HIGHER MATHEMATICS

Syllabus

Code and name of the specialty	121 Software Engineering	Institute / faculty	Faculty of Computer Science and Software Engineering
Name of the program	“Software Engineering”	Department	Department of Software Engineering and Management Information Technologies
Program type	Educational and professional	Language of instruction	Ukrainian, English

LECTURER

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Ph.D., Ph.D., Professor, Professor of Computer Mathematics and Data Analysis (NTU "KhPI"). Author and co-author of over 100 scientific and educational publications. Basic course: higher mathematics.

General information about the course

Summary	The discipline "Higher Mathematics (Part 1)" is a discipline in the cycle of general training in the specialty 122 "Computer Science". The course covers the main sections of higher mathematics. The course provides three semantic modules and involves the formation of modern mathematical thinking, learning the basic mathematical tools needed to analyze and model processes and phenomena in finding optimal solutions and choosing the best means of implementing these solutions, research methods and solving mathematically formalized problems, the ability to analysis and synthesis of the obtained results and input facts. The discipline "Higher Mathematics (Part 2)" is a discipline in the cycle of general training in the specialty 122 "Computer Science". The course covers the main sections of higher mathematics. The course provides five content modules and provides for the formation of modern mathematical thinking, learning the basic mathematical tools needed to analyze and model processes and phenomena in finding optimal solutions and choosing the best means of implementing these solutions, research methods and solving mathematically formalized problems, ability to analyze and synthesize the obtained results and input facts.
Course objectives	Mastering by students the mathematical apparatus necessary for further study and work, development of logical and algorithmic thinking of students; mastering by students of methods of research and the decision of mathematical problems; developing students' ability to independently expand their mathematical knowledge and conduct mathematical analysis of applied and engineering problems.

Format	Lectures, practical classes, independent work. Final control - exam.
Semester	1, 2

Student workload (credits)/Type of course (mandatory/selective)	12 / Mandatory	**Lectures (hours)**	112	**Practical classes (hours)**	96	**Independent work (hours)**	152

Програмні компетентності	GC 01. Ability to abstract thinking, analysis and synthesis. GC 05. Ability to learn and master modern knowledge. PC 20. Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering problems.

Learning outcomes	Teaching and learning methods	Forms of assessment (current CAS assessment, final FAS assessment)
PLO 1. Analyze, purposefully search for and select the necessary information and reference resources and knowledge to solve professional problems, taking into account modern advances in science and technology.	Interactive lectures with presentations, "bug tracking of lectures", practical classes with the use of group dynamics, project training	Written individual tasks for calculation and graphic works (CAS), assessment of knowledge in practical classes (CAS), express-survey (CAS), online testing (CAS), final / semester control in the form of a semester exam, according to the schedule of the educational process (FAS))

ASSESSMENT AND GRADING

Ranges of points corresponding to grades

Total score (points) for all types of learning activities	ECTS grading scale	The national grading scale
90-100	A	excellent
82-89	B	good
74-81	C	
64-73	D	satisfactorily
60-63	E	
35-59	FX	unsatisfactory with the possibility of reassembly
0-34	F	unsatisfactory with mandatory re-study of the discipline

Allocation of grade points

Part 1
100% final assessment in the form of an exam (40%) and current assessment (60%).
40% exam: semester exam, according to the schedule of the educational process.
60% current rating:
• 20% assessment of tasks in practical classes;
• 30% written individual calculation and graphic tasks;
• 10% intermediate control (3 online tests)
Part 2
100% final assessment in the form of an exam (40%) and current assessment (60%).
40% exam: semester exam, according to the schedule of the educational process.60%
поточне оцінювання:
• 20% assessment of tasks in practical classes;
• 30% written individual calculation and graphic tasks;
• 10% intermediate control (3 online tests)

Course policy	Compliance with the rules of internal regulations of the university. Active participation in the learning process. Students must attend classes according to schedule and adhere to ethical behavior. In the absence of students will need to complete all tasks to compensate for missed classes. Participation in practical classes involves preliminary preparation and early processing of all necessary materials for productive discussions during the lesson. Written individual calculation and graphic tasks must be submitted by the deadline.

