V. N. Karazin Kharkiv National University

School of Mathematics and Computer Sciences

Course Descriptions

Bachelor of Applied Mathematics

2023 – 2026

Index

**For students who have not previously taken this discipline.*

Core Units

History of Ukraine

Teaching of this course is provided by the School of History of Karazin Kharkiv National University.

Code	OK 01
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester

Philosophy

Teaching of this course is provided by the School of Philosophy of Karazin Kharkiv National University.

Code	OK 02
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester

Foreign Language

Teaching of this course is provided by the School of Foreign Languages of Karazin Kharkiv National University.

Code	OK 03
ECTS credits	10
Attendance time	Semesters 1, 3 – 3; semester 2 – 4.
Language of instruction	English
Duration	3
Cycle	2 Winter Semesters and 1 Summer Semester

Foreign Language for Professional Purposes

Teaching of this course is provided by the School of Foreign Languages of Karazin Kharkiv National University.

Code	OK 04
ECTS credits	3
Attendance time	3
Language of instruction	English
Duration	1
Cycle	Each Summer Semester

Elements of Mathematical Logic and Discrete 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	None
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

Mathematical Analysis

Code	OK 06
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	None
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 (4 WH). Semesters #2, #3, #4: Lecture (4 WH), Exercise (4 WH).
Workload	• Classroom hours: 224 h • Exercise: 256 h • Individual study time/ preparation and postprocessing/exam: 420 h • **Total: 900 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

Elements of Algebra and Number Theory

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 • **Total: 180 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

Linear Algebra

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: 168 h • **Total: 360 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

Discrete Mathematics

Code	OK 09
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Poslavskyi Serhii
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Elements of Mathematical Logic and Discrete Mathematics
Learning objectives	The students will • get acquainted with basics of combinatorics, • learn the generating function method and its application to recurrence sequences, • get acquainted with basics of graph theory, • get knowledge in discrete probability theory, • learn methods to solve different problems.
Syllabus	• Basics of combinatorial analysis. Permutations and combinations. • Newton's binomial formula. • Recurrence equations and generating functions. • Basics of discrete probability theory. • Basics of graph theory.

Literature	- Lecture notes. - Oscar Levin. Discrete Mathematics: An Open Introduction. 3rd Edition, 2021. - Edward A. Bender, S. Gill Williamson. Lists, Decisions and Graphs. 2010. - Harris Kwong. A Spiral Workbook for Discrete Mathematics. Open SUNY Textbooks, 2015.
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 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: - Probability Theory - Mathematical Statistics

Analytic Geometry

Code	OK 11
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 will • 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 (2 WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing: 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	Differential Geometry

Differential Equations

Code	OK 11
ECTS credits	8
Attendance time	4
Language of instruction	Ukrainian
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: 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

Differential Geometry

Code	OK 14
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	2
Cycle	Each Summer 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 (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, 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

Measure Theory and Integration

Code	OK 13
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Dr. Sc. Larissa Fardigola
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Elements of Mathematical Logic and Discrete Mathematics, Linear Algebra
Learning objectives	The students will • get acquainted with the modern theory of measure, • learn the theory of Lebesgue integral, • get acquainted with the signed measures and the concept of absolutely continuous functions, and functions of bounded variation.
Syllabus	• Classes of sets. • Functions of sets and measures. • Measurable functions. • Lebesgue integral. • Signed measures, absolutely continuous functions, and functions of bounded variation. • Integration over a product spaces.

Literature	C. Borel, Lecture Notes in Measure Theory, Matematik Chalmers och Göteborgs Universitet412 96, Göteborg, 2006, http://www.math.chalmers.se/~borell/MeasureTheory.pdf . M. Veraar, Measure and Integration, https://fa.ewi.tudelft.nl/~veraar/teaching/lecture_notes_KW2.pdf . F. Burk. Lebesgue Measure and Integration. Pure and Applied Mathematics (New York). John Wiley & Sons,Inc., New York, 1998.
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 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	Is required in - Functional analysis - Equations of Mathematical Physics - Probability Theory - Methods of Optimization - Calculus of Variations and Optimal Control - Mathematical Statistics

Complex Analysis

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
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	• BV Shabat, Introduction to complex analysis. V.1, American Mathematical Society, 1992 • Lavrentev MA, Shabat BV Methods of the theory of function of complex variable. 1987, 544 p. • Edward C. Titchmarsh. The Theory of Functions. Oxford University Press; 2nd edition (May 13, 1976) • 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 (1 WH) Summer: Lecture (2 WH), Exercise (2 WH)
Workload	• Classroom hours: • Lectures: Fall 32 h, Winter 32 h • Exercise: Fall 16 h, Winter 32 h • Individual study time/ preparation and postprocessing: 98 h • **Total: 210 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

Functional Analysis

Code	OK 15
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Prof. Valerii Korobov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied 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 functional analysis, • study different investigation approaches framed in functional analysis, • be able to apply functional analysis methods to solve specific problems.

Syllabus	• Metric spaces. • Normalized spaces. • Hilbert spaces. • Linear bounded operators. • The uniform boundedness principle. • Bounded and unbounded operators. Extension of an operator. • Inverse operator. Closed operator. • Spectrum of an operator. • Compact operators. • Symmetric and self-adjoint operators • The Hahn-Banach theorem. • General view of linear continuous functionals.
Literature	• S. Banach. Theory of Linear Operations. Elsevier, 1987. • 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 (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 and oral examination and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the exam grade.
Basis for	Deepening in: • Partial Differential Equations • Applied Functional Analysis • Control Theory

Probability Theory

Code	OK 16
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Aleksey Piven’
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Theory of Measure and Integral
Learning objectives	The students will • get acquainted with the measure-theoretic probability theory, • get knowledge in the study of distributions of random variables, • learn the law of large numbers and the central limit theorem.
Syllabus	• Random events. • Classical definition of a probability. • Kolmogorov axioms. • Random variables and random vectors and their distributions. • Expectation, moments, and variance of random variables. • Covariance and correlation coefficients of random variables. • Convergences of sequences of random variables. • Independent random variables and independent events. • Law of large numbers. • Central limit theorem.

