Natural science and mathematics. The equation of the fall of the body as an example of a mathematical model. Principles of constructing mathematical models. Classification of mathematical models. Mechanical oscillations. Electrical oscillations.<br>Basis of the dynamical systems theory. Mathematical models of chemical processes. Mathematical models in biology. Dynamic models of the economy. Models of transfer processes. Models of oscillatory processes.<br>Models of stationary processes. Variational principles of physics. Statistical modeling. Models of quantum mechanics. Ill-posed problems and mathematical models.<br>Inverse problems of mathematical physics. | | |

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|---|---|---|---|
| Code**VA2216** | Vector Analysis | | |
| Prerequisite | Multivariable Calculus | Postrequisite | Some special courses |
| Credits | 3 | Semesters | 4 |
| Aim of discipline | To give students a clear idea about the basic concepts of vector analysis for solving problems on the topics of the course. This course gives a comprehensive overview of practical techniques of the course. The objectives of the course included the development of students' logical thinking and mathematical culture to explore other mathematical subjects. | | |
| Abstract of discipline | The course of Vector Analysis is the fourth course of mathematical analysis for students of Mathematics specialty. There is familiarization with the fundamental ideas (line integrals, surface integrals, Stokes theorem, Ostrogradsky theorem) and methods of vector analysis (evaluation of line integrals, evaluation of surface integrals and finding the divergence and the curl of the vector field, evaluating flux integrals, using divergence theorem to find flux). The emphasis is on proving of basic theorems of Multivariate Differential Calculus as well as on developing computational skills in employing the powerful tools of calculus for solving theoretical and applied problems. | | |

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|---|---|---|---|
| Code**OT2217** | General topology | | |
| Prerequisite | Differential geometry | Postrequisite | Some special courses |
| Credits | 3 | Semesters | 3 |
| Aim of discipline | As a result of studying the module, students should know the definitions of the basic concepts of topology, the basic theorems, to establish the foundational aspects of topology and to investigate properties of topological spaces and concepts inherent to topological spaces. | | |
| Abstract of discipline | Sets, operations on sets, maps between sets, the cardinality of a set, the comparison of cardinalities. The comparison of cardinalities, infinite sets, Bernstein theorem. Countable sets, the countability of a product of countable sets, the countability of the set of algebraic numbers. Topology on a set, open and closed subsets. Bases of topology, metric spaces, subspaces. Continuous maps, homeomorphisms. Countability axioms, compactness. | | |

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|---|---|---|---|
| Code**KA3218** | ComplexAnalysis | | |
| Prerequisite | MultivariableCalculus | Postrequisite | Some special courses |
| Credits | 3 | Semesters | 5 |
| Aim of discipline | To introduce the basic ideas of complex analysis, with particular emphasis on Cauchy's Theorem and the calculus of | | |

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| | residues. |
| Аннотация дисциплины/ Abstract of discipline | This course introduces the calculus of complex functions of a complex variable. It turns out that complex differentiability is a very strong condition and differentiable functions behave very well. Integration is along paths in the complex plane. The central result of this spectacularly beautiful part of mathematics is Cauchy's Theorem guaranteeing that certain integrals along closed paths are zero. This striking result leads to useful techniques for evaluating real integrals based on the 'calculus of residues'. |

| Code**DUShP 3219** | Partial Differential Equations | | |
|---|---|---|---|
| Prerequisite | Ordinary Differential Equations | Postrequisite | Some special courses |
| Credits | 4 | Semesters | 6 |
| Aim of discipline | to provide students with the skills, knowledge and attitudes required to solve differential equations at a level that is necessary for further scientific and professional activity. | | |
| Аннотация дисциплины/ Abstract of discipline | The course includes a variety of differential equations and their solutions, with emphasis on applied problems in engineering and physics. The lecture course is accompanied with exercises, which develop student skills to solve specific problems | | |

| Code**ShM3220** | Numericalmethods | | |
|---|---|---|---|
| Prerequisite | DifferentialEquations | Postrequisite | Mathematical modeling |
| Credits | 4 | Semesters | 7 |
| Aim of discipline | The course will develop numerical methods to solve inverse and ill-posed equations. Basic elements of the theory of inverse and ill-posed problems will be given with proofs. The course will further develop problem solving skills. | | |
| Abstract of discipline | The definition of inverse and ill-posed problems. Initial boundary value problem for the Laplace equation. Well-posedness of the direct problem. Uniqueness and existence of the generalized solution to the direct problem. Formulation of the conjugate problem.<br>Reduction of the inverse problem for Laplace equation to an operator equation. Ill-posed problem to the heat conduction equation. Well-posedness of the direct problem. Uniqueness and existence of the generalized solution to the direct problem for the heat conduction equation. Formulation of the conjugate problem.<br>Reduction of the inverse problem for the heat conduction equation to an operator equation. Research conditional stability. Gradient methods for numerical solving the inverse problem. | | |

| Code**P2221** | Programming |
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|---|---|---|---|
| Prerequisite | ICT, Discret mathematics | Postrequisite | Mathematical modeling |
| Credits | 3 | Semesters | 3 |
| Aim of discipline | Description by learning software and the acquisition of knowledge and skills students implement of data processing algorithms, resulting in problems of algebra, mathematical analysis, mathematical statistics, and linear programming problems by means of modern high-level languages. | | |
| Abstract of discipline | Programming system. Algorithm and its properties. Ways of representing algorithms. The programming language C / C ++. Primary and secondary operations C ++. Assignment operator. Loop statements. Nested loops. The syntax and semantics of the operators of the cycle. Operators Break and continue. Initialization of arrays. Two-dimensional arrays. Initialization of arrays. Functions. Declaration functions. The functions without parameters. Formal and actual parameters. Recursive functions. Dynamic variables. Pointers and pointer arithmetic. Methods of accessing an array. Operations with pointers. The transfer of dimensional arrays of pointers and function without using pointers. Two-dimensional arrays and pointers. The transfer of two-dimensional arrays to functions. The files. Functions for working with files. Lines. Functions for working with strings. Stacks. Queues. Lists. Hash table. Binary search. Search algorithms. Algorithms on graphs. The algorithms NP-completeness Algorithm Reverse Polish Notation. | | |

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|---|---|---|---|
| Code**F3222** | Physics | | |
| Prerequisite | no | Postrequisite | Theoretical Mechanics |
| Credits | 3 | Semesters | 5 |
| Aim of discipline | Physics can be defined as a science that investigates the fundamental concepts of matter, energy, and space and the relationships between them. | | |
| Abstract of discipline | Mechanic. Dynamics. Molecular physics and thermodynamics. Electricity and magnetism. Optics. Quantum physics. Formation of students understanding of modern physical picture of the world and the scientific worldview, the basic physical phenomena; mastery of fundamental concepts, laws and theories of classical and modern physics, as well as methods of physical research; mastery of techniques and methods of solving specific problems in various fields of physics; introduction of modern scientific equipment, the skills of behavior of physical experiment, the ability to highlight specific physical content in future activities applications. | | |

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|---|---|---|---|
| Code**TM 3223** | Theoretical Mechanics | | |
| Prerequisite | Differential geometry | Postrequisite | Partial Differential Equations, Numerical methods |
| Credits | 3 | Semesters | 6 |
| Aim of discipline | Studying by the students the laws of nature, obtaining the skills of mathematical models constructing the nature and | | |

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| | engineering processes and their analysis on the basis of the found solutions, development of the future specialists' ability to research findings. |
| Abstract of discipline | Kinematics. Statics. Dynamics of the point mass and the system. Dynamics of the solid body. Bases of analytical mechanics. |

**MAJOR DISCIPLINES (MD)**
**OBLIGATORY COMPONENT (OC)**

| Code**TVMS 2301** | Probability theory and Mathematical Statistics | | |
|---|---|---|---|
| Prerequisite | | Postrequisite | |
| Credits | 4 | Semesters | 5 |
| Aim of discipline | The above justifies the importance of familiarizing students with the specialty "Mathematics" of modern universities with the basics of the course in probability theory and mathematical statistics. | | |
| Abstract of discipline | The common space of elementary events. Random variables. Numerical characteristics of random variables. Limit theorems. Characteristic functions. Basic concepts of sampling theory. Point estimates. Sufficient statistics and optimal estimates. Methods of finding estimates. Interval estimation. Testing of statistical hypotheses. Linear Regression and Least Squares. | | |

| Code**FA3302** | Functional analysis | | |
|---|---|---|---|
| Prerequisite | | Postrequisite | |
| Credits | 4 | Semesters | 6 |
| Aim of discipline | Learning of the basic concepts of infinite dimensional linear spaces and linear operators between them (normed spaces, Banach spaces, Hilbert spaces, bounded operators); explanation of differences between finite and infinite dimensional spaces and learning their fundamental properties; introduction to the concept of duality and learning its role in infinite dimension through the representation theorem of a linear functional and weak topology; explanation of spectral theory of compact self-adjoint operator. | | |
| Abstract of discipline | Normed spaces, metric spaces, Banach spaces and their examples (including spaces of continuous functions, integrable functions, bounded sequences, zero convergent sequences).<br>Inner (Scalar)product space, Hilbert space and examples. Riesz-Fischer theorem.<br>Orthonormal systems, Fourier coefficients, orthonormal basis. Basic results: Bessel inequality, Parseval identity Linear operators and their norm. Examples of the linear operators. Baire theorem. Open mapping theorem and | | |