The structure and content of the course

Part 1

Lecture 1	Determinants, their calculations and properties.	Practical lesson 1	Methods of calculating the determinants of the second, third and higher orders.	**Individual work**	Reduction of determinants of higher orders to the upper triangular and lower triangular form.
Lecture 2-3	Matrices, basic concepts, types of matrices, actions on matrices. Inverse matrix. Matrix equations.	Practical lesson 2	Performing operations with matrices: adding matrices, subtracting, multiplying matrices by a number, product of two matrices, transposition.		Finding the inverse matrix. Solving matrix equations.
Lecture 4	Rank of the matrix.	Practical lesson 3	Calculation of ranks of matrices by the method of separation of minors and reduction of a matrix to a trapezoidal form.		Determinant of Vandermond, determinant of the product of two matrices. Determinant of the inverse matrix.
Lecture 5-6	Systems of linear algebraic equations. Cramer's rule. Inverse matrix method. Kronecker-Capelli theorem. Gaussian method.	Practical lesson 4	Solution of systems by the method of Gauss, Cramer, inverse matrix. Basic, partial and general solution.		Elements of vector algebra and analytic geometry.
Lecture 7	Systems of linear algebraic homogeneous equations. Fundamental system of solutions.	Practical lesson 5	Finding the fundamental system of solutions.		Completion of individual homework on the topic: "Linear algebra".
Lecture 8-9	Basic concepts and symbols of set theory. Numerical sets. Variables. Function, ways of its task. Numerical sequence boundary and its simplest properties.	Practical lesson 6	Calculating the boundary of a numerical sequence by definition.		Classification of functions. Basic elementary functions, their properties and graphs. The concept of elementary function. The area of value and the area of definition of elementary functions.
Lecture 10	Infinitely small and infinitely large sequences. Boundary of monotonic sequence.	Practical lesson 7	Analytical calculation of sequence boundaries.		Arithmetic properties of boundaries. Supremum and infimum of a numerical set. The number "e" as the boundary of the monotonic sequence.
Lecture 11–12	The boundary of a function at a point and infinity (according to	Practical lesson 8	Calculating the boundaries of functions of such types of		Comparison of infinitesimal quantities. Properties are equivalent

	Heine). Boundary properties. Determining the boundary of a function using inequalities (according to Cauchy). The first and second significant boundaries and their consequences.		uncertainties, which are revealed by the first and second definite boundaries and their consequences. Table of infinitesimal functions.		to infinitesimal.
Lecture 13	Continuity of a function at a point and in an interval. Basic theorems on continuous functions. Classification of breakpoints of a function. Continuity of basic elementary functions.	Practical lesson 9	Investigation of functions for continuity. Finding breakpoints and determining the type of breaks. Graphic schematic representation of the graph of the function around the breakpoints.		Completion of individual homework on the topic: "Theory of boundaries".
Lecture 14–15	The concept of derivative, its geometric and physical meaning. Relationship between continuity and differentiation of a function. Rules of differentiation. Derivative of a compound function. Differentiation of implicit function. Logarithmic differentiation. Derivatives of basic elementary functions.	Practical lesson 10	Finding derivatives of compound functions, functions given implicitly. Consideration of cases for the application of logarithmic differentiation.		Improving the technique of differentiation.
Lecture 16	Functions and lines given parametrically. Differentiation of functions given parametrically.	Practical lesson 11	Finding derivative functions given parametrically.		Improving the technique of differentiation.
Lecture 17–18	Derivatives of higher orders, Leibniz's formula. Function differential. Invariance of the form of the first differential of the function. Higher order differentials.	Practical lesson 12	Calculation of higher order derivatives. Application of the method of mathematical induction.		Geometric and physical application of derivatives.
Lecture 19	Cases of non-differentiability of functions continuous at a given point. Fermat, Roll, Lagrange and Cauchy theorems.	Practical lesson 13	Application of the differential to approximate calculations.		
Lecture 20-21	Lopital's rule. Disclosure of exponential uncertainties. Taylor and McLaren formulas.	Practical lesson 14	Application of Lopital's rule to reveal different types of uncertainties encountered in calculating the boundaries of		Using Taylor's formula when calculating the boundaries of functions.

