V.N. Karazin Kharkiv National University

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V.N. Karazin Kharkiv National University

Module Descriptions

Bachelor of Science Pure Mathematics

2023

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Compulsory courses

Electives

Practical course

Research work

Abstract Algebra

Modules referring to Pure Mathematics

Code	OK.09
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Elements of Algebra and Number Theory, Linear Algebra
Learning objectives	The students will learn group theory, including basic and some more advanced concepts.
Syllabus	• *Basic concepts of group theory.* Definition of a group. Examples of groups. Subgroups. Lagrange's theorem. Orders of group elements. Cyclic groups. Group homomorphisms. Normal subgroups. Quotient groups. Direct product of groups. • *Structure of groups.* Abelian groups. Classification of finitely generated abelian groups. Free groups. Generators and relations. Group actions. Sylow theorems. Groups of order *pq*. • *Application of finite groups in combinatorics.* Burnside's lemma. Pólya's counting theory.
Literature	• E. B. Vinberg, A Course in Algebra, AMS, 2003.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h • Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.

Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Algebra related elective courses.

Analytic geometry

Modules referring to Pure Mathematics

Code	OK11
ECTS credits	8
Attendance time	4
Language of instruction	Ukrainian, English
Duration	2
Cycle	each Semester
Coordinator	Dr. Olena Shugailo
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics,
Recommended prerequisites	Elements of Algebra and Geometry
Learning objectives	The students: • use scalar, vector and mixed product of vectors to find length, angles and volumes in Euclidean vector spaces • solve various problems related to lines and planes in affine and Euclidean spaces • learn the canonical equations and geometric characteristics of curves and surfaces of the second order • use Linear Algebra tools to reduction of a general equation of the curve and the surface of the second order to the canonical form and solve different problems related to these objects • get knowledge in the general theory of curves and surfaces of the second order
Syllabus	• Affine space. Affine coordinate system. • Measurement tools in Euclidean vector spaces. • Straight lines and planes in affine and Euclidean spaces. • Canonical theory of curves and surfaces of the second order. • Some methods of forming surfaces, their equations. • Reduction a general equation of a curve and surface

	of the second order to the canonical form. Finding the canonical coordinate system. • General theory of curves and surfaces of the second order
Literature	• Борисенко О. А., Ушакова Л. М. Аналітична геометрія, Харків: Основа, 1993 • Gibson C.G. Elementary Euclidean Geometry: An Introduction, Cambridge University Press.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing/exam: 112 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Differential Geometry

Complex analysis

Modules referring to Pure Mathematics

Code	OK. 16
ECTS credits	7
Attendance time	3 Winter Semester, 4 Summer Semester
Language of instruction	Ukrainian, English
Duration	2
Cycle	Each Semester
Coordinator	Prof. Serhiy FAVOROV
Instructor(s)	Prof. Serhiy FAVOROV, Assoc. Prof. Natalia GYRIA
Allocation of study programmes	B.Sc. Mathematics, compulsory module
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Differential Geometry
Learning objectives	The students will: • Get knowledge of basic concepts of Complex Analysis • Get practice in the applications of complex analysis in other mathematical disciplines
Syllabus	• Complex plane and functions of a complex variable • Holomorphic and harmonic functions Complex Integration and Cauchy's theorem • Cauchy's integral formula and its application • Zeros of holomorphic functions and analytic prolongation • Laurent series and isolated singular points • Application of Cauchy's theorem on remainders • Geometric principles of the theory of functions • Properties of entire and meromorphic functions. • Elementary conformal mappings. • Dirichlet problem and its application in the theory of conformal mappings
Literature	1. BV Shabat, Introduction to complex analysis. V.1, American Mathematical Society, 1992 2. Lavrentev MA, Shabat BV Methods of the theory of function of complex variable. 1987, 544 p. 3. Edward C. Titchmarsh. The Theory of Functions. Oxford University Press; 2nd edition (May 13, 1976) 4. Comprehensive analysis. Examples and problems. (edited by

	V.G. Samoilenko). KNU named after T. Shevchenko, 2010.
Teaching and learning methods	Winter: Lecture (2 WH), Exercise (1WH) Summer: Lecture (2 WH), Exercise (2WH)
Workload	Total: 210 h • Classroom hours: • Lectures: Fall 32 h, Winter 32 h • Exercise: Fall 16 h, Winter 32 h • Individual study time/ preparation and postprocessing/exam: 98 h
Assessment	The assessment includes HW assignments, Control assignments, Individual assignment.
Grading procedure	Fall: The module grade is the sum of preliminary study achievements and the final test grade (Credit) Winter: The module grade is the sum of preliminary study achievements and the final Exam grade.
Basis for	• Partial Differential Equations • Mathematical Physics • Functional Analysis

Differential Geometry

Modules referring to Pure Mathematics

Code	OK14
ECTS credits	8
Attendance time	4
Language of instruction	Ukrainian, English
Duration	2
Cycle	each Semester
Coordinator	Dr. Eugene Petrov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Analytical Geometry, Topology, Ordinary Differential Equations
Learning objectives	The students will: • be familiar with the classical notions of differential geometry of curves and surfaces • learn the fundamental theorems of differential geometry and how to apply them for solving problems • get acquainted with the special classes of surfaces • learn the basic notions of tensor calculus and Riemannian geometry
Syllabus	• Regular curves and surfaces • Flat curves, their curvature, natural equations and classical theorems • Spacial curves, the Frenet frame and formulae, the fundamental theorem for spacial curves • The first fundamental form of a regular surface and its applications, isometries • The second fundamental form of a regular surface, normal, geodesic, Gaussian and mean curvatures • The fundamental equations for surfaces and their applications • Special coordinate systems • Surfaces of constant curvature

	• Minimal surfaces • Intrinsic geometry and the Gauss-Bonnet theorem • Basics of tensor calculus and Riemannian geometry
Literature	• A.V. Pogorelov. Differential Geometry. P. Noordhoff, 1960 • Yu. Aminov. Differential Geometry and Topology of Curves. Gordon and Breach, 2000
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing: 112 h
Assessment	The assessment consists of written test, written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test or examination grades.
Basis for	All further courses in Differential Geometry

Discrete Mathematics

Modules referring to Pure Mathematics

Code	OK10
ECTS credits	4
Attendance time	1
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer Semester
Coordinator	Dr. Oleksiy Shcherbyna
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis.
Learning objectives	The students will: • to get acquainted with rule of product and rule of sum, binomial coefficients and inclusion–exclusion principle; • be able to calculate sums; • obtain probability in discrete case; • use normal distribution for approximation binomial distribution;
Syllabus	• Rule of product and rule of sum; • binomial coefficients; • special numbers in combinatorics (Fibonacci numbers, Catalan numbers, Stirling numbers); • calculation of sums; • discrete probability theory; • discrete random variable; • expectation and variance of discrete random variable; • Bernoulli scheme; • standard normal distribution; • De Moivre-Laplace theorem;
Literature	• Ronald L. Graham, Donald E. Knuth, Oren Patashnik. Concrete Mathematics. Addison-Wesley, 1994;