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| | homomorphism theorem. Closed graph theorem and applications. Uniform boundedness principle and consequences. Dual space and adjoint operator. Hahn-Banach theorem and consequences. Reflexive spaces.<br>Elements of the theory of distributions. The resolvent set and the spectrum of a bounded linear operator. Compact sets and the Ascoli-Arzela theorem. Compact operators: examples, spectral properties |

**MAJOR DISCIPLINES (MD)**
**ELECTIVE COMPONENT (EC)**

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|---|---|---|---|
| Code | Group of elective course subjects on Function theory: *Fourier series, Applied functional analysis, Measure and Lebegues Integration theory, Spectral theory of linear operators, Approximation Theory, Pseudo-differential Operators on compact Lie groups, Hyperbolic equations with distributional data and coefficients, Non-harmonic Analysis*. | | |
| Prerequisite | Mathematical analysis, Multivariable Calculus, Vector Analysis, Complex Analysis, Differential Equations, Functional Analysis | Postrequisite | Some special courses in the direction |
| Credits | 25 | Semesters | 5-6-7 |
| Aim of discipline | The course *Applied functional analysis* introduces those notions and results of functional analysis that are relevant for applications to, e.g., partial differential equations, numerical analysis, signal processing, probability theory and stochastic analysis<br>The course *Measure and Lebegues Integration theory* introduces the concepts of measure and integral with respect to a measure, to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems.<br>The Nonharmonic Analysis is an advanced course of the modern mathematics and is developing the branch of mathematics nowadays | | |
| Abstract of discipline | Fundamentals of functional analysis used for applications to mathematical and computational sciences. Students study the theory of function spaces, such as Lebesgue spaces and Sobolev spaces and Fourier transforms, and their applications to partial differential equations.<br>Definition of a measurable space and sigma-additive measures, Construction of a external(outer) measure, Lebesgue's measure, the Lebesgue-Stieltjes measures, Examples of non-measurable sets, Measurable Functions, Integral with respect to a measure, Lusin's Theorem, Egoroff's Theorem, Fatou's Lemma, Monotone Convergence Theorem, Dominated Convergence Theorem, Product Measures and Fubini's Theorem. The Radon-Nikodym theorem, covering theorems, differentiability of monotone functions almost everywhere, definition of Lebesgue integral, Riesz representation theorem. | | |

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| | Global distributions generated by the boundary value problem. L-Fourier transforms. L-Convolutions. Plancherel formula, Sobolev spaces H(s, L), and their Fourier images. Spaces lp (L) and lp(L*). Schwartz' kernel theorem. L-Quantization and full symbols. Difference operators. Sobolev embedding theorem. Conditions for L2-boundedness.Global symbols: L-symbols and L-Fourier multipliers on compact manifolds with boundary.Schatten classes and nuclearity on manifolds with boundary. Review on Analysis without WZ condition. |

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|---|---|---|---|
| Code | Group of elective subjects of Algebra and Mathematical logic: *Number Theory, Elements of Computability Theory, Algebraic system, The theory of algorithms, Introduction to models, Introduction to classical geometry.* | | |
| Prerequisite | Linear algebra, Analytical geometry Discrete mathematics, Mathematical logic | Postrequisite | Some special courses in the direction |
| Credits | 25 | Semesters | 5-6-7 |
| Aim of discipline | As a result of studying the module, students should know elements of Computability Theory, basic concepts of algebra as groups, rings and their homomorphism; interpretation and model, sub-models, elimination of quantifiers and examples of categorical theories; and have presentation about various types of geometry: affine geometry, projective, elliptic, hyperbolic geometry and their possible models. | | |
| Abstract of discipline | Class of primitive recursive functions. Primitive recursive predicates. Cantor and Gödel numberings. Minimization operator. Class of partial recursive, total recursive and recursive functions. The notion of Turing machine. Recursion theorem. Rice theorem. Myhill's theorem for characterization recursively enumerable predicates. Post numbering. Computable numberings. Reducibility of numberings. Principal numberings. Enumeration reducibility. Recursive operators. Incomplete sets. Friedberg's solution. Group's homomorphisms and isomorphisms. Rings. Subrings. Algorithm to find a finite number of polynomials for the construction of the Gröbner basis. Interpretation and model. Submodels. Elementary submodel. The Tarski-Waugh theorem of an elementary model. Morley's theorem on categoricity. Affine geometry. The line at infinity. Affine transformations and their invariants. Projective geometry. Elliptic geometry.<br>Hyperbolic geometry. Models of the hyperbolic plane. | | |

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| Code | Group of elective subjects on Stochastic Analysis: *Stochastic Differential Equations, Stochastic financial mathematics, Stochastic processes, Non-parametric statistic and learning theory, The theory of random matrices.* | | |
| Prerequisite | Mathematical analysis, Multivariable Calculus, Differential Equations, Probability Theory and Mathematical statistics | Postrequisite | Some special courses in the direction |
| Credits | 25 | Semesters | 5-6-7 |

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| Aim of discipline | The course *Stochastic Differential Equations* familiarizes students with important concepts of the theory of random (ordinary) differential equations and random partial differential equations.<br>The purpose of the course *Stochastic financial mathematics* is the introduction into some mathematical concepts and tools which are indispensable for understanding the modern mathematical theory of finance, training of students with the basic methods of the stochastic calculus and its application to the mathematics of financial derivatives using the example of a binomial model.<br>The purpose of teaching the discipline *Stochastic processes* is to familiarize students of mathematical and other specialties of universities with the basic concepts and sections of the theory of random processes, relying on a rigorous in the mathematical sense and at the same time suitable for initial familiarization |
| Abstract of discipline | Brief information about random functions and bases of random analysis. Random operators. Random Compressing Operators. Random differential equations and their solutions. The existence, uniqueness, and measurability of a random solution. Probabilistic characteristics of solutions of random differential equations. Methods for finding the mathematical expectation of a random solution. Stochastic integrals and stochastic differential equations Ito and Stratonovich. Cauchy problem for various classes of random differential equations. Asymptotic properties of solutions of the Cauchy problem for certain random equations of parabolic type. The questions of averaging of some random equations of parabolic type.<br>Martingales. Markov processes. Determine the Binomial no-arbitrage pricing model. Derive random walk with Gaussian steps, discrete Wiener process and First passage time. Reflection principle<br>Basic concepts of the theory of random processes; Convergence; Continuity; Derivatives; Integrals. The main classes of random processes. Correlation theory of stationary (in a broad sense) processes. Finite-dimensional distributions of random processes. Stochastically equivalent processes. Kolmogorov's theorem. Wiener process. Properties of the trajectory of Wiener process. Markov and strictly Markov properties of Wiener process. Poisson process. Elements of the theory of martingales. Elements of the theory of Markov processes. Introduction to the theory of the Ito stochastic integral. The replacement formula for Ito variables. |

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| Code | Group of elective subjects on differential equations problems: *Qualitative theory of differential equations, Periodic and conditionally periodic solutions of differential equations, The theory of generalized Lyapunov' exponents, Asymptotic methods for solving singularly perturbed equations, Integral and integro-differential equations, Theoretical and computational questions of the equations of mathematical physics, Modern methods for solving boundary value problems of partial differential equations,Methods of Teaching Mathematics. Boundary value problems of mathematical physics. Introduction to the inverse problems theory of mathematical physics. Special functions in problems of mathematical physics.* | | |
| Prerequisite | Differential Equations | Postrequisite | Some special courses in the direction |

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|---|---|---|---|
| Credits | 25 | Semesters | 5-6-7 |
| Aim of discipline | To provide students with the skills, knowledge and attitudes required to solve partial differential equations at a level that is necessary for further scientific and professional activity. | | |
| Abstract of discipline | The course includes a variety of differential equations and their solutions, with emphasis on applied problems in engineering and physics. The lecture course is accompanied with exercises, which develops student skills to solve specific problems. | | |