Literature	• Feller W., An introduction to the probability theory and its application, J. Willey and Sons, New York, 1971 • Meester R., A natural introduction to probability theory. Birkhäuser, 2008. • Gnedenko B.V., Theory of Probability, Gordon and Breach Science Publishers, 1978
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 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 statistic • Data analysis

Equations of Mathematical Physics

Code	OK 20
ECTS credits	8
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 (2 WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing: 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: • Functional analysis • Partial Differential Equations

Computer Programming

Code	OK 18
ECTS credits	8
Attendance time	4
Language of instruction	Ukrainian, English
Duration	2
Cycle	Each Semester
Coordinator	Assoc. Prof. Maxim Bebiya
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	None
Learning objectives	The students will • master basic concepts of programming, • acquire efficient programming skills in C and FORTRAN, • get acquainted with basic data structures and algorithms.
Syllabus	• Introduction of programming languages. • Basics of FORTRAN language and mathematical computations. • Fundamentals of C programming. • Key concepts of data types, control flow, functions, pointers, arrays, file handling, memory management. • Introduction to algorithms and data structures.

Literature	• Chapman S.J. Fortran for Scientists and Engineers. 4th ed, New York: McGraw Hill Education, 2018. • Markus A. Modern Fortran in Practice., New York: Cambridge University Press, 2012 • Brian W. Kernighan, Dennis M. Ritchie. The C Programming Language, Englewood Cliffs, NJ: Prentice Hall, 1988. • Paul Deitel, Harvey M. Deitel. C How to Program with an Introduction to C++, Pearson, 2016. • Stephen Prata, C Primer Plus. Addison-Wesley Educational Publishers Inc, 2013. • Donald E. Knuth. Art of Computer Programming, Volume 3: Sorting and Searching, Addison-Wesley Professional, 1998.
Teaching and learning methods	Lecture (2 WH), Exercise (2 WH)
Workload	• Classroom hours: 64 h • Exercise: 64 h • Individual study time/ preparation and postprocessing: 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	• Courses in the field of computer science • Numerical analysis

Methods of Optimization

Code	CU19
ECTS credits	3
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Tetiana Revina
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra
Learning objectives	The students will • get acquainted with basics of linear programming and game theory, • learn the classical methods to find solutions of linear programming problems and transportation problems.
Syllabus	• Linear programming problems. Simplex method. Dual problems of linear programming. • Methods to solve different transportation problems. • Antagonistic matrix games.
Literature	• Frederic S. Hillier, Gerald J. Lieberman. Introduction to Operations Research. McGraw Hill, 2010. • Hamdy A. Taha. Operations Research: an Introduction, Pearson, 2007.
Teaching and learning methods	Lecture (1 WH), Exercise (2 WH)

Workload	• Classroom hours: 16 h • Exercise: 32 h • Individual study time/ preparation and postprocessing: 42 h • **Total: 90 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: • Game theory • Theory and Methods of Decision Making

Project and Remote (Distributed) Team Management

Code	OK 20
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Sr. Lect. Olena Suzikova
Instructor(s)	
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Programming (Basic)
Learning objectives	The students will know • IT project life cycle models, • basic concepts and principles of Waterfall project methodologies, as well as Agile, Scrum, Kanban, • basic concepts and principles of development methodologies and PMI standards. • time, budget, and scope control methods, • methodologies for building distributed teams.
Syllabus	• Management of communications on projects. • Management of the distributed project team. • Planning and management of deadlines. • Time management. • Identification and reducing risks. • Compliance with people's expectations. • Forming the culture and values of the team. • Evaluation of the resources and the cost part of the project. • Assess the complexity of project or product support. • Justification of the decisions made in IT project management.

Literature	• Information Technology Project Management 9th Edition by Kathy Schwalbe, ISBN-10- 9781337101356, Cengage Learning, © 2018, 672 p. • Project Management Absolute Beginner's Guide 4th Edition by Greg Horine, ISBN-10- 0789756757, Que Publishing, © 2017, 448 p. • The Deadline: A Novel About Project Management by Tom DeMarco ISBN-10- 0932633390, Dorset House, © 1997, 310 p.
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 • **Total: 90 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: • Project Management

Algorithms and Data Structures

Code	OK 21
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 or Computer Science
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Programming Language (any)
Learning objectives	The students will • get acquainted with basic methods for creating and analyzing algorithms, • get acquainted with basic data structures and their usage, • learn some sorting and search algorithms, • learn basics of Python, • practice analyzing algorithms and creating programs for their implementation.
Syllabus	• Introduction to the Python language. • Analysis of algorithms (pseudocode and flowcharts; computational complexity; correctness). • Recursive and iterative algorithms. • Search and sorting algorithms. • Basic data structures: list, tree, stack, queue. • Data structures: set, dictionary, hash table.

Literature	• D. Knuth, The Art of Computer Programming, Vol. 1-3. • N. Wirth, Algorithms + Data Structures = Programs. • M. T. Goodrich, R. Tamassia, M. H. Goldwasser, Data Structures and Algorithms in Python. 2013.
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	Deepening in: • disciplines in Data Analysis • disciplines in Computer Science

Theoretical Mechanics

Code	OK 22
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Poslavskyi Serhii
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Geometry, Ordinary Differential Equations
Learning objectives	The students will • get acquainted with the basics of kinematics, • get knowledge of basic principles and equations of dynamics, • learn methods to solve different applied problems.
Syllabus	• Basics of kinematics. Kinematics of a rigid body. • Basics of dynamics. Axioms of classical mechanics. • Dynamics of systems. • Basics of analytical mechanics. Lagrange’s equations of the second kind.
Literature	• Grant R. Fowles, George L. Cassiday. Analytical Mechanics. 7th Edition. Thomson Brooks/Cole, 2005. • Nivaldo A, Lemos. Analytical Mechanics. Cambridge University Press, 2004. • Antonio Fasano, Stefano Marmi. Analytical Mechanics. Oxford University Press, 2002.
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 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: • Hydrodynamics • Oscillation Theory • Solid Mechanics

Numerical Analysis

Code	OK 23
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
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 computers.
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 (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 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

Processing, Storage and Transmission of Data in the Modern Information Technologies

Code	OK 24 BK 2.7 / BK 2.8 / BK 2.9
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Sr. Lect. Olena Suzikova
Instructor(s)	
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Programming (Basic)
Learning objectives	Students acquire knowledge about the transfer and processing of information on the Internet and modern computer systems and study the peculiarities of technologies from the point of view of the processes of such information exchange and information processing.
Syllabus	• Principles of information transmission technologies. • Principles of operation of web resources and browsers. • Main types of HTTP requests and interpretation of server responses. • The specifics of the client-server architecture • data transmission formats. • Basic front-end, back-end, and mobile technologies, principles of operation, their peculiarities. • Basics of programming using HTML and JS.