	• William Feller. An Introduction to Probability Theory and Its Applications, 1984.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral credit and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the credit grade.
Basis for	Deepening in Probability Theory and Mathematical Statistics

Elements of Algebra and Number Theory

Modules referring to Pure Mathematics

Code	OK.07
ECTS credits	6
Attendance time	6
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics, B.Sc. Computer Science, B.Sc. Pedagogy
Recommended prerequisites	none
Learning objectives	The students will learn elementary number theory and algebra of complex numbers and polynomials of one variable.
Syllabus	• Basic number theory: divisibility, greatest common divisor, linear Diophantine equations, prime numbers, unique factorization into primes, residue classes, Chinese remainder theorem, Fermat’s little theorem, Euler’s theorem. • Complex numbers: definition, geometric interpretation, trigonometric form, De Moivre’s formula, roots of unity, solving cubic and quartic equations. • Polynomials of one variable: definition, degree, greatest common divisor, irreducible polynomials, unique factorization into irreducibles, roots of polynomials, number of roots, interpolation, root multiplicities, derivative (with application to multiple roots), partial fractions.
Literature	• D. Burton, Elementary Number Theory, McGraw-Hill, 2005. • A. G. Kurosh, Higher Algebra, Mir, 1975. • E. B. Vinberg, A Course in Algebra, AMS, 2003.

Teaching and learning methods	Lecture (3 WH), Exercise (3 WH)
Workload	• Lecture: 48 h • Exercise: 48 h • Individual study time / preparation and postprocessing / exam: 84 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Linear Algebra • Abstract Algebra

Elements of Mathematical Logic and Discrete Mathematics

Modules referring to Pure Mathematics

Code	OK 05
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Svetlana Ignatovich
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics, B.Sc. Computer Science
Recommended prerequisites	-
Learning objectives	The aim of the course is to prepare students to learn mathematics at the university level. The students will: ● get an idea of the basic concepts and methods in the set theory, mathematical logic, discrete mathematics, ● practice solving, discussing and understanding simple introductory problems in the set theory, mathematical logic, discrete mathematics
Syllabus	● Elements of set theory. Operations with sets.

	Elements of mathematical logic. Propositions and connectives. Predicates and quantifiers. Operating with quantifiers. ● Mathematical proofs: examples of theorems and their proofs. Mathematical induction. ● Relations: equivalence and partial order. ● Elements of combinatorics. Permutations and combinations, binomial theorem, Pascal's triangle. ● Elements of graph theory.
Literature	● Lecture notes. ● K. Devlin, Introduction to Mathematical Thinking, 2012. ● Smullyan R. M. A beginner's guide to mathematical logic – Dover, NY: Publications, Inc., Mineola, 2014.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	● Classroom hours: 32 h ● Exercise: 32 h ● Individual study time/ preparation and postprocessing: 56 h ● **Total: 120 h**
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	All university-level mathematical disciplines

Equations of Mathematical Physics

Modules referring to Pure Mathematics

Code	OK20
ECTS credits	9
Attendance time	4
Language of instruction	Ukrainian, English
Duration	2
Cycle	each Semester
Coordinator	Dr. Tamara Fastovska
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations
Learning objectives	The students will: • get acquainted with basic equations of elliptic, parabolic and hyperbolic type • learn the classical methods to find solutions • get knowledge in the study of classical solutions to partial differential equations
Syllabus	• Classification of partial differential equations . • Boundary value problems to the Laplace equation. Harmonic functions. Green’s function. Potentials. • Special functions. Fourier method for elliptic equations. • Heat equation. Classical solutions, existence and uniqueness. Cauchy problem, Poisson formula. Fourier method. • Wave equation. Cauchy problem, characteristics, formulas for solutions, existence and uniqueness. Fourier method.
Literature	• Evans L., Partial Differential Equations, AMS, 2010. • Mikhlin S.G., Linear equations of mathematical physics, Holt, Rinehart and Winston 1967. • Tikhonov A.N., Samarskii A.A., Equations of

	mathematical physics, Dover Publications, 2013.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing/exam: 142 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Functional analysis • Partial Differential Equations

Functional analysis

Modules referring to Pure Mathematics

Code	OK18
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer Semester
Coordinator	Prof. Dr. Volodymyr Kadets
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra
Learning objectives	The students will learn: • Basic theory of metric and Banach spaces, classical examples, Hahn-Banach theorem and its application • Basic theory of Hilbert spaces, classical examples, Fourier theory in Hilbert spaces. • Basic operator theory, spectral theorems. • The methods of investigation of sets in normed spaces, completeness property, properties of operators. • To calculate norms of elements and operators, scalar products .
Syllabus	• Infinite dimensional linear spaces. Hahn-Banach theorem. • Normed and Banach spaces. • Continuous operators • Closed graph theorem • Banach-Steinhaus theorem • Hilbert spaces. Orthoprojectors. • Fourier series. • Spectral theorems.
Literature	• Kolmogorov A. N. and Fomin S. V., Elements of the Theory of Functions and Functional Analysis,

	Martino Fine Books, 2012. • Liusternik L. A. , Sobolev V. J. Elements of Functional Analysis, Frederick Ungar Publishing Co; 1st Edition, 1961.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Functional analysis • Partial Differential Equations

Harmonic analysis

Modules referring to Pure Mathematics

Code	OK17
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer Semester
Coordinator	Prof. Dr. Volodymyr Dubovoy
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Complex Analysis
Learning objectives	The students will learn: • how to expand periodic functions into Fourier series and investigate the pointwise and uniform convergence. • the expansions of odd and even functions and of functions defined on an arbitrary interval. • Fourier transforms of some functions
Syllabus	• Fourier series. Theorems on approximation of continuous functions. • Fourier series in Euclid spaces. • Properties of Fourier coefficients. • Trigonometric Fourier series. Dirichlet integral, pointwise and uniform convergence. Cesàro method. Fejér’s theorem. Weierstrass theorems. • Fourier transform. Convolution and its Fourier transform. Cauchy problem for heat equation.
Literature	• Vladimir A. Zorich. Mathematical Analysis II , Springer, 2016 • Edwards R.E. . Fourier Series, Springer, V.1 . Springer, 1982.

Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Functional analysis • Partial Differential Equations

Linear Algebra

Modules referring to Pure Mathematics

Code	OK.08
ECTS credits	12
Attendance time	6
Language of instruction	Ukrainian, English
Duration	2
Cycle	Each semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics, B.Sc. Pedagogy
Recommended prerequisites	Elements of Algebra and Number Theory
Learning objectives	The students will learn basic linear algebra.
Syllabus	• Systems of linear equations. • Determinants. • Vector spaces. • Matrix operations. • Linear operators in vector spaces. • Bilinear and quadratic forms. • Euclidean spaces. • Linear operators in Euclidean spaces. • Polynomials in several variables over a field.
Literature	• A. G. Kurosh, Higher Algebra, Mir, 1975. • E. B. Vinberg, A Course in Algebra, AMS, 2003. • A. I. Kostrikin, Yu. I. Manin. Linear Algebra and Geometry, CRC Press, 1997.
Teaching and learning methods	Lecture (3 WH), Exercise (3 WH)
Workload	• Lecture: 96 h • Exercise: 96 h • Individual study time / preparation and postprocessing / exam: 168 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.

Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Abstract Algebra • Functional Analysis

Mathematical analysis

Modules referring to Pure Mathematics

Code	OK06
ECTS credits	30
Attendance time	Semester 1 - 6. Semesters 2, 3, 4 - 8
Language of instruction	Ukrainian, English
Duration	4
Cycle	each Semester
Coordinator	Dr. Sergiy Gefter
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics
Recommended prerequisites	-
Learning objectives	The students will: • get to know the fundamentals analytical methods, in particular the limit process • learn to work with functions using both the graphical representation as also the symbolic one • study the behavior of functions using differential calculus • use differential calculus and integral calculus to model real phenomena • learn to solve on their own mathematical problems • discover connections to other subjects as linear algebra, geometry and topology
Syllabus	• The real field. Convergent sequences. The number e . Series. The root and ratio tests. Absolute convergence. Power series. • Limits of functions. Continuous functions. Discontinuities. • Differentiation. Derivatives of higher order. • Taylor's theorem. Taylor's series. Convex functions. • Infinite products. • The Riemann integral. Integration and differentiation.

	• Improper integrals, Beta and Gamma functions. • Functions of several variables. • Double and triple integral. Change of variables. • Vector Analysis.
Literature	• Walter Rudin, Principles of Mathematical Analysis, International Series in Pure and Applied Mathematics, McGraw Hill, 3rd Edition, 1976. • Vladimir A. Zorich. Mathematical Analysis II , Springer, 2016. • Boris Demidovich. Problems in Mathematical Analysis. 1989.
Teaching and learning methods	Semester #1: Lecture (2 WH), Exercise (4WH). Semesters #2, #3, #4: Lecture (4 WH), Exercise (4WH).
Workload	• Classroom hours: 224 h • Exercise: 256 h • Individual study time/ preparation and postprocessing/exam: 420 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Functional analysis • Complex analysis • Harmonic analysis • Differential geometry • Equations of mathematical physics

Mathematical Statistics

Modules referring to Pure Mathematics

Code	OK24
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer Semester
Coordinator	Dr. Tamara Fastovska
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Measure Theory and Integration, Probability Theory, Numerical Analysis
Learning objectives	The students will: • get acquainted with the basics of the theory of mathematical statistics • learn the methods of descriptive statistics • learn the most important estimation methods and statistical test • learn the basics of regression analysis • model problems from application areas and investigate them with statistical methods
Syllabus	• Basics of statistical theory. • Descriptive statistics. • Point estimation of parameters. • Properties of estimators. Rao-Cramer inequality. • Confidence intervals. • Statistical hypothesis testing. Connection between hypothesis tests and confidence intervals. Analysis of variance. Nonparametric statistics. • Simple linear regression. • Multiple linear regression. • Logistic regression.
Literature	• Sheldon M. Ross. Introduction to Probability and

	Statistics for Engineers and Scientists, Academic Press (2004). • Crame´r H. Mathematical methods of statistics, Princeton University Press (2016).
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Deepening in: • Stochastic • Optimization • Data Science

Measure and integration theory

Modules referring to Pure Mathematics

Code	OK. 15
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Vladimir KADETS
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Topology
Learning objectives	The students will get knowledge of basic Measure Theory and Lebesgue integral as well as modern achievements.
Syllabus	• Metric spaces. • Lebesgue measure • Measurable and integrated functions. • Charges • Relationships between derivative and integral.
Literature	**Basic literature** Kadets V.M. Course of functional analysis and measure theory. Textbook. - Lviv: Publisher I.E. Chizhikov, 2012. – 590 p. – (Series "University Library") **Supporting literature** Berezansky Yu.M., Us GF, Sheftel Z.G., Functional analysis, Kyiv: "Higher School", 1990.
Teaching and learning methods	Lecture (4 WH),
Workload	Total: 120 h • Classroom hours: • Lectures: 64 h • Individual study time/ preparation and postprocessing/exam: 56 h •
Assessment	The assessment includes Control assignments and Individual

	assignment.
Grading procedure	The module grade is the sum of preliminary study achievements and the final Exam grade.
Basis for	• Functional Analysis • Probability Theory

Numerical Analysis

Modules referring to Pure Mathematics

Code	OK 23
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Valerii Korobov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Programming Language (any)
Learning objectives	The students will: ● get acquainted with basic numerical methods ● apply numerical methods to solve the different problems ● learn the methods of functions' interpolation, numerical integration, least squares approximation, and numerical differentiation ● get knowledge in the numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer
Syllabus	● Lagrange, Newton, Hermite interpolation polynomials. ● Cubic splines interpolation. ● Approximation of functions. ● Numerical integration. ● Numerical differentiation.

Literature	• Richard L. Burdenand, J. Douglas Faires, Numerical Analysis, Brooks/Cole, 2001. • J. Stoer and R. Bulirsch, Introduction to Numerical Analysis, Springer-Verlag, 1980. • A. Greenbaum, T. Chartier, Numerical Methods: Design, Analysis, and Computer Implementation of Algorithms, 2012.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h • **Total: 120 h**
Assessment	The assessment consists of written and oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Numerical Methods for Solving Differential and Integral Equations • Numerical Optimization

Ordinary Differential Equations

Modules referring to Pure Mathematics

Code	OK 12
ECTS credits	8
Attendance time	4
Language of instruction	Ukrainian,English
Duration	2
Cycle	each Semester
Coordinator	Assoc. Prof. Oleksandr Makarov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics, B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra
Learning objectives	The students will ● get acquainted with basics of ordinary differential equations and linear partial differential equations ● learn the classical methods to find solutions of equations and linear systems of equations ● get knowledge in theorems of existence and uniqueness of the solution of Cauchy problems ● get knowledge of the basics of Lyapunov's stability theory
Syllabus	● Classification of ordinary differential equations of the first order. ● Linear ordinary differential equations and systems. ● Theorems of existence and uniqueness of the solution of Cauchy problems. ● Linear partial differential equations. ● Basics of Lyapunov's stability theory.
Literature	● Pontryagin L.S. Ordinary Differential Equations, Pergamon Press, 1962. ● Philip Hartman. Ordinary Differential Equations, SIAM, 1982.

Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing/exam: 112 h • **Total: 240 h**
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Partial Differential Equations • Equations of Mathematical Physics • Theoretical Mechanics • Calculus of Variations and Optimal Control • Numerical Methods for Solving Differential and Integral Equations

Probability Theory

Modules referring to Pure Mathematics

Code	OK23
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter Semester
Coordinator	Dr. Oleksiy Shcherbyna
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Discrete Mathematics, Functional Analysis.
Learning objectives	The students will: • to get acquainted with the axiomatic construction of probability theory, law of large numbers and the central limit theorem; • to learn basic distributions of probability theory; • to get acquainted with the conceptions of conditional expectation, Markov chain and Poisson process.
Syllabus	• axiomatic construction of probability theory; • random variables and their moments; • law of large numbers; • central limit theorem; • conditional expectation; • Poisson process.
Literature	• Rick Durrett. Probability: Theory and Examples, Cambridge 2019; • William Feller. An Introduction to Probability Theory and Its Applications, 1984.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h

	• Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in Mathematical Statistics

Programming

Modules referring to Pure Mathematics

Code	OK.19
ECTS credits	16
Attendance time	4
Language of instruction	Ukrainian, English
Duration	4
Cycle	Each Semester
Coordinator	Prof. Olga ANOSHCHENKO
Instructor(s)	Olga ANOSHCHENKO
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Discrete mathematics
Learning objectives	Basic concepts and typical programming techniques, creation of foundations for further, more in-depth study of them, providing theoretical knowledge and practical skills on the basics of algorithm development and analysis.
Syllabus	• General concepts related to solving problems using a computer. • General concepts related to programming in the C++ language. • Systematization of information about operations and operators of the C++. • Functions in the C++ . • Pointers. Dynamic variables • Character strings • Structures, associations, enumeration • Operations with files • Recursion • Linked data structures • Trees • Abstract data types. • Sorting.
Literature	**Basic literature** 1. Shpak Z.Ya. Programming in S. language - Lviv: publication of Lviv Polytechnic University - 2011. - 436 p. 2. Kovalyuk T.A. Algorithmization and programming. – Magnolia 2006 – 2021. – 400 p. 3. Brian W. Kernighan, Denis M. Ritchie. Programming language S. - 232 p. **Supporting literature** Steven Prata. Programming language S. Lectures and exercises. -

	K: DiaSoft - 2012.
Teaching and learning methods	Lecture (2WH), Lab/exercise (2HW)
Workload	Total: 480 h Classroom hours: • Lectures 128 h (32+32+32+32) • Lab/Exercise 128 h (32+32+32+32) • Individual study time/ preparation and postprocessing/exam: 224 h (56+56+56+56)
Assessment	The assessment includes: Control assignments and Individual assignment.
Grading procedure	Credit (1st – 3rd semesters), Exam (4th Semester)
Basis for	• Symbolic Computations and Modelling

Symbolic Computing and Modeling

Modules referring to Pure Mathematics

Code	OK. 22
ECTS credits	5
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Oleksandr YAMPOLSKIY
Instructor(s)	Prof. Oleksandr YAMPOLSKIY
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations
Learning objectives	The students will: • Solve problems of Calculus, Linear Algebra, Differential Geometry and Differential Equations using the system of symbolic calculations. • Represent results of computations graphically.
Syllabus	• LinearAlgebra package in MAPLE system. • Calculus package in MAPLE system • VectorCalculus package in MAPLE system • Tensor package in MAPLE system • Plots package in the MAPLE system • Grobner Package in MAPLE system
Literature	Basic: • Monagan MB, Geddes KO, Heal KM, Labahn G, Vorkoetter SM, McCarron J., DeMarco P. Maple Advanced Programming Guide Maplesoft (15 version), a division of Waterloo Maple Inc. - 2009. - 452 p. • L. Bernardin, P. Chin, P. DeMarco, KO Geddes, DEG Hare, KM Heal, G. Labahn, JP May, J. McCarron, MB Monaghan, D. Ohashi, SM Vorkoetter. Maple Programming Guide (Version 18), Maplesoft, a

	division of Waterloo Maple Inc. - 2014. - 664 p. Supporting: • Edwards(Author), Calculus Projects Using Maple, Mathematica, and Matlab. Pearson Higher Education (Oct. 25 1998) • B. Barnes(Author),G..R. Fulford(Author) Mathematical Modeling with Case Studies: Using Maple and MATLAB, Third Edition. Chapman and Hall/CRC; 3rd edition (Dec 16 2014)
Teaching and learning methods	Lecture (2 WH), Computer Lab (1WH)
Workload	Total: 90 h. • Classroom hours: 32 h • Exercise: 16 h • Individual study time/ preparation and postprocessing/exam: 42 h
Assessment	The assessment includes HW assignments, Control assignments, Individual assignment.
Grading procedure	The module grade is the sum of preliminary study achievements and the final test grade (Credit)
Basis for	• Partial Differential Equations • Geometry of Riemannian manifolds • Algebraic geometry (solving systems of polynomial equations)

Topology

Modules referring to Pure Mathematics

Code	OK13
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Eugene Petrov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Analytical Geometry
Learning objectives	The students will: • get acquainted with the fundamental notions and constructions of general topology • learn the classical topological invariants and how to use them in proofs • learn the basics of manifolds and surfaces toplogy
Syllabus	• Topological and metric spaces, bases • Continuous maps and homeomorphisms • Topological constructions: induced topology, factorization, direct product • Countability and separation axioms • Compact spaces • Connected and path connected spaces • Manifolds and surfaces
Literature	• J.R. Munkres. Topology. Prentice Hall, 2000 • C. Kosniowski. A first course in Algebraic Topology. Cambridge University Press, 1980 • O.Ya. Viro, O.A. Ivanov, N.Yu. Netsvetaev, V.M. Kharlamov. Elementary Topology. AMS, 2008
Teaching and learning	Lecture (2 WH), Exercise (1WH)

methods	
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Is used in: • Differential geometry • Functional analysis • All further courses in topology

Additional topics in functional analysis

Electives referring to Pure Mathematics

Code	BK2.2.7- BK2.2.10
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Dr. Volodymyr Kadets
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Functional Analysis, a, Measure and Integration Theory
Learning objectives	The students will learn: • fixed points theorems and their applications • elements of topological groups • elements of Banach algebras
Syllabus	• Fixed point theorems and applications. Contractive mappings. Hausdorff distance. Brouwer's theorem. The Schauder's principle. • The Picard and Peano theorems on the existence of a solution to the Cauchy problem for differential equations. • Kakutani's theorem on common fixed points of a family of mappings. Banach spaces with normal structure. • Topological groups and Haar measure. Definition and examples of topological groups. Properties of neighborhoods. • Compact topological groups. Uniform continuity. Equicontinuity. Compactness criteria. Haar measure. Measure induced by a compact group of isomeries. • Elements of Banach algebras. Axiomatics and examples. Subalgebra. Homomorphism.