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| Code | Group of elective subjects on Optimization problems: *General theory of extreme problems, Mathematical programming, Optimal control, The boundary problems of control theory, Practical solving of optimization problems and counterexamples in optimal control theory, Optimization problems for the distributed parameter systems and the differentiation theory.* | | |
| Prerequisite | Differential Equations, Variation calculus and Methods of optimization | Postrequisite | Some special courses in the direction |
| Credits | 25 | Semesters | 5-6-7 |
| Aim of discipline | The purpose of the subject *General theory of extreme problems* is to acquire the general theory of extreme problems in Banach space.<br>The purpose of the subject *Optimal control* is to study the base of the theory and methods of minimization of extreme problems.<br>The aim of this course *Practical solving of optimization problems and counterexamples in optimal control theory* is the analysis of the easy enough examples of the optimal control problems with non-trivial properties. | | |
| Abstract of discipline | The main problems of optimal control. Differentiation of nonlinear operators. Differentiation of nonlinear functionals. Existence and uniqueness theorems of solution of the Cauchy problem for differential equation in Banach space at control. Iteration process of the Newton-Kantorovich. Weierstrass theorem in Banach space.<br>Convex sets and convex functionals. Strong convex functionals. Theorem about global minimum. Optimality condition. Projection of the point on the set. The properties of the convex sets and convex functionals.<br>Functional gradient on the set of solutions of ordinary differential equations. Lipshitz condition for functional gradient. Optimality condition.<br>There are the easiest models of the serious practical optimization problems with the same difficulties. The formal using of the standard optimization methods here leads to serious difficulties. We consider the convergence of the iterative optimization methods, the existence and the uniqueness of the optimal control, the sufficiency of the necessary conditions of optimality, the singular control, the well-posedness of the optimal control problems by Tihonov and Hadamard, the bifurcation of extremals. | | |

**INTERDISCIPLINARY MODULE**

| | | | |
|---|---|---|---|
| Code**BD 3312** | Bigdata | | |
| Prerequisite | | Postrequisite | Some special courses in the direction |
| Credits | 2 | Semesters | 6 |
| Цель дисциплины/Aim of discipline | This course is appropriate for Maths majors who wish to familiarize with the applied/computational mathematics as a future direction in graduate school or professional degrees, this course serves as an “integrated approach” to introduce prospective math majors to learn about applications of mathematics to challenges facing almost all areas of graduate study, research and opening job markets in industry, health profession, accounting, finance and high technology | | |
| Abstract of discipline | Graphs and networks with applications to clustering for high- dimensional data; simplicial complexes, Euler characteristic and higher Betti numbers; connectedness and compactness in topological and metric spaces with applications to point cloud data sets; topological and geometric concepts needed for study of nonlinearity in data such as non-linear regression; pattern recognition in point clouds; geometric concepts for nonlinear regression via surfaces and hypersurfaces; computations with curves, surfaces and hypersurfaces in Euclidean spaces with applications to point cloud data sets, persistent homology, statistical manifolds. | | |

| | | | |
|---|---|---|---|
| Code**MMBM 3313** | Mathematical models in biology and medicine | | |
| Prerequisite | Multivariable Calculus, Differential Equations, Probability Theory and Mathematical statistics | Postrequisite | Some special courses in the direction |
| Credits | 2 | Semesters | 6 |
| Aim of discipline | Discipline aims to familiarize students with the theoretical and practical information, which reflects the main trends in the development of modelling biological and ecological systems using differential equations. | | |
| Abstract of discipline | Mechanistic and phenomenological models, focusing on population biology that can be analyzed using deterministic discrete- and continuous-time spatial- and non-spatial models, and demonstrates how mathematical techniques such as linear stability analysis, phase planes, singular perturbation and travelling waves, can provide important information about the behavior of complex models. | | |

| | | | |
|---|---|---|---|
| Code**AM3314** | Actuarial mathematics | | |
| Prerequisite | Mathematical analysis, Differential Equations, Probability Theory and Mathematical statistics | Postrequisite | Some special courses in the direction |
| Credits | 2 | Semesters | 6 |
| Aim of discipline | Throughout the years many insurance companies were formed in Kazakhstan and the government issued a law on | | |

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| | "The Insurance Market Activities" that has the development of the national insurance system as its main goal. In particular, according to the law each insurance company must have a licensed actuary as a staff member to be able to carry out insurance activities in the insurance market in Kazakhstan. The minimum requirement for actuaries of the Republic of Kazakhstan includes 6 courses. This course is a part of the first course out of six required courses to become a licensed actuary in the Republic of Kazakhstan. |
| Abstract of discipline | Accumulation Function. Simple Interest. Compound Interest. Present Value and Discount Factor Annuity immediate, annuity due. Equations of Value.Perpetuities.Varying Annuities. Survival Probability. The Law of Mortality and the Construction of Mortality Tables.<br>Stationary Population. Expectation of Life. Multiple Decrement Models. Life Annuities. Immediate and Deferred Annuity. Commutation Functions. Life Annuities payable m-thly. Varying Life Annuities. Life Insurance. Insurance Payable at the Moment of Death. Varying Life Insurance. Joint-Life Actuarial Functions. Types of Joint-Life Insurance Policies. Reversionary Annuity. PensionPlan. Different Types of Pension Plans. |

| Code**TSASPAD 3315** | SAS Technologies in Applied Data Analysis | | |
|---|---|---|---|
| Prerequisite | Probability Theory and Mathematical statistics | Postrequisite | Some special courses in the direction |
| Credits | 2 | Semesters | 6 |
| Aim of discipline | Training the specialists, capable to use SAS programming technologies for the solution data analysis tasks. Description the basic SAS/BASE programming, macros concepts, SQL, SAS/STAT statistical analysis methods library: dispersion analysis, linear regression, logistic regression, the generalized linear models, Tobit models, the survival analysis, clustering. Bayesian analysis; interactive programming language for processing IML matrix data: matrix, linear algebra and numerical methods in IML, integration withSAS/BASE, R, C++; explanation SAS/BASE programming technology aspects (syntax, semantics, rules, ways to work with it). | | |
| Abstract of discipline | SAS analytic platform, technologies review. SAS U edition. SAS Data sets. SAS libraries. SAS/BASE Programming language bases. Variables attributes in SAS. Data sets options. SAS Macro. Macro substitutions. SQL usage and implementation features in SAS. SQL & Reporting. SAS/STAT statistical analysis methods library (MODULE I). Examining data distributions, obtaining and interpreting sample statistics using the UNIVARIATE and MEANS procedures. Logistic regression. Analysis of Variance (ANOVA). Target Marketing. Churn Prediction. Credit Scoring, Collection Scoring. Fraud Detection. The generalized linear models. The SAS/STAT survival analysis. Interactive programming language for processing IML matrix data. Introduction to IML. Integration with SAS/BASE, C++. SAS/IML SAS/IML Linear algebra and Numerical methods. Practical cases, working on projects. | | |

## PROFESSIONAL PRACTICE MODULE

| | | | |
|---|---|---|---|
| Code**UP** | Educational Internship | | |
| Prerequisite | Core disciplines | Postrequisite | Practice Training |
| Credits | 2 | Semesters | 2 |
| Aim of discipline | To consolidate and deepen the theoretical training of the trainee, to acquire practical skills and competencies in the sphere of professional activity. | | |
| Abstract of discipline | In the educational practice the following practical skills and competencies are formed:<br>- the ability to realize the social importance of their future profession, to have a high motivation to carry out their professional activities;<br>- the ability to work with information from various sources, including network resources of the Internet, to solve professional and social problems;<br>- the ability to maintain programming skills;<br>- the ability to demonstrate general scientific knowledge of the natural sciences, mathematics and computer science;<br>- the ability to acquire new scientific and professional knowledge, using modern educational and information technologies;<br>- the ability to understand and apply a modern mathematical apparatus in research and application;<br>- the ability in the research and production team to solve the tasks of professional activity;<br>- the ability to critically rethink the accumulated experience, change, if it is necessary, the type and nature of their professional activities. | | |

| | | | |
|---|---|---|---|
| Code**PP** | PracticeTraining | | |
| Prerequisite | Core disciplines | Postrequisite | Educational Practices |
| Credits | 2 | Semesters | 4, 6 |
| Aim of discipline | Depending on the types of activity, stage, and place of passing practice, the objectives of the practice can be:<br>• obtaining skills in research and development;<br>• solving scientific problems;<br>• acquisition of practical skills in the field of training at a specific workplace as an executor;<br>• use in the writing of the final work skills obtained during the practice. | | |
| Abstract of discipline | In the Practice Training following practical skills and competencies are formed:<br>• gaining experience in teamwork;<br>• search and study of scientific literature on a selected topic;<br>• study and critical analysis of methods for solving scientific problems on a selected topic; | | |