Literature	• Networking Made Easy: Get Yourself Connected (Computers Made Easy) Paperback by James Bernstein ISBN 1720034109, Independently published ©2018, 149 p. • Computer Networking. This Book Includes: Computer Networking for Beginners and Beginners Guide By Russell Scott, ISBN , Independently published, ISBN-10 - 1652202803, ISBN-13-978-1652202806 ©2019 359 p. • Web Design Playground HTML & CSS The Interactive Waby Paul McFedries, ISBN 9781617294402 , Manning © 2019 440 p. • Learning Web Design, 5th Edition by Jennifer Robbins, ISBN 9781491960202, O'Reilly Media, Inc., © 2018, 624 p.
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 • **Total: 90 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: • Business analysis • Data Analytics • Programming Advance

Calculus of Variations and Optimal Control

Code	OK 25
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Maxim Bebiya
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations
Learning objectives	The students will • get acquainted with the general framework of calculus of variations, • master effective methods of solving variational problems, • learn fundamentals of optimal control, • model problems from application areas and investigate them with optimal control methods.

Syllabus	• Variational problems with and without constraints. • The first variation and the first necessary condition, Euler's equation. • Broken extremals. The Weierstrass-Erdmann corner condition. • Free endpoint problems. The problem of Bolza. The isoperimetric problem. • The second variation. Legendre's, Jacobi's (second order) necessary conditions for local extremum. • Weierstrass's necessary condition. • Sufficient conditions for extremum. • Controllability of linear systems. • Optimal control and Pontryagin's maximum principle. • Time optimality.
Literature	• John A. Burns, Introduction to the Calculus of Variations and Control with Modern Applications, CRC Press Taylor & Fransis Group, Boca Raton, 2014. • F. Rinder, Calculus of Variations, Springer, 2018. • E.B. Lee, Markus, Foundations of Optimal Control Theory, John Wiley, New York, 1967. • L.S. Pontryagin, V.G. Boltyanskii, R.V.Gamkrelidze, E. F. Mishechenko, The Mathematical Theory of Optimal Processes, John Wiley & Sons, New York-London, 1962.
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 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	• Courses in the field of analysis and numerics. • Data Science

Mathematical Statistics

Code	OK 26
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Aleksey Piven'
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Theory of Measure and Integral, Probability Theory
Learning objectives	The students will • learn the sampling method in the statistic, • learn the estimation methods for parameters of distributions, • learn the method of the interval estimation and confidence intervals, • learn the methods of testing hypothesis, • learn the basics of the correlation and regression analysis.
Syllabus	• Empirical distribution function and histogram. • Point estimation of parameters, maximum likelihood estimation, method of moments. • Confidence intervals for parameters of a normal distribution. • Statistical testing hypothesis for parameters of the normal distribution. • $\chi 2$ test. • Estimating of a correlation coefficient. • Simple linear regression, the least squares method.

Literature	• Cramer H. Mathematical methods of statistics, 1946 • Kendall, M.G. and Stuart, A. The Advanced Theory of Statistics. Volume 1: Distribution theory, Charles Griffin & Co Limited,1963 • Kendall, M.G. and Stuart, A. The Advanced Theory of Statistics. Volume 2: Inference and Relationship, Charles Griffin & Co Limited, 1961 • Lehmann, E. L., Romano, J. P., Testing statistical hypotheses. Springer, 2005
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 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: • Applied statistics • Stochastic • Machine Learning • Data Science

Databases and Information Systems

Code	OK 27 BK 2.10 / BK 2.11 / BK 2.12
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Sr. Lect. Olena Suzikova
Instructor(s)	
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Set Theory, Relational Calculus, Programming (Basic)
Learning objectives	The students will • get acquainted with models used to represent data and knowledge in information systems, • learn the features of relational database models and approaches to their construction, • get knowledge about the procedure for creating and optimizing databases, • know the basics of the SQL language.
Syllabus	• Conducting an analysis of the problem area for which the database is being created. • Designing and optimizing a relational database model. • Developing databases for the problem area. • Performing data analysis using MySQL database and SQL.

Literature	• Database Systems: A Practical Approach to Design, Implementation, and Management, 6th edition, ISBN 978-0-13-294326-0, by Thomas Connolly and Carolyn Begg, Pearson Education © 2015 • An Introduction to Database Systems, 8/e C. J. Date, S. Swamynathan and A. Kannan • ISBN 9788177585568, Pearson Education © 2006, 968 p. • https://www.w3schools.com/MySQL/default.asp - electronic resourse
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 • **Total: 90 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 examination grade.
Basis for	Deepening in: • Business analysis • Data Analytics • Programming Advance

Data Analysis

Code	OK 28
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Kateryna Stiepanova
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Discrete Mathematics, Computer Programming, Algorithms and Data Structures, Numerical Analysis, Knowledge Graph and Data Modelling
Learning objectives	The students will • get acquainted with basic concepts of data analysis, • familiarize with the main types of data structures and their use, • learn the basics of data analysis in modeling and data analysis tasks, • study the use of data analysis methods when solving applied problems.
Syllabus	• Introduction to data analysis. • Visual data analysis. • Intelligent data analysis. • Analysis of text information and data in real time. • Elements of dispersion analysis.