	Isomorphism. Invertibility in Banach algebras. The inversion formula. The spectrum. Liouville's theorem for Banach space-valued functions. Commutative Banach algebras. Maximal ideals, complex homomorphisms and invertibility. • Application: Wiener's theorem on absolutely convergent Fourier series. Gelfand compact, Gelfand homomorphism. • Extreme points of convex sets, Krein-Milman theorem. The Stone-Weierstrass theorem.
Literature	• V. Kadets. A course in functional analysis and measure theory, Springer, 2018. • W. Rudin. Functional analysis, International Series in Pure and Applied Mathematics. New York, NY: McGraw-Hill. xviii, 1991.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Deepening in: • Functional analysis • Partial Differential Equations

Applied Functional Analysis

Electives referring to Pure Mathematics

Code	BK 2.2.11 BK 2.2.12 BK 2.2.13
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Tamara Fastovska
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Functional, Measure Theory and Integration
Learning objectives	The students will: • get acquainted with the basics of the theory of distributions, unbounded operators and Sobolev spaces • learn the applications in the theory of partial differential equations
Syllabus	• Distribution theory. Space of test functions and distributions. • Basic operations with distributions. • Direct product and convolution of distributions. • Tempered distributions. • Bounded and unbounded operators. Extension of an operator. Inverse operator. Closed operator. Closed extensions. • Symmetric and self-adjoint operators • Friedrichs extension. • Spectrum of an operator. • Compact operators. • Sobolev spaces on the whole space. • Sobolev spaces in half-space.

	• Sobolev spaces on bounded domains and on boundaries. • Interpolation spaces.
Literature	• Akhiezer N. I., Glazman I. M., Theory of linear operators in Hilbert space, Mineola, NY: Dover, 1993. • Lions J. L., Magenes E., Non-Homogeneous Boundary Value Problems and Applications:Vol.1, Berlin: Springer, 1972. • Vladimirov V.S., Equations of Mathematical Physics, Marcel Dekker INC., 1971.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Deepening in: • Partial Differential Equations • Functional Analysis • Control Theory

Asymptotic Methods in Mathematics

Electives referring to Pure Mathematics

Code	BK2.2.9
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter Semester
Coordinator	Dr. Oleksiy Shcherbyna
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Complex Analyses, Linear Algebra, Functional Analyses.
Learning objectives	The students will: • to get acquainted with Laplace method and saddle point method of searching for asymptotic behavior; • to use these methods for searching asymptotic behavior of different well-known mathematical functions;
Syllabus	• Laplace method; • saddle point method; • asymptotic of the orthogonal polynomials: Hermits polynomials, Laguerre polynomials.
Literature	• M. V. Fedoryuk. The Saddle-Point Method, Nauka, Moscow, 1977. • Lavrentiev M. A., Shabat B. V., Methods of the Theory of Complex Variable, Nauka, Moscow, 1973.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	

	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	

Classical Problems of Geometry

Electives referring to Pure Mathematics

Code	BK 2.2.5 BK 2.2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Vasyl Gorkavyy
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Analytical Geometry, Discrete Mathematics, Differential Geometry
Learning objectives	The students will: • learn a series of topics from the classical theory of curves and surfaces • develop skills and abilities for performimg individual and collective mathematical research in geometry
Syllabus	• Polyhedra, combinatorial and metric properties, convex polyhedra and Euler formula • Bendings and infinitesimal bendings of polyhedra, Cauchy theorem and the rigidity of convex polyhedra, Gluck theorem • Flexible polyhedra, the bellows conjecture and Sabitov theorem • Linear bendings and the model flexibility of polyhedra • Geodesics on polyhedra • Minkowski problem for polyhedra • Isoperimetric problem • Mylar balloons • Integral inequalities for the curvatures of curves (Fenchel-Borsuk, Fary-Milnor)
Literature	• Alexandrov A.D., Convex Polyhedra. Springer, 2005 • Pogorelov A.V., The multi-dimensional Minkowski

	problem. V.H. Winston, 1978 • Berger M., A panoramic view of Riemannian Geometry. Springer, 2003 • Schneider R., Convex bodies: the Brunn-Minkowski theorem. Cambridge University Press, 2013 • Santalo L., Integral geometry and geometric probability. Cambridge University Press, 2004 • Aminov Yu.A., Differential geometry and topology of curves. CRC Press, 2003
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Further courses in Differential Geometry

Difference equations

Electives referring to Pure Mathematics

Code	BK 2.2.3 BK 2.2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Sergiy Gefter
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations
Learning objectives	The students will: • get acquainted with the basics of the theory of difference equations • study different approaches to the finding solutions of difference equations
Syllabus	• Linear First-Order Difference Equations. • Numerical Solutions of Differential Equations. • Difference Calculus. • General Theory of Linear Difference Equations. • Linear Homogeneous and Nonhomogeneous Equations with Constant Coefficients. • Systems of Linear Difference Equations. • Stability of Linear Systems.
Literature	• Saver Elaydi. An introduction to difference equations, 3rd ed. Undergraduate texts in mathematics. Springer, 2005. • Kelley, W.G., and A.C. Peterson, Difference Equations, An Introduction with Applications, Academic Press, New York, 1991.

Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	All futher lectures Deepening in: • Numerical analysis • Control Theory

Dynamics in Mathematics

Electives referring to Pure Mathematics

Code	BK 2.2.1
ECTS credits	4
Attendance time	2
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer Semester
Coordinator	Dr. Oleksiy Shcherbyna
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analyses, Linear Algebra, Differential Equations, Analytical Geometry
Learning objectives	The students will: • get acquainted with the basic concepts of dynamical systems, types of fixed points, harmonic oscillation, mathematical pendulum and Newton systems; • get knowledge in the methods of using the fixed point theorem;
Syllabus	• General concepts of dynamical systems; • fixed-point theorem; • classification of fixed points; • conservation lows; • mathematical pendulum; • Newton systems; • chaos in dynamical systems;
Literature	• Anatole Katok, Boris Hasselblatt. Introduction to the Modern Theory of Dynamical Systems. Cambridge University Press, 2012. • Kathleen T. Alligood, Tim D. Sauer, James A. Yorke. CHAOS: An introduction to Dynamical System. Springer, 1996.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h

	• Exercise: 32 h • Individual study time/ preparation and postprocessing/exam: 56 h
Assessment	The assessment consists of written or oral credit and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the credit grade.
Basis for	Dynamical Systems

Dynamical Systems

Electives referring to Pure Mathematics

Code	BK 2.2.3 BK 2.2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Tamara Fastovska
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Measure Theory and Integration, Ordinary Differential Equations
Learning objectives	The students will: • get acquainted with the basics of the theory of dynamical systems • study different approaches to the investigation of qualitative behaviour of solutions to partial differential equations
Syllabus	• Discrete and continuous dynamical systems • Trajectories and invariant sets. • Lyapunov stability. • 1D continuous systems. 2D continuous systems. Poincaré-Bendixson theory. • Bifurcation theory. • Dissipative dynamical systems. Asymptotic smoothness and compactness. Global attractors. • Gradient systems.
Literature	• Chueshov I. Dynamics of quasi-stable dissipative systems, New York, Heidelberg, Berlin etc. : Springer, 2015. • Chueshov I. Introduction to the Theory of Infinite Dimensional Dissipative Systems, Kharkiv: Acta, 2002.

	• Teschl G. Ordinary Differential Equations and Dynamical Systems, 2012
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	All futher lectures Deepening in: • Partial Differential Equations • Functional Analysis • Control Theory

Elements of affine and projective geometry

Electives referring to Pure Mathematics

Code	BK 2.2.1
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Olena Shugailo
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Analytic Geometry, Linear Algebra
Learning objectives	The students: • get acquainted with the basics of Euclidean and non-Euclidean geometries • find the analytical equations of the Euclidean, affine, and projective transformations, establish their geometric meanings • find affine and projective classifications of curves and surfaces of the second order
Syllabus	• Classification of orthonormal transformation. • Affine transformation, its invariant. • Projective transformation, its invariant. • Different models of projective plane and space. • Affine and projective classifications of curves and surfaces of the second order.
Literature	• Modenov, P. S.; Parkhomenko, A. S. Geometric Transformations (2 vols.): Euclidean and Affine Transformations, and Projective Transformations. New York: Academic Press. (1965)
Teaching and learning methods	Lecture (2 WH), Exercise (1 WH)
Workload	• Classroom hours: 32 h • Exercise: 16 h

	• Individual study time/ preparation and postprocessing: 42 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Deepening in: • Differential Geometry • Elective courses in Geometry

Elements of Stability Theory and Delay Differential Equations

Electives referring to Pure Mathematics

Code	BK 2.2.5, BK 2.2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Oleksander Rezounenko
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations
Learning objectives	The students will: ● get acquainted with the basics of the theory of delay differential equations ● study of qualitative behaviour of solutions to delay differential equations ● get ready to explicitly solve different types of equations with discrete and distributed delays
Syllabus	● Lyapunov stability. ● The method of steps for simple delay differential equations with constant delay. ● The existence and uniqueness theorem of continuous solutions. ● Examples of differential equations with time-dependent delay. ● Solution map (shift operator along solutions) for delay equations/ systems. Dynamical systems. ● Systems with state-dependent delay. Examples of non-uniqueness of solutions. ● Systems with state-dependent delay: methods of

	study.
Literature	- J.K. Hale, S.M. Verduyn Lunel, Introduction to Functional Differential Equations, Series Title: Applied Mathematical Sciences, Springer New York, 1993; DOI: https://doi.org/10.1007/978-1-4612-4342-7 K. Iosida, Functional Analysis. Springer-Verlag Berlin Heidelberg 1995 A. Kolmogorov, S.Fomin, Elements of the Theory of Functions and Functional Analysis, Martino Fine Books, 2012. - O.Diekmann, S.A. van Gils, S.M. Verduyn Lunel, H.-O. Walther, Delay equations. Functional, complex, and nonlinear analysis. Applied Mathematical Sciences, 110. Springer-Verlag, New York, 1995. - R.E. Bellman, K.L. Cooke, Differential-Difference Equations. Santa Monica, CA: RAND Corporation, 1963. https://www.rand.org/pubs/reports/R374.html.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	- Classroom hours: 32 h - Exercise: 32 h - Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	All futher lectures Deepening in: - Ordinary Differential Equations - Partial Differential Equations - Functional Analysis

Fundamentals of algebraic topology

Electives referring to Pure Mathematics

Code	BK 2.2.2
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Eugene Petrov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Linear Algebra, Topology
Learning objectives	The students will: • get acquainted with the simplest homotopical and homological algebraic invariants of topological spaces and maps • learn how to calculate algebraic invariants • learn how to use algebraic invariants in proofs and problem solving
Syllabus	• Homotopy and homotopy equivalence • Fundamental group and simply connected spaces • Coverings, their properties, and their use in the calculation of fundamental groups • Homotopy groups and their applications • Brouwer and Borsuk-Ulam theorems • The degree of a continuous map between spheres and its applications • Chain complexes, their homology and cohomology • Simplicial homology and related invariants • Singular homology, its properties and connections with homotopical invariants • Cellular homology and its calculation
Literature	• C. Kosniowski. A first course in Algebraic Topology. Cambridge University Press, 1980

	• A. Hatcher. Algebraic Topology. – Cambridge University Press, 2001. • O.Ya. Viro, O.A. Ivanov, N.Yu. Netsvetaev, V.M. Kharlamov. Elementary Topology. AMS, 2008
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Futher courses in Topology or Differential Geometry

Geometry of Submanifolds

Electives referring to Pure Mathematics

Code	BK 2.2.11 BK 2.2.12 BK 2.2.13
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Eugene Petrov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Linear Algebra, Topology, Differential Geometry, Ordinary Differential Equations, Riemannian Geometry
Learning objectives	The students will: • learn the basics of differential topology, • learn the fundamental notions, techniques, and equations of the geometry of submanifolds • learn how to apply these techniques in various problems
Syllabus	• The basic concepts of differential topology • The induced metric and connection • Gauss-Codazzi-Ricci equations • Totally geodesic and totally umbilic submanifolds • Minimal submanifolds and submanifolds with the parallel mean curvature vector field • Hypersurfaces in the Euclidean space
Literature	• M. Dajczer. Submanifolds and isometric immersions. Publish or Perish, 1990 • B.-Y. Chen. Geometry of submanifolds. Dover, 2019 • T.H. Colding, W.P. Minicozzi II. A course in minimal surfaces. AMS, 2011 • K. Kenmotsu. Surfaces with constant mean curvature. AMS, 2003
Teaching and learning	Lecture (2 WH), Exercise (2WH)

methods	
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Further courses in Differential Geometry