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|---|---|
| | • application of learned scientific methods in solving new problems;<br>• familiarization with the main stages of the scientific substantiation of the development and engineering and technical activities of the organization;<br>• search and study of additional sources necessary to complete the assignmenton the formation of initial data, mathematical topics;<br>• An independent implementation of the development of fragments of a particular project implemented by a team of employees of the base enterprise and/or other students. |

| | | | |
|---|---|---|---|
| Code EP | Educational Practices | | |
| Prerequisite | Core disciplines | Postrequisite | In the work of educational institutions |
| Credits | 4 | Semesters | 8 |
| Aim of discipline | To practice the formation and development of professionally significant qualities of the future teacher, necessary for realizing the ideas of modern education in the conditions of the current pedagogical process. | | |
| Abstract of discipline | Achievement of the set goal is provided by solving the following tasks of pedagogical practice:<br>- familiarization with the current state of educational work and accumulated pedagogical experience in an educational institution;<br>- the acquisition of the skills necessary for the successful implementation of educational and educational work, taking into account the psychological characteristics of students of a certain age;<br>- formation of a creative approach to pedagogical activity, enrichment and expansion of the pedagogical outlook, development of a strategy for the behavior of the teacher in various pedagogical situations;<br>- improving the ability to monitor the pedagogical process, to design, implement and evaluate the results of relevant pedagogical activities;<br>- education of a sense of responsibility for the results of their work. | | |

| | | | |
|---|---|---|---|
| Code**PdP** | Pre-Graduation Internship | | |
| Prerequisite | Major disciplines | Postrequisite | In the future professional activity |
| Credits | 2 | Semesters | 8 |
| Aim of discipline | The Pre-Graduation Internship is to provide theoretical and practical results that are sufficient for the successful implementation and protection of final qualifying work. | | |
| Аннотация дисциплины/ Abstract of discipline | Pre-Graduation Internship helps to perpetuate and deepen students' theoretical knowledge obtained during the training, and the ability to set goals, analyze the results and draw conclusions, the acquisition, and development of skills of independent research work. | | |

**For specialization Actuarial Mathematics**

**BASIC DISCIPLINES (BD) ELECTIVE COMPONENT (EC)**

| | | | |
|---|---|---|---|
| Code**OFM1210** | Fundamentals of financial mathematics | | |
| Prerequisite | Mathematical analysis, Probability theory | Postrequisite | Actuarial Principles 1 |
| Credits | 3 | Semesters | 2 |
| Aim of discipline | Throughout the years many insurance companies were formed in Kazakhstan and the government issued a law on "The Insurance Market Activities" that has the development of the national insurance system as its main goal. In particular, according to the law each insurance company must have a licensed actuary as a staff member to be able to carry out insurance activities in the insurance market in Kazakhstan. The minimum requirement for actuaries of the Republic of Kazakhstan includes 6 courses. This course is a part of the first course out of six required courses to become a licensed actuary in the Republic of Kazakhstan. | | |
| Abstract of discipline | Accumulation Function. Simple Interest. Compound Interest. Present Value and Discount Factor<br>Nominal Interest Rate. Constant and Varying Force of Interest. Net Present Value. Rate of Return. Unknown Rate of Interest. Time-Weighted Rate of Return. Annuity immediate, annuity due. Equations of Value. Perpetuities.<br>Unknown Time and Unknown Interest Rate. Continuous Annuities. Varying Annuities. Arithmetic Increasing and Decreasing Annuities. Amortized Loans. Amortization Schedule. Sinking Fund Loans. Yield Rate. Price of a Bond. Book Value of a Bond. Bond Amortization Schedule. Callable Bond. Investment Duration. Modified Duration. BondConvexity. LifeContingency. Review Session. | | |

| | | | |
|---|---|---|---|
| Code**DMML1212** | Discrete mathematicsand Mathematical logic | | |
| Prerequisite | Mathematical analysis, Probability theory | Postrequisite | Actuarial Mathematics |
| Credits | 3 | Semesters | 2 |
| Aim of discipline | Mastery of the tools, including basic concepts and results, and the techniques and methods of obtaining the results of discrete mathematics. Also the techniques and methods for obtaining the results of mathematical logic. | | |
| Abstract of discipline | This course examines sets and operations on them, relations and operations on them. Also, we introduce elements of number theory and combinatorics including: rules of the account, the Dirichlet principle, inclusion-exclusion, the placement and combinations, recursive relations, diophantine equations. Hamiltonian, bipartite, Eulerian and planar | | |

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| | graphs. The theory of the calculus of propositions, the logic of predicates, and the predicate calculus is introduced. The completeness and consistency of the propositional calculus, the independence of the system of axioms of the propositional calculus, Post's theorem on the completeness of functions of the algebra of logic, and the Levenheim-Skolem theorem are proved. |

| Code**TMIL 2213** | Measure and Lebegues Integration theory | | |
|---|---|---|---|
| Prerequisite | Mathematical analysis | Postrequisite | Functional analysis, probability theory |
| Credits | 4 | Semesters | 3 |
| Aim of discipline | To introduce the concepts of measure and integral with respect to a measure, to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems. | | |
| Abstract of discipline | Definition of a measurable space and sigma-additive measures, Construction of a measure form outer measure, Construction of Lebesgue's measure, Lebesgue-Stieltjes measures, Examples of non-measurable sets, Measurable Functions, Integral with respect to a measure, Lusin's Theorem, Egoroff's Theorem, Fatou's Lemma, Monotone Convergence Theorem, Dominated Convergence Theorem, Product Measures and Fubini's Theorem. Selection of advanced topics such as the Radon-Nikodym theorem, covering theorems, differentiability of monotone functions almost everywhere, descriptive definition of the Lebesgue integral, description of Riemann integrable functions, k-dimensional measures in n-dimensional spaces, Riesz representation theorem. | | |

| Code**P2214** | ProgramminginC# | | |
|---|---|---|---|
| Prerequisite | Mathematical Analysis, Theory of Algorithms | Postrequisite | ??? |
| Credits | 4 | Semesters | 3 |
| Aim of discipline | C# is a modern, object-oriented programming language intended to create simple yet robust programs. Designed specifically to take advantage of CLI features, C# is the core language of the Microsoft .NET framework. In this course, students gain the skills to exploit the capabilities of C# and of the .NET Framework to develop programs useful for a broad range of desktop and Web applications. | | |
| Abstract of discipline | Students will learn how to<br>• Create, compile and run object-oriented C# programs using Visual Studio;<br>• Write and understand C# language constructs, syntax and semantics;<br>• Develop reusable .NET components via interface realization and standard design patterns; | | |

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| | • Leverage the major namespaces and classes of the .NET Framework;<br>• Access databases using Language Integrated Query (LINQ).<br>Course summary. NET and C#. C# Types and Operators. Method Issues. Class and Interface Issues. Arrays. Strings. Regex. Miscellaneous Issues. C# Properties and Indexes. Operator Overloading. User-DefinedConversions/Casts. C# Enums and Structures. C# Attributes.Exception Handling. Multi-Threading. Reflection. File I/O. Add-on Serialization. ADO.NET.LINQ. Generics. |

| Code**TSP2216** | The theory of random processes | | |
|---|---|---|---|
| Prerequisite | Theory of Probability and Mathematical Statistics; Random processes | Postrequisite | Elective courses in the field of "Theory of Probability and Mathematical Statistics" |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | Description of the basic concepts of random processes; introducing basic concepts of Poisson and Markov processes; explanation of differences between discrete-time and continuous-time processes; introduction of concept of martingales and random walk; explanation of basic techniques for random processes. | | |
| Abstract of discipline | The subject of random processes and its applications. Index set. Discrete-time and continuous-time processes. State space. Discrete and real-valued processes. Sample function. Increment. General point processes. Markov chains. Transient evolution. Reducibility. Periodicity. Ergodicity. Steady-state analysis. Limiting distributions. Reversible Markov chains. Birth–death processes. Markov chains with rewards. Continuous-time Markov processes. Kolmogorov differential equations. General birth – death processes. Mixed Poisson processes. Renewal processes. Excess life. A general approach to random walks. Lattice random walk. Ladder epochs. The Wiener-Hopf factorization. Martingales in discrete and continuous time. Filtration. Stopping Time. Submartingales. Supermartingales. Doob's inequality. Branching processes. Brownian motion. Wiener processes. Levy processes. | | |

| Code**APP2217** | Actuarial principles and their applications-1 (for actuary) | | |
|---|---|---|---|
| Prerequisite | Interest theory. The theory of life insurance. | Postrequisite | Actuarial Principles 2 |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | . The objective of this course is to develop student's knowledge of basic actuarial principles applicable to a variety of | | |