Literature	• A. Bryman, Handbook of Data Analysis. Pub. by Sage Publications, 2009, 728 p. • Daniel T. Larose, Data Mining methods and models. Wiley, 2006, p.322 • Daniel T. Larose, Discovering knowledge in data. Wiley, 2005, p. 222 • Alexander Paprotny, Michael Thess, Realtime data mining. Springer, 2013, p. 313
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 examination grade.
Basis for	Deepening in: • Mathematical Statistics • Databases and Information Systems • Mathematical Modelling with Python • Research Practice • Bachelor's Thesis

Numerical Methods for Solving Differential and Integral Equations

Code	OK 29
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Dr. Sergii Dukhopelnykov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Ordinary Differential Equations, Numerical Analysis
Learning objectives	The students will • study of approximate methods for solving hypersingular, singular and logarithmic integral equations, • learn the method of discrete singularities, discretization with a Nystrom-type algorithm, • get knowledge in the study of approximate methods for solving differential equations by finite difference and finite element methods.
Syllabus	• Basics of difference equation method, finite element method. • Boundary integral equation. Fredholm theorems. • Integral equation of the I and II kind. Singular integral equation, hyper-singular integral equation, parametric representations of the integral operators. • Interpolation quadrature formulas, Nystrom-type algorithm, convergence of solution.

Literature	• David Colton, Inverse Acoustic and Electromagnetic Scattering Theory/ David Colton, Rainer Kress. – Springer, 2013. – p. 405. • I.K. Lifanov, Hypersingular Integral Equations and Their Applications/ I.K. Lifanov, L.N. Poltavskii, G.M. Vainikko, – CRC Press, 2003. – p. 416 • Computational Galerkin Methods / C. A. J. Fletcher – Springer, 1984. – p. 309
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	Deepening in: • Special courses in electrodynamics

Term Research Paper

Code	OK 30
ECTS credits	3
Attendance time	-
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	-
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	-
Learning objectives	A term paper is an individual assignment that involves a student's independent work to deepen and generalize the knowledge gained in several academic disciplines.
Syllabus	-
Literature	-
Teaching and learning methods	Performing an individual assignment under scientific supervision.
Workload	Individual work: 90 h
Assessment	The assessment takes into account the quality of the term paper and its defense.
Grading procedure	The grade is assigned by the committee on the basis of the defending the term paper.
Basis for	Research activity.

Research Practice

Code	OK 31
ECTS credits	5
Attendance time	-
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	-
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	-
Learning objectives	• Deepening and strengthening of theoretical knowledge of applied mathematics, the ability to use it in practice, • Formation and development of professionally significant personal qualities. • Development of professional culture, ability to organize own activities, communicate and work in a team. • Formation of creativity, creative thinking, development of the need for self-study and continuous self-improvement. • Development of the ability to work with scientific and technical information, to draw meaningful conclusions, to check and justify the correctness of the reasoning and decisions.
Syllabus	-
Literature	-
Teaching and learning methods	Performing an assignment individually or in a group.
Workload	Individual work or work in a group: 150 h

Assessment	• Getting a research assignment. • Performing assignments in small research teams. • Preparation and defense of the report.
Grading procedure	The grade is the sum of preliminary achievements in performing the assignment and the grade assigned by the committee, which takes into account the quality of the report and its defense.
Basis for	Research activity.

Bachelor's Thesis

Code	OK 32
ECTS credits	3
Attendance time	-
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	-
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	-
Learning objectives	A bachelor's thesis includes the solution of a complex specialized task in applied mathematics, characterized by complexity and/or uncertainty of conditions, using mathematical methods and/or software tools.
Syllabus	-
Literature	-
Teaching and learning methods	Performing an individual assignment under scientific supervision.
Workload	Individual work: 90 h
Assessment	The assessment takes into account the student's activity, the level of completion of the individual assignment, the quality of the prepared thesis and its defense. Before the defense, the paper is checked for academic plagiarism.
Grading procedure	The grade is assigned by the Examination committee on the basis of the quality of the thesis and its defense. The Examination committee takes into account opinions of the supervisor and the reviewer.
Basis for	Research activity.

Selective Units

Inter-faculty Selective Discipline 1

Students can select any course offered by any faculty at Karazin Kharkiv National University.

Code	BK 01
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester

Inter-faculty Selective Discipline 2

Students can select any course offered by any faculty at Karazin Kharkiv National University.

Code	BK 02
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester

Inter-faculty Selective Discipline 3

Students can select any course offered by any faculty at Karazin Kharkiv National University.

Code	BK 03
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester

Inter-faculty Selective Discipline 4

Students can select any course offered by any faculty at Karazin Kharkiv National University.

Code	BK 04
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester

Unit 1 (2 Elective courses)

Numerical Methods of Linear Algebra

Code	BK 2.1 / BK 2.2
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Prof. Svetlana Ignatovich
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra, Programming Language (any)
Learning objectives	The students will • learn basic methods of exact and approximate solution of systems of linear equations and finding eigenvalues and eigenvectors of matrices, • learn basics of Python language and Numpy library, • practice solving linear systems, finding eigenvalues and eigenvectors, creating and analyzing computer programs.

Syllabus	• Direct methods for solving systems of linear equations (Gaussian elimination, its modifications and complexity; LU-decomposition). • Floating-point arithmetic. IEEE-754 standard. Conditioning. Basics of NumPy. • Iterative methods for solving systems of linear equations (Jacobi and Gauss-Seidel methods; gradient-type methods for symmetric positive definite matrices). • Spectrum of matrix, its localization and direct finding (Gershgorin circles, Leverier-Faddeev method). • Computing eigenvalues and eigenvectors (power method and its modifications; QR-decomposition and QR-algorithm, Householder method, Hessenberg form). • Least squares method.
Literature	• Lecture notes. • W. Ford. Numerical Linear Algebra with Applications. 2015. • A. Greenbaum, T. Chartier. Numerical methods. 2012.
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 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: • Numerical Analysis • Disciplines in Data Analysis • Disciplines in Computational Mathematics

Discrete Probability Theory

Code	BK 2.1 / BK 2.2 BK 2.3 / BK 2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester or each Winter Semester
Coordinator	Assoc. Prof. Aleksey Piven’
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Elements of Mathematical Logic and Discrete Mathematics, Discrete mathematics, Linear Algebra
Learning objectives	The students will • get acquainted with the discrete probability space, • get knowledge in the study of distributions of discrete random variables, • learn the finite Markov chains.
Syllabus	• Random events. • Classical definition of a probability. • Discrete probability space. • Conditional probability. • Independent events. • Discrete random variables and its distributions. • Discrete random vectors. • Expectation, moments, and variance of discrete random variables. • Covariance and correlation coefficient of discrete random variables. • Generating function of discrete random variables. • Regular, ergodic, and absorbing finite Markov chains.