Graph Theory

Electives referring to Pure Mathematics

Code	BK 2.2.1
ECTS credits	3
Attendance time	2
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter Semester
Coordinator	Dr. Oleksiy Shcherbyna
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	
Learning objectives	The students will: • get acquainted with the basic concepts of graph theory: vertex, edge, path, cycle, tree, Hamilton path, Euler path, chromatic number, flow; • learn the classic methods and algorithms for searching matching; • get knowledge in the study of flow method for graph theory;
Syllabus	• Basic concepts in graphs; • matching; • paths and cycles: • planar graphs; • coloring; • flows;
Literature	• Frank Harary. Graph Theory. Addison-Wesley, 1969. • Reinhard Diestel. Graph Theory. Springer, 2017.
Teaching and learning methods	Lecture (2 WH), Exercise (1WH)
Workload	• Classroom hours: 32 h • Exercise: 16 h • Individual study time/ preparation and

	postprocessing/exam: 42 h
Assessment	The assessment consists of written or oral credit and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the credit grade.
Basis for	Programming

Introduction to Algebraic Number Theory

Electives referring to Pure Mathematics

Code	BK 2.2.7 BK 2.2.8 BK 2.2.9 BK 2.2.10
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Elements of Algebra and Number Theory, Linear Algebra, Abstract Algebra
Learning objectives	We give an introduction to the theory of algebraic number fields. We discuss the similarities and differences of the ring of integers and rings of algebraic numbers (unique factorization into primes, decomposition laws, prime ideals, and so on). We also provide examples of applications of this theory to some specific problems in number theory.
Syllabus	• *Elementary theory of algebraic numbers.* Euclidean domains, PIDs and UFDs. Gaussian integers and sums of two squares. Legendre symbol and quadratic reciprocity. Algebraic numbers and algebraic integers. Quadratic number fields and their rings of integers. Decomposition laws for quadratic number rings (the UFD case). • *Ideals in algebraic number rings.* Ideal classes and fractional ideals. Ideal classes for the quadratic case. Dedekind domains. Unique factorization into prime ideals. Ideal norm and its properties. Decomposition laws for quadratic number rings (the general case). Applications to quadratic forms.
Literature	• K. Ireland, M. Rosen. A Classical Introduction to Modern Number Theory. Springer, 1982.

	• M. Trifković. Algebraic Theory of Quadratic Numbers. Springer, 2013.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h • Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	none

Introduction to Cryptography

Electives referring to Pure Mathematics

Code	BK 2.2.3 BK 2.2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Elements of Algebra and Number Theory, Linear Algebra
Learning objectives	The objective of the course are the foundations of mathematical (mainly number-theoretical) methods of cryptography, “classic” and public key. Necessary concepts of number theory are presented in the course as its base.
Syllabus	• *Topics in number theory.* Time estimates for doing arithmetics. Divisibility and the Euclidean algorithm. Prime numbers and factoring. Congruences. Finite fields. Quadratic residues and reciprocity. • *Elements of cryptography.* “Classic” cryptography. The idea of public key cryptography. RSA cryptosystem. Discrete log and Diffie-Hellman cryptosystem. Pseudoprimes and primality tests. Factoring: the rho method and factor bases.
Literature	• N. Koblitz. A Course in Number Theory and Cryptography. Springer, 1994. • S. D. Galbraith. Mathematics of Public Key Cryptography. Cambridge Univ. Press, 2012.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h

	• Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	none

Introduction to Inverse Spectral Problems

Electives referring to Pure Mathematics

Code	BK 2.2.11 BK 2.2.12 BK 2.2.13
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer semester
Coordinator	Prof. Dmitry Shepelsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Complex Analysis, Ordinary Differential Equations
Learning objectives	We are going to study inverse problems related to a particular infinite dimensional system generated by the Sturm-Liouville differential equation.
Syllabus	• *Direct problems for Sturm-Liouville operators.* Differential Sturm-Liouville operator: the fundamental system of solutions. Estimates for the fundamental system. Frechet derivatives of solutions of the fundamental system. Asymptotics of eigenvalues end eigenfunctions: primary estimates. Asymptotics of eigenvalues end eigenfunctions: refining the estimates. • *Inverse problems for Sturm-Liouville operators.* Boundary value problems for hyperbolic partial differential equations. Boundary value problems of mixed type. Transformation operators. Completeness of the eigenfunctions of the Sturm-Liouville operators. Inverse problems. “Half-inverse problems”.
Literature	• Kirsch A. An Introduction to the Mathematical Theory of Inverse Problems, SpringerVerlag, New York, 1996.

	• Poschel J., Trubowitz E., Inverse Spectral Theory, Academic Press, London, 1987.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h • Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	none

Lie Algebras

Electives referring to Pure Mathematics

Code	BK 2.2.11 BK 2.2.12 BK 2.2.13
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Summer semester
Coordinator	Dr. Eugene Karolinsky
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Elements of Algebra and Number Theory, Linear Algebra, Abstract Algebra
Learning objectives	The course is devoted to the theory of Lie algebras, including the structure of complex semisimple Lie algebras and their representations.
Syllabus	• *Basic concepts of Lie algebras.* Definition of a Lie algebra. Category of Lie algebras. Basic examples. Lie algebras and linear algebraic groups. Lie functor. Representation of Lie algebras. Representations and g-modules. Irreducibility and complete reducibility. • *Solvable, nilpotent, and semisimple Lie algebras.* Solvable and nilpotent Lie algebras. Lie's and Engel's theorems. Invariant bilinear forms. Killing form. Cartan's criterion for solvability. Semisimple Lie algebras: definition, decomposition into a direct sum of simple ideals, Cartan's criterion for solvability, examples. Complete reducibility of finite dimensional representations of semisimple Lie algebras. Derivations of semisimple Lie algebras. Jordan decomposition in complex semisimple Lie algebras. • *Structure of semisimple Lie algebras.* Complex finite dimensional sl(2)-modules. Cartan subalgebras. Root

	decomposition and its properties. Root systems. • *Classification of semisimple Lie algebras and their representations.*
Literature	• J. E. Humphreys, Introduction to Lie Algebras and Representation Theory, Springer, 1973. • A. L. Onishchik, E. B. Vinberg, Lie Groups and Algebraic Groups, Springer, 1990.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h • Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	none

Operator Theory

Electives referring to Pure Mathematics

Code	BK 2.2.5 BK 2.2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Aleksey Shcherbina
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Functional Analysis, Measure and Integration Theory
Learning objectives	The students will: • get acquainted with the basics of the theory of Hilbert Spaces, bounded operators and compact operators • learn the applications in the theory of linear integral equations
Syllabus	• Examples end basic properties of Hilbert spaces. • Orthogonal series in Hilbert space. • Fourier series, orthonormal bases, and the Parseval Identity. • Gram–Schmidt orthogonalization and the existence of orthonormal bases. • Hilbert space geometry. • The general form of linear functionals on a Hilbert space. • Bilinear forms on a Hilbert space. • Self-adjoint operators and their quadratic forms. • Compact self-adjoint operators. • The Fredholm theory and its application to linear integral equations. • Spectral theorem for bounded self-adjoint operators. • Spectral theory for unitary operators.