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| | financial security systems: life, annuities, health, property & casualty insurance, retirement systems and investments. The candidate will be required to understand the purpose of these systems, the design and development of financial security products and the concepts of anti-selection and risk classification factors. The course covers principles and practices applicable to the determination of premiums and rates, reserving and the valuation and funding of these financial security systems. |
| Abstract of discipline | Financial annuities immediate, annuities due. Perpetuity. Variable financial annuities. Loans: Amortization, Amortization Schedules, Sinking Fund. Outstanding loan balance.TI BAII CalculatorProfessional. Bonds. Price of Bonds. Book value of bonds. Callable bonds. Bond Amortization. Modified Duration of Bonds. Life Annuities. Life Insurance. The Economics of Insurance. Ratemaking, gross premium components. Insurance Reserve and Loss Reserving in Property and Casualty Insurance. Loss Reserving in Property and Casualty Insurance. Review of Some Problems. Review Session. |

| Code **TSZh 3222** | Theory of life contingencies | | |
|---|---|---|---|
| Prerequisite | Interest theory, Probability Theory | Postrequisite | Actuarial Principles 1, Actuarial Principles 2 |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | Throughout the years many insurance companies were formed in Kazakhstan and the government issued a law on “The Insurance Market Activities” that has the development of the national insurance system as its main goal. In particular, according to the law each insurance company must have a licensed actuary as a staff member to be able to carry out insurance activities at the insurance market in Kazakhstan. The minimum requirement for actuaries of the Republic of Kazakhstan includes 6 courses. This course is part of the first course out of six required courses to become a licensed actuary in the Republic of Kazakhstan. | | |
| Abstract of discipline | Life Contingencies and Life Tables.<br>The Law of Mortality and the Construction of MortalityTables. Expectation of Life. Multiple Decrement Models Introduction to Life Annuities. Commutation Functions. Insurance Payable at the Moment of Death. Varying Life Annuities. Annual Premiums and Unearned Premium Reserves for a Life Annuity. Introduction to Life Insurance. Types ofLifeInsurance. Commutation Functions and Basic Identities for Life Insurance. Insurance Payable at the Moment of Death. Varying Life Insurance. Life Insurance Annual Premiums and Reserves. Discussion Session: Exercises on Life Insurance Annual Premiums and Reserves.<br>Joint-Life Actuarial Functions. Types of Joint-Life Insurance Policies. Last-Survivor Problems. Reversionary Annuity. Discussion Session: Exercises on the Last-Survivor Problems and Reversionary Annuity Pension Plan. Pension Applications | | |

| | | | |
|---|---|---|---|
| Code**SUBD 3223** | Database management system | | |
| Prerequisite | Programming in C# | Postrequisite | |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | To build the foundation in database field, to develop competence in database design, and to give an introduction to the use of database management systems for applications. | | |
| Abstract of discipline | Introduction to Databases and Database Systems. Theoretical-graphical data models. Basic notions of a relational model. Relational Algebra operations. Additional Relational Algebra operations. Relational calculus. SQL: data definition language, data manipulation language. SQL: data query language. Modeling of DB based on normalization principles. Infological modeling. Principles of integrity supporting in relational data model. Physical DB models. Distributed data processing. Transaction models. Overview of the Object-Oriented Databases. | | |

**MAJOR DISCIPLINES (MD)**
**ELECTIVE COMPONENT (EC)**

| | | | |
|---|---|---|---|
| Code | Group of elective subjects for Actuary specialization*: Actuarial principles and their applications-2; Stochastic processes; Non-parametric statistic and learning theory; The theory of random operations; Multidimensional Statistical Analysis; Time series statistics*<br>*Financial Statistics; Statistics of random processes; Mathematical models of investment; Applied Statistics.* | | |
| Prerequisite | Theory of Probability and Mathematical Statistics; Differential equations; Random processes. | Postrequisite | Elective courses in the field of "Theory of Probability and Mathematical Statistics" |
| Credits | 25 | Semesters | 5-6-7 |
| Aim of discipline | The objective of this course is to develop student's knowledge of basic actuarial principles applicable to a variety of financial security systems: life, annuities, health, property & casualty insurance, retirement systems and investments. The candidate will be required to understand the purpose of these systems, the design and development of financial security products and the concepts of anti-selection and risk classification factors. The course covers principles and practices applicable to the determination of premiums and rates, reserving and the valuation and funding of these financial security systems. | | |
| Abstract of discipline | Life Contingencies and Life Tables. The Law of Mortality and the Construction of Mortality Tables. | | |

| | |
|---|---|
| | Stationary Population. Expectation of Life. Multiple Decrement Models. Life Annuities. Commutation Functions. Varying Life Annuities. Annual Premiums and Unearned Premium Reserves for a Life Annuity. Introduction to Life Insurance. Insurance Payable at the Moment of Death. Life Insurance Annual Premiums and Reserves. Joint-Life Actuarial Functions. Last-Survivor Problems. Pension Plan. Pension Applications |

**INTERDISCIPLINARY MODULE**

| Code**MD3314** | Mathematical demography | | |
|---|---|---|---|
| Prerequisite | The theory of life insurance. Actuarial principles-1. Actuarial principles-2 | Postrequisite | Life insurance choice courses |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | The main objective of this course is to study modern models used as a tool for demographic analysis, modern demographic processes in the world, their trends, application for calculating the forecasting of the population of Kazakhstan and regions. | | |
| Abstract of discipline | Theoretical bases of demography. . Mathematical foundations of demography. Demographic Methods for Determining the Population. Demographic projections. | | |

| Code**EMM 3315** | Economic-mathematicalmodels | | |
|---|---|---|---|
| Prerequisite | The theory of life insurance. Actuarial principles-1. | Postrequisite | Life insurance choice courses |
| Credits | 3 | Semesters | 1 |
| Aim of discipline | Study of applied and mathematical methods of financial analysis, modern methods of mathematical calculations and research used in solving applied problems of optimization in economics and finance, standard methods of calculating economic and socio-economic indicators characterizing the activities of economic entities. | | |
| Abstract of discipline | Financial markets and mathematical models. One-period deterministic models of the financial economy. Multi-period deterministic models of the financial economy. Decision-making under uncertainty. One-period models of the financial market under conditions of uncertainty. One-period CAPM Stochastic models of the financial market with discrete time. Stochastic models of the financial market with continuous time. | | |

**CONLUSIONS OF EXPERTS**

Duke University

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CHARLES M. BECKER
Research Professor and Associate Chair
email: cbecker@econ.duke.edu

To: Faculty of Mathematics
Al-Farabi Kazakh National University
Almaty, Kazakhstan

From: Charles Becker

Concerning: External Evaluation of proposed educational program – Mathematics (Specialty 58060100; emphasis on Actuarial Mathematics): Expert Conclusion

Date: July 17, 2017

Expert Conclusion: **Accept** (endorse proposed educational program)

**Comments on Document**:

**Overall, this is a very strong document. Anyone graduating with the courses described here will be well prepared to start a career as an actuary.**

1. Indeed, the first thought that comes to mind is that perhaps there is too much material: the effort required to grasp the content of this program would require intense passive study and memorization, and that will come at the cost of active learning.
2. Related to this is the sense that some of the courses essentially reflect the courses that the professors would like to teach, rather than what would be most useful for students. Some alternative courses are mentioned below.
3. Of all the courses missing, the ones I would most like to see are:
    a. Mathematical demography
    b. Population demography
    c. Simulation techniques, with emphasis on Monte Carlo approaches
    d. Regression analysis with emphasis on causal relationships and forecasting; time series econometrics.
    e. Health economics is another important course that is not covered...more important than physics or abstract math at the advanced level.
    f. Epidemiology
4. Another useful course: assessing data quality; data reduction methods (principal components analysis)...
5. I recommend that you remove references to specific hardware and software in the document, since these will change over time!

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6. Actuaries should have some experience in assessing confidence intervals for their forecasts, and when there are many uncertain parameters, this means Monte Carlo techniques.

7. There is also value in inference from small samples. I would recommend a separate course in Bayesian techniques, if possible.

8. Many mathematics courses in the document are highly theoretical. I would recommend a more applied emphasis.

9. A dynamic programming course that also covers Pontryagin's principle might be worthwhile – perhaps more so than calculus of variations (or the courses could be combined). Stochastic calculus is also important for the finance side of the profession, but I see that it is covered elsewhere.

10. As noted above, I would not refer to specific languages, programs, or packages. R and Matlab might be more useful than C++. Students also need to gain familiarity with a regression package, most likely STATA (and SAS). At this point, students should be exposed to SAS, STATA (secondarily), R, C++, and Matlab.