Literature	• R. Meester: A natural introduction to probability theory. Birkhäuser, 2008. • Brémaud P., Discrete Probability Models and Methods. Probability on Graphs and Trees, Markov Chains and Random Fields, Entropy and Coding, 2017 • Kemeny J.G., Snell V., Finite Markov Chains, 1963
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 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: • Probability theory • Mathematical statistics

Basics of Game Theory

Code	BK 2.1 / BK 2.2
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Tetiana Revina
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra
Learning objectives	The students will • get acquainted with basics of Game theory, • learn the classical methods to find solutions.
Syllabus	• Linear programming methods. • Introduction to Game theory. • Strategic games. • Nash Equilibrium. • Normal-form games with pure strategies. • Two-player finite games (bimatrix games). • Mixed strategies. • Reduction of the problem of finding a set of optimal strategies to the equivalent Linear programming problem. • Some classic games.

Literature	• Osborne M. J. An introduction to game theory. Vol. 3. No. 3. New York: Oxford university press, 2004. • Tadelis S. Game theory: an introduction. Princeton university press, 2013. • Carmichael F. A guide to game theory. Pearson Education, 2005.
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 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: • Methods of Optimization

Unit 2 (2 Elective courses)

Theory and Methods of Decision Making

Code	BK 2.3 / BK 2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Tetiana Revina
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra, Discrete Mathematics
Learning objectives	The students will • get acquainted with basics of Game theory, Decision making and Fuzzy Logic, • learn the classical methods to find solutions.
Syllabus	• Strategic Games. • Nash Equilibrium. • Normal-form games with pure strategies. • Two-player finite games (bimatrix games). • Mixed strategies. • Repeated Games. • Cooperative and non-cooperative games. • Cournot Duopoly. • Rational Decision making. • Fuzzy Logic. • Fuzzy control systems.

Literature	• Osborne M. J. An introduction to game theory. Vol. 3. No. 3. New York: Oxford university press, 2004. • Tadelis S. Game theory: an introduction. Princeton university press, 2013. • Slovic P., Lichtenstein S., Fischhoff B. Decision making. Wiley, 1988. • Albright S. C., et al. Data analysis and decision making. Vol. 577. South-Western/Cengage Learning, 2011. • Zadeh L. A. Fuzzy logic. Computer 21.4 (1988): 83-93. • McNeill F. M. and Thro E. Fuzzy logic: a practical approach. Academic Press, 2014. • Dernoncourt F. Introduction to fuzzy logic. Massachusetts Institute of Technology 21 (2013): 1-25.
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 or oral test 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: • Methods of Optimization

Discrete Probability Theory*

Code	BK 2.3 / BK 2.4 BK 2.1 / BK 2.2
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester or each Winter Semester
Coordinator	Assoc. Prof. Aleksey Piven’
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Elements of Mathematical Logic and Discrete Mathematics, Discrete mathematics, Linear Algebra
Learning objectives	The students will • get acquainted with the discrete probability space, • get knowledge in the study of distributions of discrete random variables, • learn the finite Markov chains.
Syllabus	• Random events. • Classical definition of a probability. • Discrete probability space. • Conditional probability. • Independent events. • Discrete random variables and its distributions. • Discrete random vectors. • Expectation, moments, and variance of discrete random variables. • Covariance and correlation coefficient of discrete random variables. • Generating function of discrete random variables. • Regular, ergodic, and absorbing finite Markov chains.

Literature	• R. Meester: A natural introduction to probability theory. Birkhäuser, 2008. • Brémaud P., Discrete Probability Models and Methods. Probability on Graphs and Trees, Markov Chains and Random Fields, Entropy and Coding, 2017 • Kemeny J.G., Snell V., Finite Markov Chains, 1963	
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 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: • Probability theory • Mathematical statistics	

**For students who have not previously taken this discipline.*

Basics of Web-Programming

Code	BK 2.3 / BK 2.4
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Maxim Bebiya
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Computer programming
Learning objectives	The students will • study basics of web development, • learn how to make web pages more appealing and add interactivity, • learn how to use third-party API’s to add functionality to websites, • get acquainted with server-side programming.
Syllabus	• Web page structuring with HTML5. • Web page styling with CSS. • Basics of JavaScript. • DOM manipulation. • Using web API's as a client with JS. • Server-side programming with Node.js and Express. • Storing and retrieving data in and from database.

Literature	• D. DuRocher HTML and CSS QuickStart Guide. 2021. • D. Flanagan, JavaScript: The Definitive Guide, O'Reilly Media, 2020 • M. Casciaro, L. Mammino, Node.js Design Patterns: Design and Implement Production-grade Node.js Applications Using Proven Patterns and Techniques, Packt Publishing, 2020
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 or oral test and preliminary graded study achievements.
Grading procedure	The module grade is the sum of preliminary study achievements and the examination grade.
Basis for	• Courses in computer science

Unit 3 (2 Elective courses)

Controllability and Stabilization

Code	BK 2.5 / BK 2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Tetiana Smortsova
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Differential Equations
Learning objectives	The students will • get acquainted with basics of linear control theory, and optimal control theory under control restrictions, • learn methods to construct controls solving different problems for linear and triangular control systems, • get knowledge in Pontryagin's maximum principle and its applications.
Syllabus	• Controllability and stabilizability of linear control systems. • Controllability and stabilizability of triangular control systems. • Controllability on a subspace. • Linear steering problem. Pontryagin's maximum principle. • Geometric criterion of local controllability.