Literature	• Akhiezer N. I., Glazman I. M., Theory of linear operators in Hilbert space, Mineola, NY: Dover, 1993. • Kadets V.M., A Course in Functional Analysis and Measure Theory, Springer International Publishing AG, part of Springer Nature, 2018. • Vladimirov V.S., Equations of Mathematical Physics, Marcel Dekker INC., 1971.
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the test grade.
Basis for	Deepening in: • Functional Analysis • Partial Differential Equations

Riemannian Geometry

Electives referring to Pure Mathematics

Code	BK 2.2.7 BK 2.2.8 BK 2.2.9 BK 2.2.10
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Vasyl Gorkavyy
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Topology, Differential Geometry, Ordinary Differential Equations
Learning objectives	The students will: • get familiar with the fundamental concepts of Riemannian geometry • learn the applications of these concepts to different mathematical and physical problems
Syllabus	• Elements of differential topology • Fundamental notions of Riemannian geometry • Affine manifolds • Levi-Civita connection • Geodesics on Riemannian manifolds • The completeness of Riemannian manifolds and Hopf-Rinow theorem • Curvatures of Riemannian manifolds and the spaces of constant curvature • Jacobi fields and their applications • Diameter and curvature, Bonnet and Myers theorems • Cartan-Hadamard theorem • Injectivity radius and Klingenberg theorem • Elements of general relativity
Literature	• Lee J.M. Riemannian manifolds. Springer, 1997

	• Sternberg S., Lectures on Differential Geometry. AMS, 1999 • Berger M., A panoramic view of Riemannian Geometry. Springer, 2003
Teaching and learning methods	Lecture (2 WH), Exercise (2WH)
Workload	• Classroom hours: 32 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	Further courses in Differential Geometry

Topics in Complex Analysis

Electives referring to Pure Mathematics

Code	BK 2.2.7 BK 2.2.8 BK 2.2.9 BK 2.2.10
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	each Winter semester
Coordinator	Prof. Serhii Favorov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Mathematics
Recommended prerequisites	Complex Analysis
Learning objectives	The main objective of the discipline is to teach students the theoretical basics and methods of the theory of functions of many complex variables and to apply these methods to other mathematical disciplines.
Syllabus	• Multiple power series. • Holomorphic functions of many variables. • Properties of holomorphic functions of many variables. • Subharmonic and plurisubharmonic functions. • Hartogs' series and domains, radius of convergence, corollaries. • Pseudo-convexity, holomorphic convexity, holomorphic shells. • d-dash problem for differential forms with compact support and in polydiscs. • Meromorphic functions and Cousin's problems. • The Weierstrass preparation theorem.
Literature	• B. V. Shabat. Introduction to complex analysis, Part II. Functions of several variables. AMS, 1992. • M. Hervé. Several Complex Variables: Local Theory. Oxford Univ. Press, 1987.

	• L. Hörmander. An Introduction to Complex Analysis in Several Variables. North Holland, 1990.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Lecture: 32 h • Exercise: 32 h • Individual study time / preparation and postprocessing / exam: 56 h
Assessment	The assessment consists of written or oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	none

Research practice

Practical course

Code	OK. 25
ECTS credits	6
Attendance time	
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Chair of the Department
Instructor(s)	Research work advisor
Allocation of study programs	B.Sc. Mathematics, compulsory module
Recommended prerequisites	
Learning objectives	• Explain mathematical concepts in language understandable to non-mathematicians. • Be able to work with special literature in a foreign language. • Solve problems using suitable mathematical methods, check the conditions for the fulfillment of mathematical statements, correctly transfer conditions and statements to new classes of objects, find and analyze correspondences between the given problem and known models. • Solve specific mathematical problems formulated in a formalized form; perform basic transformations of mathematical models. • Search for the necessary scientific and technical information in scientific literature, databases, and other sources of information. • To be able to use existing knowledge in mathematics and other areas of knowledge to obtain new results, build examples, prove new theorems based on existing ones, present research results in the form of a completed work, present and defend its content.
Syllabus	Research practice of students (as a type of industrial

	practice) is the final stage of training, which is carried out during the graduation course with the aim of generalizing and improving the professional competences (knowledge, practical skills and abilities) acquired by them, gaining professional experience and forming readiness for independent work, as well as collecting materials for course research work. The topic of scientific research practice is the guarantor of the program, considering the interests of applicants and the topic of future course work. The purpose of research practice is to gain experience in independent research in the field of mathematics and to collect materials for writing a research term paper.
Literature	
Teaching and learning methods	
Workload	Individual study time 180 h
Assessment	Report on results of research practice
Grading procedure	Credit, after report
Basis for	

Term research work
Research work

Code	OK. 26
ECTS credits	6
Attendance time	
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Chair of the Department
Instructor(s)	Research work advisor
Allocation of study programmes	B.Sc. Mathematics, compulsory module
Recommended prerequisites	
Learning objectives	• Have skills in using specialized computer and applied mathematics software and use Internet resources. • Explain mathematical concepts in language understandable to non-mathematicians. • Be able to work with special literature in a foreign language. • Solve problems using suitable mathematical methods, check the conditions for the fulfillment of mathematical statements, correctly transfer conditions and statements to new classes of objects, find and analyze correspondences between the given problem and known models. • Solve specific mathematical problems formulated in a formalized form; perform basic transformations of mathematical models. • Search for the necessary scientific and technical information in scientific literature, databases, and other sources of information. • To be able to use existing knowledge in mathematics and other areas of knowledge to obtain new results, build examples, prove new theorems based on existing ones, present research results in the form of a completed work, present and defend its content.

Syllabus	The topic of scientific research course work is determined by the supervisor, who is appointed by the decision of the department based on the proposal of the program guarantor. The guarantor determines the general direction of coursework, requirements for their content and originality.
Literature	
Teaching and learning methods	
Workload	Individual study time 90 h
Assessment	Term research work
Grading procedure	Credit, after public presentation.
Basis for	