11. An elective course in Machine Learning could be useful for some.

12. Physics and Functional Analysis won't hurt, but I don't see why it is in an actuarial science curriculum. More statistics also would be more valuable than a course in topology.

13. The course in Mathematical models in biology and medicine would do well to focus on humans.

14. Regression analysis merits a separate course rather than inclusion in another statistics course.

15. Students also need a research seminar that focused on using Kazakh data – both individual and population.

16. I have also run the draft proposal through a spell-check and made hundreds of changes, mainly of run-on words. However, there are probably 100 changes, mainly of run-on strings of words, which I did not change: someone should do this.

Signed:

Charles M. Becker
Research Professor of Economics and Associate Department Chair

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**Michael Ruzhansky Ph.D.**
Professor of Pure Mathematics

Imperial College London

**REPORT**

on "EDUCATIONAL PROGRAMMATHEMATICS,Specialty 5B060100 –Mathematics" by AL-FARABI KAZAKH NATIONAL UNIVERSITY

This program is devoted to bachelor students. In the main part, disciplines divided by blocks. In the first block,there are listedgeneraleducationsubjects:

1. The modem history of Kazakhstan;
2. Kazakh (Russian) Language;
3. Foreign Language;
4. PhilosophyofScientificKnowledge.

Developers indicate them as compulsory disciplines. In my opinion, they should not be compulsory.

In the second block,list of basic disciplinesare given. All subjects are related to mathematics except

1. Professionally-Oriented Kazakh (Russian) Language;
2. Professionally-Oriented Foreign Language.

In the third block, we have Major disciplines for mathematics group and for actuary group. All disciplines are suitable for these groups.

In the fourth and fifth blocks, list of elective courses for mathematics group and for actuary group are given. Almost all courses are modem and fulfill with European high educational mathematical programs.

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**Michael Ruzhansky Ph.D.**
Professor of Pure Mathematics

Imperial College London

The sixth block relates to interdisciplinary courses.I think that the disciplines given in this block are interesting and useful for developing relationship between different disciplines.

Overall, the subjects suggested in this program related to mathematics correspond to European standard.

Expert

Professor Michael Ruzhansky

24 June 2017

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**МОСКОВСКИЙ**
**ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ**

**имени М.В. ЛОМОНОСОВА**
**(МГУ)**

**МЕХАНИКО-МАТЕМАТИЧЕСКИЙ**
**ФАКУЛЬТЕТ**

Ленинские горы, Москва, ГСП-2, 119992
Телефон: 939-12-44, Факс: 939-20-90

22.09.2017 № 201-17/101-03
На № _____

**To**: Faculty of Mathematics at Al-Farabi Kazakh National University, Almaty, Kazakhstan
**From**: M.K. Potapov, Professor, Doctor of Physics and Mathematics, Lomonosov Moscow State University
Concerning: external evaluation of proposed educational program – Mathematics (Specialty 5B060100): Expert Conclusion
**Date**: July 30, 2017
**Expert conclusion**: Accept (endorse proposed educational program)

1. Mathematics, like any other discipline, always faces the challenge of time. Thus, the methodology of teaching mathematics needs to evolve constantly. This is especially true given that mathematics is a fundamental tool for modeling and explaining phenomena in various scientific disciplines in this era of rapidly changing technology. However, keeping the purity of fundamental mathematics is also essential if we want to distinguish it from applied programs such as "Applied and Computational Mathematics." Fulfilling these two requirements - methodological modernity and fundamental integrity – is, in my opinion, the main purpose of adjusting the previous program. Ideally, every change will bring the best out of the existing conditions while leaving some space for demands of the modern life. In my opinion, this program deals with this task exceptionally well. The courses included in the program incorporate not only a breadth of knowledge in theoretical mathematics, but also include the application of mathematics to real-life phenomena.

very happy to emphasize that Al-Farabi Kazakh National University nurtures these qualities in youngsters (the word "youngsters" is used due to the statistical majority of a students' demographic in the area). In general, universities in Central Asia are highly encouraged to stimulate this attitude in their researchers, faculty, and students.

5. If I have to mention some flaws of the program, I must mention a few typos and a difficult structure of the presented material.

**Conclusion**

The program is full and diverse. It might be a challenge for faculty to keep the lectures and seminars focused on the overall understanding of the material by students rather than on an in-depth knowledge of the topic. Thus, with this variety of topics, I think it is better to focus on a fundamental understanding of concepts introduced in the course. Courses included in the program certainly demand a lot of independent learning from students. However, the skills they gain while learning to work independently will only help students in their future careers.

Overall, I would support the program without any changes to its content. The program is necessary and sufficient in fulfilling the goals of the educational program.

**Signed**:

M.K. Potapov

Professor, Doctor of Physics and Mathematics

NAZARBAYEV
UNIVERSITY

**CONLUSIONS OF ANASTASIOS BOUNTIS**
**August 15 2017**

**General Remarks:**

1. This is a very ambitious and all - inclusive Study Program of Mathematics. It is well – written and correctly described, but extremely demanding for even the best students (and teachers!) on an international scale. Therefore**, it should be reduced considerably in scope and description**.
2. The layout of the Program is extremely repetitive. Often the same passages are written many times. Even to read it takes several hours and I believe this could discourage even the brightest and most motivated students (and teachers!).
3. My main conclusion, therefore, is that **the program should be significantly reduced** to a document of 70 – 80 pages containing the detailed description of all the undergraduate as well as graduate courses.
4. **One idea is to break down the Program into Divisions** like: 1) Pure Mathematics, 2) Mathematical Physics, 3) Statistics, Actuarial Science and Finance, 4) Mathematics of Biology and Chemistry, 5) Computational Mathematics and Informatics
   Thus, after taking Core Courses (like Analysis, Algebra, Topology, Geometry) for 2 years, each student will be asked to choose a Division.
5. **Divide your Electives into groups,** one for each of the above Divisions. Then you may also wish to divide the Electives of each Division into Obligatory ones (from which the student of that Division MUST select 2-3) and Free Electives, from which students from all Divisions are free to choose.

**Concerning the Program as it is on the Web (see below):**

6. Your webpages describing your Sections, your Faculty and their specialties **must also be in English.**
7. Regarding your **future Program for Master's Degree**, it should not coincide with those of the Bachelor's Degree. It is a good idea to add to the Master's course titles terms such as: "Advanced…" , "Special Topics of…", "and Applications", etc.
8. For your **future Program of Doctoral Studies**: I do not recommend listing topics at all, since all studying must have been completed at the Bachelor's and Master's levels. What is customary to say is something like "Faculty members of the Department are willing to guide Doctoral students to complete a Ph.D. thesis in the areas of: Mathematics and Mechanics, mathematical modeling and computer simulation, automation and control, computer hardware and software, computer science, engineering and management, space engineering and technology, information security systems."
9. Concerning **the listing of special topics for Tracks 1 and 2,** I have made some modifications below in what concerns Differential equations and Control Theory.
10. See also the **list of textbooks I have written down at the end**. Note: The students must know briefly, in 4-5 lines, what is the content of each course and then me given the titles of 1-2 books on which the teaching will be based. All books must have a part for the undergraduate and one for graduate level.

10. See also the **list of textbooks I have written down at the end**. Note: The students must know briefly, in 4-5 lines, what is the content of each course and then me given the titles of 1-2 books on which the teaching will be based. All books must have a part for the undergraduate and one for graduate level.

**Additional Remarks:**

11. In the undergraduate course descriptions, avoid using advanced and specialized terminology, like singular, nonlinear, complex, etc.
12. It would be a very good idea to include in your advanced undergraduate courses and certainly your graduate courses the topics **of Analytical Mechanics** and also **Special Relativity**.
13. Especially your course in Analytical Mechanics MUST include a detailed description of Lagrangian and Hamiltonian Mechanics, which I didn't find anywhere.
14. Please include PYTHON among the computer programming languages taught at the undergraduate level.

| | |
|---|---|
| Track 1: Differential equations and mathematical physics | **Module 1: Qualitative theory of differential equations**<br>• Qualitative theory of differential equations<br>• Dynamical systems theory<br>• Perturbation theory<br><br>**Module 2: Boundary-value problems for differential equations**<br>• Boundary-value problems for ordinary differential equations<br>• Boundary-value problems for partial differential equations<br>**Module 3:** Equations of mathematical physics<br>• Special functions, orthogonal polynomials and integral transforms<br>• Wave, heat, Laplace and Schroedinger's equations<br><br>**Module 4: Special Topics**<br>• Fluid mechanics and Navier–Stokes equations<br>• Integro-differential equations<br>• Inverse problems of mathematical physics |
| Track 2: Control theory | **Module 1: Theory of dynamical systems**<br>• Stability theory for autonomous dynamical systems<br>• Dynamics of driven nonlinear systems<br><br>**Module 3: Boundary-value problems and control systems**<br>• Methods for solving boundary value problems<br>• Inverse problems for stochastic differential equations |

| | |
|---|---|
| | **Module 4: Optimal control theory**<br>• Boundary value optimal control problems<br>• Differential game theory |