Literature	• E.B. Lee, L. Markus. Foundations of Optimal Control Theory. R.E. Krieger Publishing Company, 1987. • L.S. Pontryagin. Selected works, V. 4. The Mathematical Theory of Optimal Processes. CRC Press, 1987. • Korobov V.I. Geometric Criterion for Controllability under Arbitrary Constraints on the Control, J. of Optim. Theory and Applications, 2007, Vol. 134. •
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 or oral test 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: • Optimal Control • Robust Systems

Knowledge Graph and Data Modelling

Code	BK 2.5 / BK 2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Kateryna Stiepanova
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Discrete Mathematics, Computer Programming, Numerical Analysis
Learning objectives	The students will • familiarize with the basic concepts of the data graph model and the knowledge graph, • learn the basics of data modeling, • learn how to use the data model when solving applied problems, • apply the most used algorithms to graphs, • model the knowledge graph using real data from the database, • be able to analyze it and provide an interpretation.
Syllabus	• Basic concepts and structure of knowledge graph construction. • Selection of influential factors and development of a data schema. • Schema modeling using a knowledge graph. • Application of parameters to nodes and edges of the graph. • The architecture of the data circulation system, its research. • Development of a modular system for graph nodes and edges. • Evaluation of the speed of data circulation of the constructed architecture.

Literature	• Eric Redmond and Jim R. Wilson, Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement, 2012. • Aleksa Vukotic, Jonas Partner, Tareq Abedrabbo, Nicki Watt, Dominic Fox, Neo4j in Action, 2014. • Onofrio Panzarino, Learning Cypher, Packt Publishing Ltd, 2014. • Mahesh Lal, Neo4j Graph Data Modeling, Packt Publishing Ltd, 2015 • Ian Robinson, Jim Webber, Emil Eifrem, Graph Databases: New Opportunities for Connected Data, "O'Reilly Media, Inc.", 2015.
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 or oral 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: • Applied Problems of Bigdata Analysis • Data Analysis • Databases and Information Systems • Basics of Game Theory • Research Practice • Bachelor's Thesis

Mathematical Modelling with Python

Code	BK 2.5 / BK 2.6
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Prof. Svetlana Ignatovich
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra, Differential Equations, Programming Language (any)
Learning objectives	The students will • get acquainted with some methods of creating algorithms for mathematical and computer modeling, visualization and analysis of results, • get acquainted with Numpy, Scipy, Matplotlib libraries, • practice in computer experiments using Numpy, Scipy, Matplotlib libraries, analyzing their results and drawing conclusions.
Syllabus	• Modeling processes associated with randomness: random walks; percolation; problems from the theory of queuing. • Mathematical models described by ODE: vector fields, phase portraits. Linear systems of ODE. • Nonlinear systems of ODE: singular points, limit circles, chaotic behavior (Lorentz attractor). • Recurrent equations and chaotic behavior: spider diagrams, bifurcations. • Recurrent equations in complex plane: Mandelbrot set, Julia set. Newton basins.

Literature	• Lecture notes. • Bliss K. M., Fowler K. R., Galluzzo B. J., Math Modeling: getting started & getting solutions. SIAM, Handbook, 2014. • Kaplan D., Glass L. Understanding nonlinear dynamics, Springer, 1995.
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 or oral 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: • Disciplines in Data Science • Disciplines in Mathematical Modelling

Unit 4 (3 Elective courses)

Oscillation Theory

Code	BK 2.7 / BK 2.8 / BK 2.9
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Assoc. Prof. Poslavskyi Serhii
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Ordinary Differential Equations, Theoretical Mechanics
Learning objectives	The students will • get acquainted with the basics of small oscillations of mechanical systems, • learn methods to investigate stability of equilibrium and stability of motion, • get knowledge in basic properties of Hamiltonian systems, • get knowledge in bifurcation types in nonlinear dynamical systems.
Syllabus	• Basics of analytical statics. Equilibrium of mechanical systems. • Theorems on stability of equilibrium. • Small oscillations of systems near equilibrium. • Stability of motion. • Properties of Hamiltonian systems. • Basics of theory of nonlinear oscillations.

Literature	• Daniel Arovas. Lecture Notes on Nonlinear Dynamics. – University of California, San Diego • Nivaldo A, Lemos. Analytical Mechanics. Cambridge University Press, 2004. • Antonio Fasano, Stefano Marmi. Analytical Mechanics. Oxford University Press, 2002.
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 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: • Electrodynamics • Hydrodynamics • Materials Science

Method of Controllability Function

Code	BK 2.7 / BK 2.8 / BK 2.9
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Valerii Korobov
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra, Ordinary Differential Equations, Calculus of Variations and Optimal Control, Controllability and Stabilization
Learning objectives	The students will • get acquainted with basic notions and theorems on Pontryagin's maximum principle, dynamic programming, Lyapunov's stability theory, controllability function method, • learn the classical methods to find solutions of various control problems.
Syllabus	• Pontryagin's maximum principle for time-optimal control problem. • The basic concepts of dynamic programming. Bellman's equation. • Lyapunov's stability theory. • Controllability function method. Basic notions and the main theorem. • Solving of the synthesis problem for the canonical system with one-dimensional control (chain of integrators system). • The controllability function as the time of motion (settling-time function). • Solving of the synthesis problem for the canonical system with multivariate control.

Literature	• Korobov V.I. A general approach to the solution of the bounded control synthesis problem in a controllability problem. Math. USSR Sb. 1980; 37(4): 535-557 • Korobov V.I., Sklyar G.M. Methods for constructing positional controls, and a feasible maximum principle. Dif. Equ. 1990; 26(11): 1422-1431 • Choque Rivero A.E., Korobov V.I., Skoryk V.O. Controllability function as the time of motion I. Mat. Fiz. Anal. Geom. 2004, 11, no. 2, 208-225 • Bellman R., Kalaba R. Dynamic programming and modern control theory. Vol. 81. New York: Academic Press; 1965. • Brunovsky P. A classification of linear controllable systems, Kybernetika, 1970, 6, no. 3, 173-188. • Lyapunov A.M. The general problem of the stability of motion,Int. J. Control. 1992;55(3):531-534 • Pontryagin L.S., Boltyanskii V.G., Gamkrelidze R.V., Mishchenko E. The Mathematical Theory of Optimal Processes, Interscience, New York. 1962
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 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: • Controllability of Robust Systems • The Basics of Control Theory

Processing, Storage and Transmission of Data in the Modern Information Technologies*

Code	BK 2.7 / BK 2.8 / BK 2.9 OK 24
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Sr. Lect. Olena Suzikova
Instructor(s)	
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Programming (Basic)
Learning objectives	Students acquire knowledge about the transfer and processing of information on the Internet and modern computer systems and study the peculiarities of technologies from the point of view of the processes of such information exchange and information processing.
Syllabus	• Principles of information transmission technologies. • Principles of operation of web resources and browsers. • Main types of HTTP requests and interpretation of server responses. • The specifics of the client-server architecture • data transmission formats. • Basic front-end, back-end, and mobile technologies, principles of operation, their peculiarities. • Basics of programming using HTML and JS.