**Include the following textbooks as reading material in the corresponding undergraduate and graduate courses:**


1) J. Kevorkian and J. Cole, Perturbation Methods in Applied Mathematics", Springer 1982.
2) P. Drazin, "Nonlinear Systems", Cambridge University Press, 1992.
3) P. Drazin and R. Johnson, "Solitons: An Introduction", Cambridge University Press, 2002.
4) E. Sontag, "Mathematical Control Theory", Springer, 1998.
5) D. Smith, "Variational Methods in Optimization", Dover Books on Mathematics, 1998
6) M. Morse, "Variational Analysis: Critical Extremals and Sturmian Extensions", J. Wiley and sons, 1973.
7) D. Logan, "Applied Mathematics", 3d edition, Wiley, 2013.
8) H.T. Davis, "Introduction to Nonlinear Differential and Integral Equations", Dover, 1956."
9) J. Guckemheimer and P.Holmes, "Nonlinear Differential Equations, Dynamical Systems and Bifurcations of Vector Fields", Springer, 1983.
10) M. Lieberman and A. Lichtenberg, "Regular and Chaotic Dynamics", Springer, 1992.
11) L. Perko, "Differential Equations and Dynamical Systems", Springer, 2001.
12) S. Strogatz, "Nonlinear Dynamics and Chaos", Westview Press, 2014.
13) A. S. Fokas, "Unified Approach to Boundary Value Problems", vol. 78, Conf. Series, SIAM, 2008.
14) T. Bountis and H. Skokos, "Complex Hamiltonian Dynamics", Springer, 2012.
15) J. M. Coron, "Control and Nonlinearity", Mathematical Surveys and Monographs, Vol. 136; 2007.
16) S. Wiggins, "Introduction to Applied Nonlinear Dynamical Systems and Chaos", Springer, 1990.
17) D. Powers, "Boundary Value Problems for Partial Differential Equations", Academic press, 6th edition, 2009.
18) Rufus Isaacs, "Differential Games", J. Wiley, 1965.



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ҚАЗАҚСТАН РЕСПУБЛИКАСЫ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ
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**РЕСПУБЛИКАНСКОЕ ГОСУДАРСТВЕННОЕ ПРЕДПРИЯТИЕ НА ПРАВЕ ХОЗЯЙСТВЕННОГО ВЕДЕНИЯ «ИНСТИТУТ МАТЕМАТИКИ И МАТЕМАТИЧЕСКОГО МОДЕЛИРОВАНИЯ»**
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29.09.17 № 01-04/167

# EVALUATION REPORT

## on the educational program 5B060100 "Mathematics"

The evaluated educational program 5B060100 "Mathematics" has been designed on the basis of State Compulsory Education Standard of the Republic of Kazakhstan. The Passport of the educational program contains the following information: qualification of the graduate, purpose of the program, brief characteristic of activities of graduates. A list of cultural and professional competencies that the graduates are expected to possess as a result of completing the program is provided. Learning outcomes in the context of the disciplines studied are developed.

In the core curriculum of the specialty, a full list of disciplines is defined for three cycles: General Education (GE), Basic Disciplines (BD) and Majors. Within each of these cycles, academic disciplines are divided into 2 types - basic component and optional component (elective disciplines).The program contains a catalog of disciplines and their description.

In general, the educational program contains 129 credits of theoretical training, distributed in cycles as follows: GE - 22 credits, BD - 72 credits, Majors - 33 credits, interdisciplinary module - 2 credits. Practical training of students is also provided: educational practice - 2 credits, professional practice - 2 credits, pedagogical practice - 4 credits, pre-diploma practice - 2 credits. For the final certification and additional types of learning, 3 and 8 credits are allocated, respectively.

The content of the educational program ensures the necessary integrity, combining the fundamentality of training with the interdisciplinary nature of the specialists' professional activities. Effective education technologies are determined in order to achieve learning outcomes.

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*Recommendations and remarks*

1. There is no clear description of educational trajectories in the Passport of the educational program. When studying the curriculum of the specialty it was revealed that there are 2 directions of students' preparation: Mathematics and Actuarial Mathematics. I consider it expedient to define these educational trajectories in the Passport of the educational program, and also to reflect the features of each of them in the list of professional competencies.
2. Vocational training of students includes 4 credits of pedagogical practice. Is this kind of practice necessary for students majoring in Actuarial Mathematics? As a recommendation, I propose to include in the content of the educational program a brief description of all types of practice for students of each educational trajectory.
3. In the core curriculum of the specialty, there are some discrepancies in credits number:
   - The basic component of BD is provided by 8 credits, as it is indicated in the curriculum. But for actuaries this component consists of 11 credits
   - The optional component of BD for actuaries in the 4th semester comprises 15 credits instead of 12 credits indicated in the curriculum
   - Six credits were allocated for the 7th semester, including 2 credits for GE and 4 credits for BD. But for actuaries, BD discipline is not specified.
4. The optional component of the curriculum is supposed to provide students with an opportunity to choose disciplines from the catalog of electives. But in the 1st, 2nd, and 5th semesters alternative BD disciplines for students of the educational trajectory 5B060100 "Mathematics" are not offered.

*Conclusion*

In general, the educational program developed by the Department of Fundamental Mathematics of the Kazakh National University named after al-Farabi meets the basic requirements of the State Compulsory Education Standard and promotes the formation of general cultural and professional competencies in the field of preparation graduates of the specialty 5B060100 "Mathematics".

Reviewer, Doctor of physical and mathematical sciences,
professor D. Dzhumabaev

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№ 27-01/475

**Экспертное заключение**
**на образовательную программу Mathematics, разработанную на английском языке разработчиками Казахского национального университета имени Аль-Фараби в рамках специальности бакалавриата 5В060100 –Математика**

1. **Общая характеристика и актуальность образовательной программы Mathematics.** Программа полностью соответствует Государственному общеобразовательному стандарту по специальности 5В060100 –Математика. Содержание программы предполагает подготовку специалистов высокого класса, способных продолжить свое профессиональное развитие на любом из обозначенных направлений: преподавание, инжиниринг и технологии, экономика и финансы, обучение в магистратуре по смежным специальностям. Считаем, что данная программа действительно соответствует заявленной цели: формирование у студентов фундаментальных знаний и компетенций в области математики, необходимых для успешного изучения количественных отношений реального мира в соответствии с современными требованиями технологий и естественных наук. Программа направлена на развитие общекультурных компетенций (cultural competences) и профессиональных компетенций (professional competences).

Учебный план программы в соответствии с государственным стандартом состоит из следующих модулей: государственный обязательный, социально-коммуникативный, блок профессиональных модулей, модули индивидуальных образовательных траекторий, междисплинарный модуль и профессиональная практика.

2. **Актуальность программы**. Стремительное увеличение доли цифровых и информационных технологий в мировой экономике приводит к увеличению потребности мирового и республиканского рынка труда в

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специалистах с высоким уровнем математической подготовки. При этом становится очевидным, что для обеспечения конкурентоспособности одних только академических знаний недостаточно. Развитие современных технологий предъявляет все более высокие требования к компетенциям выпускников математических факультетов ВУЗов. Новая программа «5В060100 –Математика» разработана в соответствии с современными требованиями к уровню бакалавра наук.

3. **Особенности программы**. Обучение по программе производится на английском языке. В результате студенты должны уметь:

- понимать специализированные технические и математические тексты,
- строить диалог и обсуждение на профессиональные темы с зарубежными коллегами,
- вести преподавание математики на английском языке в средней школе (в случае выбора профессии учителя).

Знание английского языка предоставляет неограниченные возможности в получении информации в любой области технологий и наук, а также делает выпускника более конкурентоспособным на рынке труда.

Важной отличительной особенностью программы является ее отказ от обучения по индивидуальной образовательной траектории (ИОТ): Студент после второго курса имеет возможность выбрать разные предметы из перечня элективных дисциплин. Образовательная группа по обучению элективной дисциплины образуется по предварительному набору студентов из разных курсов, что увеличит вероятность функционирования группы; студенту предоставляется возможность послушать и другие дисциплины необходимые для его будущего исследования; студент может набрать больше кредитов. Такая направленность позволяет расширить возможности выпускника в выборе дальнейшей специализации, сделать его более мобильным на рынке труда в области чистой и прикладной математики.

Сохраняя фундаментальность существующих образовательных программ данная программе дополнена прикладным содержанием.