Literature	• Networking Made Easy: Get Yourself Connected (Computers Made Easy) Paperback by James Bernstein ISBN 1720034109, Independently published ©2018, 149 p. • Computer Networking. This Book Includes: Computer Networking for Beginners and Beginners Guide By Russell Scott, ISBN , Independently published, ISBN-10 - 1652202803, ISBN-13-978-1652202806 ©2019 359 p. • Web Design Playground HTML & CSS The Interactive Waby Paul McFedries, ISBN 9781617294402 , Manning © 2019 440 p. • Learning Web Design, 5th Edition by Jennifer Robbins, ISBN 9781491960202, O'Reilly Media, Inc., © 2018, 624 p.
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 • **Total: 90 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: • Business analysis • Data Analytics • Programming Advance

**For students who have not previously taken this discipline.*

Basics of Biomechanics

Code	BK 2.7 / BK 2.8 / BK 2.9
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Prof. Natalya Kizilova
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Linear Algebra, Geometry, Ordinary Differential Equations
Learning objectives	The students will • get acquainted with basic mechanical properties and processes in biological systems, • learn the mathematical modeling and optimization methods, • get knowledge on different rheology of biological fluids, solid and soft materials.
Syllabus	• Classification of biological tissues on their mechanical properties. • Mechanical principle in construction (geometry, topology, material parameters) of biological systems. • Nature-inspired solutions and their applications in medicine and technique. • Heat transfer and thermoregulation in biosystems. • Blood circulation system and pulse wave propagation in the arteries. • Regular and chaotic oscillations of human body.

Literature	• Fung Y.C. Biomechanics. Mechanical Properties of Living Tissues. Berlin: Springer-Verlag. 1981. • Kizilova N.N., Solovjova H.N. Rheology of materials. Kharkiv. 2020. • Kizilova N.N. Applied problems of microfluidics and nanofluidics. Kharkiv. 2020.
Teaching and learning methods	Lecture (2 WH), Exercise (2cWH)
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 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 modeling • Optimization theory • Partial Differential Equations

Unit 5 (3 Elective courses)

Applied Problems of Bigdata Analysis

Code	BK 2.10 / BK 2.11 / BK 2.12
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Summer Semester
Coordinator	Prof. Natalya Kizilova
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Mathematical Statistics, Probability Theory, Ordinary Differential Equations
Learning objectives	The students will • get acquainted with basic methods and approaches to analyses of big datasets, • learn the statistical and analytical methods of data analyses, • get knowledge in the contemporary software for statistical analyses of the interconnected multidimensional datasets with practical examples of the open source databases from the Internet.
Syllabus	• Classification of different types of data. • Main statistical methods for big data analyses. • Main analytical models in the data science. • Methods of the deep learning and artificial intelligence in the big data analysis. • Big data methods for the analysis of medical data; geophysical data; astrophysical data; bioinformatics.

Literature	• Prasad Y.L. Big Data Analytics. Made Easy. Notial Press. 2016. 228p. • Omar H., Jumaa A.K. Big Data Analysis Using Apache Spark MLlib and Hadoop HDFS with Scala and Java. 2020. • Marr B. Big Data in Practice. 2021.
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 or oral examination 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: • Mathematical Statistics • Probability Theory • Data Sciences

Evolution Systems

Code	BK 2.10 / BK 2.11 / BK 2.12
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Aleksey Piven’
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Mathematical Analysis, Differential Equations, Linear Algebra
Learning objectives	The students will • get acquainted with the theory of linear difference equations, • get acquainted with the theory of differential-algebraic equations, • learn the methods to find solutions of explicit and implicit linear difference equations with constant coefficients, • learn the methods to find solutions of differential-algebraic equations with constant coefficients.

Syllabus	• First order linear difference equations. • Higher order linear difference equations, fundamental set of solutions. • Linear difference equations and systems with constant coefficients. • Normal linear evolution systems of difference equations and its applications, fundamental matrix for a system. • Implicit linear difference equations over some commutative rings. • Spectral projectors for matrix pencils. • Existence and uniqueness theorem for linear differential-algebraic equations. • Existence and uniqueness theorem for implicit evolution systems of linear difference equations.
Literature	• Elaydi, S. An Introduction to Difference Equations, Springer-Verlag New York, 2005 • Campbell S. Singular systems of differential equations,1980 • Vlasenko L.A., Perestyuk N.A., On the Solvability of Impulsive Differential-Algebraic Equations. Ukr. Math. J. – 2005.– V.57.– P. 551–564. • Gefter S., Goncharuk A., Piven' A. , Implicit Linear First Order Difference Equations Over Commutative Rings. In: Elaydi, S., Kulenovic, M.R.S., Kalabusic, S. (eds) Advances in Discrete Dynamical Systems, Difference Equations and Applications. ICDEA 2021. Springer Proceedings in Mathematics & Statistics, vol 416, Springer, ham.–2023.–P. 199–216.
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	Deepening in: • Dynamical systems • Difference equations

Databases and Information Systems*

Code	BK 2.10 / BK 2.11 / BK 2.12 OK 27
ECTS credits	3
Attendance time	3
Language of instruction	Ukrainian, English
Duration	1
Cycle	Each Winter Semester
Coordinator	Sr. Lect. Olena Suzikova
Instructor(s)	
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Set Theory, Relational Calculus, Programming (Basic)
Learning objectives	The students will • get acquainted with models used to represent data and knowledge in information systems, • learn the features of relational database models and approaches to their construction, • get knowledge about the procedure for creating and optimizing databases, • know the basics of the SQL language.
Syllabus	• Conducting an analysis of the problem area for which the database is being created. • Designing and optimizing a relational database model. • Developing databases for the problem area. • Performing data analysis using MySQL database and SQL.

Literature	• Database Systems: A Practical Approach to Design, Implementation, and Management, 6th edition, ISBN 978-0-13-294326-0, by Thomas Connolly and Carolyn Begg, Pearson Education © 2015 • An Introduction to Database Systems, 8/e C. J. Date, S. Swamynathan and A. Kannan • ISBN 9788177585568, Pearson Education © 2006, 968 p. • https://www.w3schools.com/MySQL/default.asp - electronic resourse
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 • **Total: 90 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 examination grade.
Basis for	Deepening in: • Business analysis • Data Analytics • Programming Advance

**For students who have not previously taken this discipline.*

Controllability of Robust Systems

Code	BK 2.10 / BK 2.11 / BK 2.12
ECTS credits	4
Attendance time	4
Language of instruction	Ukrainian
Duration	1
Cycle	Each Summer Semester
Coordinator	Assoc. Prof. Tetiana Revina
Instructor(s)	All teachers of Mathematics
Allocation of study programmes	B.Sc. Applied Mathematics
Recommended prerequisites	Linear Algebra, Calculus of Variations and Optimal Control, Controllability and Stabilization, Controllability Function method
Learning objectives	The students will • get acquainted with basic notions and theorems on the controllability function method, interval arithmetic, stability theory for interval polynomials and interval matrixes, finite-time stabilization, • investigate interval polynomials and interval matrixes for stability, • learn the classical methods to find solutions of various control problems for systems with some uncertainties.

Syllabus	• Controllability function method. Basic notions and the main theorem. • Solving of the synthesis problem for the canonical system with one-dimensional control (chain of integrators system). • Controllability function as the time of motion (settling-time function). • Interval arithmetic. • Stability theory for polynomials and matrices. • Stability theory for interval polynomials and interval matrices. • Linear matrix inequalities. • Solution of the synthesis problem for robust systems (uncertain systems). • Finite-time stabilization.
Literature	• Bhat SP, Bernstein DS., 2000: Finite-time stability of continuous autonomous systems. SIAM Journal of Control and Optimization, 2000, 38, no. 3, 751-766 • Boyd S. et al. Linear matrix inequalities in system and control theory. Society for industrial and applied mathematics, 1994. • Choque Rivero AE, Korobov VI, Skoryk VO. Controllability function as the time of motion I. Mat. Fiz. Anal. Geom. 2004, 11, no. 2, 208-225 • Jaulin L., Kieffer M., Didrit O., Walter E. Applied Interval Analysis. London: Springer Verlag Limited, 2001. 379 p. • Korobov VI. A general approach to the solution of the bounded control synthesis problem in a controllability problem. Math. USSR Sb. 1980; 37(4): 535-557 • Korobov VI, Revina TV., Robust feedback synthesis for the canonical system. Ukr. Math. J., 2016, 68, no.3, 380-398 • Korobov VI, Revina TV. On perturbation range in the feedback synthesis problem for a chain of integrators system. IMA J. Math. Control and Information. 2021; 38(1): 396-416 • Korobov VI, Sklyar GM. Methods for constructing positional controls, and a feasible maximum principle. Dif. Equ. 1990; 26(11): 1422-1431 • Lin F. Robust control design: an optimal control approach. John Wiley & Sons, 2007. • Moore R. E., Baker Kearfott R., Michael J. Cloud. Introduction to interval analysis. Society for Industrial and Applied Mathematics, 2009. 223 p. • Rohn J. A handbook of results on interval linear problems. Czech Academy of Sciences, Prague, 2005, 80 p. • Shalaby M. A. The interval eigenvalue problem. European Congress on Computational Methods in Applied Sciences and Engineering, Barcelona, 11-14 September 2000

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 or oral examination 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: • Control Theory

Study plan

Discipline	Semester								ECTS Credits	Credit/Exam
	1 WS	2 SS	3 WS	4 SS	5 WS	6 SS	7 WS	8 SS		
Mandatory Courses										
History of Ukraine	3								3	e
Philosophy				3					3	e
Foreign Language	3	4	3						10	c,c,e
Foreign Language for Professional Purposes								3	3	c
Elements of Mathematical Logic and Discrete Mathematics	4								4	c
Mathematical Analysis	6	8	8	8					30	e,e,e,e
Elements of Algebra and Number Theory	6								6	e
Linear Algebra		6	6						12	e,e
Discrete Mathematics		4							4	c
Analytic Geometry	4	4							8	c,e
Differential Equations				4	4				8	c,e
Differential Geometry				4					4	c
Measure Theory and Integration					4				4	e
Complex Analysis					3	4			7	c,e
Functional Analysis						4			4	e
Probability Theory						4			4	e
Equations of Mathematical Physics							4	4	8	c,e
Computer Programming	4	4							8	c,c
Methods of Optimization			3						3	c
Project and Remote (Distributed) Team Management			3						3	c
Algorithms and Data Structures			4						4	c
Theoretical Mechanics					4				4	c
Numerical Analysis					4				4	e
Processing, Storage and Transmission of Data in the Modern Information Technologies						3			3	c
Calculus of Variations and Optimal Control						4			4	e
Mathematical Statistics							4		4	e
Databases and Information Systems							3		3	c
Data Analysis							4		4	c
Numerical Methods for Solving Differential and Integral Equations								3	3	c
Term Research Paper							3		3	c
Research Practice								5	5	c

Bachelor's Thesis								3	3	e
Selective Courses										
Inter-faculty Selective Discipline 1			3						3	c
Inter-faculty Selective Discipline 2				3					3	c
Inter-faculty Selective Discipline 3					3				3	c
Inter-faculty Selective Discipline 4						3			3	c
Unit 1 (2 Courses)				4x2					8	e,e
Unit 2 (2 Courses)					4x2				8	c,c
Unit 3 (2 Courses)						4x2			8	c,c
Unit 4 (3 Courses)							4x3		12	e,e,e
Unit 5 (3 Courses)								4x3	12	c,c,c
Total:	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**240**	