В содержании образовательной программы обеспечивается необходимая целостность, сочетающая фундаментальность подготовки с междисциплинарным характером профессиональной деятельности специалиста, определяются наиболее эффективные с точки зрения достижения поставленных целей виды учебных занятий, образовательные технологии.

Высокой положительной оценки заслуживает направленность новой программы на развитие навыков индивидуальной и групповой проектной деятельности.

4. **Рекомендации.** Одним из направлений деятельности выпускников данной программы заявлено преподавание математики (professional activities: math teacher, engineer, technician). Являясь представителем работодателей в области преподавания математики в средней

школе, заявляю, что объем профессиональных знаний и компетенций, предусмотренных данной программой, практически полностью покрывает требования, предъявляемые к современному учителю математики. Кроме того, на мой взгляд, для студентов, которые рассматривают педагогическую деятельность в школе как один из вариантов своего профессионального выбора, было бы правильным введение каких-нибудь элективных курсов по элементарной математике. Например, курсы по элементарной геометрии на плоскости и в пространстве. Для таких студентов было бы рациональным рассмотрение возможности долгосрочных практических работ на базе физико-математических школ города и республики.

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МЕХАНИКО-МАТЕМАТИЧЕСКИЙ
ФАКУЛЬТЕТ

«20» september 2017 г.

**Expert opinion**

to the educational program "Mathematics" in English
on the specialty 5B060100 - "Mathematics"

The educational program on specialty 5B060100 - "Mathematics" provides for the preparation of full-time education on the basis of general and secondary vocational education. The content of the educational program complies with the requirements of the state standard of educational standards and the standard curriculum.

In the educational program 5B060100 - "Mathematics" there are components that contribute to the personal development of students, forming professional competencies, developing creative abilities. For example, such elective courses as "Numerical methods for solving partial differential equations". The educational program 5B060100 - "Mathematics" is aimed at forming the key competences of the bachelor of mathematics.

The purpose of the educational program is the formation of knowledge and competences necessary to provide students with basic

knowledge in mathematics for studying new quantitative relations and spatial forms of the real world in accordance with the requirements of technology and natural science. The program focuses on providing students with systematic knowledge of the basic course of mathematics along with knowledge of elective areas based on the latest scientific achievements

Professional activity are Teacher, engineer, technician. It is noted that Bachelor's graduates can work in research institutes, public or private educational institutions, in the field of communications and banks, and actuarial activity. Bachelors graduates can continue their education at the level of graduates in this specialty or professions related to this. They can also continue research in the economy in which they will apply their knowledge directly. Specific competences (cultural competences and professional competences) are described in detail.

The main competences are defined:

by knowledge of the basic laws of the functioning and development of nature and society and the knowledge of the basic concepts of fundamental mathematical courses and the ability to identify their correlations; knowledge of the basic concepts of fundamental mathematical courses and the ability to identify their correlations;

knowledge of basic concepts and the ability to apply a deep understanding of basic mathematics (limit, continuity, derivative and integral); the ability to understand the concept and theory of normed linear spaces, metric spaces, Banach spaces, the theory of spaces of interior products and Hilbert spaces, the theory of continuity and bounded linear operators, spectral properties; apply the theory to solve

mathematical problems; the ability to abstract and recognize analogies and basic patterns; the ability to analyze and find methods for effectively solving problems in computational mathematics.

As a result of pedagogical practice conducted in secondary schools, gymnasiums and lyceums, students receive the initial experience of practical pedagogical activity by teaching subjects related to mathematics. As a result of pre-diploma practice conducted at the relevant enterprises, institutions and organizations, students apply in practice the professional skills obtained in the course of theoretical study of mathematical modules and laboratory works. During the Practice, students acquire this experience: improve their knowledge in the framework of general and specialized modules; perform mathematical modeling of various processes; Learn to design, plan and perform experimental scientific work; acquire skills of operation and maintenance of various types of computer equipment; Collect and process experimental results for use in their diploma projects. Thus, the educational program "Mathematics" in English on the specialty 5B060100 - "Mathematics" meets all the requirements for teaching materials.

To recommend the educational program "Mathematics" in English on the specialty 5B060100 - "Mathematics" for use in universities within Kazakhstan.

Doctor of Physical and Mathematical Sciences,
Professor of Higher Mathematics of
L.N. Gumilyov Eurasian Natonal University

N.A. Bokayev

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Қазақстан Республикасының заңнамасының өзгеруіне, сонымен бірге жаңа стандарттар, ережелер мен қызметтік нормаларының енгізілуіне байланысты қаржы мамандарының, соның ішінде сақтандыру саласындағы мамандардың, біліктілігін жүйелі түрде жетілдіру қажеттілігі бар.

Алайда, қазіргі уақытта Қазақстан Республикасы сақтандыру нарығының қатысушыларының сапалы білімге және үздіксіз біліктілікті көтеруге қолжетімділігі жетіспейді.

Мамандарды даярлау үрдісін жетілдіру мақсатында Қазақстан Республикасы Ұлттық Банкі (бұдан әрі - Ұлттық Банк) актуарийлерді оқыту мәселелерін қарастыруда.

Қазақстан Республикасының заңнамасына сәйкес актуарий сақтандыру және қайта сақтандыру шарттары бойынша экономикалық және математикалық есептеулерді жүзеге асыратын сақтандыру нарығы қатысушыларының бірі болып табылады.

Сонымен бірге, актуарлық қызметті жүзеге асыру үшін жеке тұлғада Ұлттық Банк берген лицензияның болуы талап етіледі.



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Қазақстан Республикасының сақтандыру қызметі туралы заңнамасына сәйкес актуарлық қызметті жүзеге асыруға берілетін лицензия алу үшін №151[1] Ережелерінде белгіленген актуарийлерді оқытудың ең қысқа міндетті бағдарламасы бойынша оқытудан өтіп және тиісті емтихандарды сәтті тапсыру қажет (қоса жіберіледі).

Актуарийлерді оқытудың халықаралық тәжірибесіне жүгінсек, дамыған мемлекеттердің басым көпшілігінде актуарийлер жоғарғы оқу орындарының магистратура және бакалавриат бағдарламалары бойынша «актуарий ғылымы» және «актуарлық математика және статистика» мамандықтарында оқытылады. Мысалы, Дат елінде актуарийлерге қойылатын талаптардың бірі – Дат университетінде актуарлық математика бойынша дәреженің болуы. Сонымен қатар, Ұлыбританияда 46 университет Актуарийлер Институты мен Факультетінде (IFoA) аккредиттелген. Аталған университеттерде «актуарлық математика» мамандығы бойынша оқуды бітіргеннен кейін үміткер кейбір емтихандарды тапсырудан босатылады. Ұқсас оқу жүйесі АҚШ, Канада, Германия елдерінде қалыптасқан.

Актуарийлерді оқытудың халықаралық тәжірибесінің негізінде Ұлттық Банк математикалық факультеттерінде «актуарий» мамандығын ашу туралы Қазақстан Республикасы Білім және ғылым министрлігіне хат жолдады. Алайда, жаңа мамандықты ашу ұзақ уақыт кезеңді (2-3 жасқа дейін) қамтуы мүмкін.

Жоғары білім берудің мемлекеттік жалпыға міндетті стандартына сәйкес бакалавриат бағдарламалары бойынша оқудың аяқталуының негізгі өлшемшарты білім алушының теориялық оқу бойынша кемінде 129 кредитін игеруі болып табылады. Сонымен бірге кредиттердің жалпы санының 65% -ын жоғарғы оқу орнынының өз еркімен анықталатын таңдау компоненттері құрайды.

Осыған орай Ұлттық Банк қосымша ретінде әл-Фараби атындағы Қазақ ұлттық университетінде механика-математика факультеті негізінде актуарлық мамандығы бойынша білім беру бағдарламаларын іске қосу мүмкіндігін қарастыруды ұсынады.

Жоғарыда айтылғанды ескере отырып, «Актуарий» білім беру бағдарламасы бойынша мамандарды дайындау мүмкіндігін талқылау үшін, Ұлттық Банк өкілдерімен кездесуді сұраймыз.

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[1] Актуарлық қызметті жүзеге асыру, актуарлық қызметті жүзеге асыру құқығына лицензия беру, актуарийдің біліктілік емтиханын тапсыру, актуарийдің қызметін тексеру үшін тәуелсіз актуарийді тарту, тәуелсіз актуарийдің сақтандыру (қайта сақтандыру) ұйымының штатында тұрған актуарий жүргізген есептеулердің шынайылығын тексеру нәтижелерін жіберу қағидаларын бекіту туралы Қазақстан Республикасының Ұлттық Банкі Басқармасының 2014 жылғы 16 шілдедегі № 151 Қаулысы