			functions of one variable. Decomposition of functions by Taylor and McLaren formulas.		
Lecture 22	Investigation of functions on monotonicity and extremum. Finding the largest and smallest values of a function on a segment.	Practical lesson 15	Determination of the monotonicity of the function. Finding extrema.		Composing and solving problems to find the largest and smallest values of a function on a segment.
Lecture 23-24	Inflection points of function, intervals of convexity and concavity. The second rule is to study the function to the extreme. Asymptotes of the graph of the function. Scheme of a complete study of the function and construction of its schedule.	Practical lesson 16	Complete study of the function and plotting.		Execution of individual homework on the topic: "Derivative and differential function of one variable.".
Part 2					
Lecture 1	Initial and indefinite integral.	Practical lesson 1	Properties, compiling a table of indefinite integrals. The simplest methods of integration.	**Individual work**	History of the origin and development of the theory of integration in mathematics.
Lecture 2	Integration by parts and replacement of a variable in the indefinite integral.	Practical lesson 2	Finding integrals using the theorem on the invariance of integration formulas. Integration by parts and replacement of a variable in the indefinite integral.		Complex numbers in algebraic form and actions on them. Geometric interpretation of a complex number. Parametric and trigonometric forms of complex numbers. Muawra's formula.
Lecture 3	Decomposition of a polynomial into factors. Rational fractions and their decomposition into the simplest.	Practical lesson 3	Finding integrals that contain a quadratic trinomial.		Binomial integral. Chebyshev's theorem.
Lecture 4	Integration of rational fractions and functions that rationally depend on trigonometric ones.	Practical lesson 4	Technique of integration of rational fractions. Methods of integration of trigonometric functions. Integration of some irrational and hyperbolic functions.		Work on computational and graphic individual homework to deepen knowledge of the calculation of the indefinite integral

Lecture 5	Defined integral; definition and geometric meaning. The simplest properties of a definite integral. Theorems on the mean integral.	Practical lesson 5	Problems that lead to the concepts of definite integral.			
Lecture 6	Sumi Darbu. Necessary and sufficient conditions for the existence of a definite integral. Integral with variable upper bound, its properties. Newton-Leibniz formula, the relationship between definite and indefinite integrals.	Practical lesson 6	Features of methods for calculating a definite integral. Integration by parts and replacement of a variable for a definite integral.		The average value of the function on the interval; estimation of a definite integral; integral with variables upper and lower limits of integration.	
Lecture 7	Calculating the area of a figure using a definite integral.	Practical lesson 7	Finding the area of a flat figure bounded by lines given analytically in the Cartesian coordinate system explicitly, in parametric form and implicitly.		Applying a definite integral to solving physical problems.	
Lecture 8	Calculation of arc length, body volume, surface area of rotation.	Practical lesson 8	Problems for finding the length of the arc, the volume of the body, the surface area of rotation in different ways of setting lines.		Application of a definite integral to calculate the boundaries of infinite sums.	
Lecture 9	Improper integrals of the first kind, their calculations. Signs of convergence. Improper integrals of the second kind, their convergence.	Practical lesson 9	Formulas of integration by parts and replacement of a variable in improper integrals. Determination of convergence by features.		Work on an individual computational and graphical problem on the application of a definite integral to solve physical and geometric problems, deepening knowledge on the calculation and study of the convergence of improper integrals.	
Lecture 10	Functions of several variables, their scope. Function boundary, continuity and discontinuities. Basic properties of continuous functions. Partial derivatives of functions of several variables. Differential function of several variables and its application to approximate calculations.	Practical lesson 10	Finding the domain of definition, the boundaries of the function of several variables.		Investigation of the continuity of the function of several variables.	
Lecture 11	Partial derivatives of compound functions. Invariance of the form of the first differential of the function.	Practical lesson 11	Calculation of partial derivatives and differentials.		Taylor's formula for the function of several variables and its application to approximate calculations.	

Lecture 12	Extreme function of several variables. A necessary condition of extremum. The concept of quadratic form and its sign significance. Sufficient extremum conditions. Conditional extremum of functions.	Practical lesson 12	Invention of the extremum of a function of several variables. Problems on the largest and smallest values of a function in a domain.		Scalar field. Derivative in direction, its properties and physical content. Gradi nt and its properties.	
Lecture 13	Tangent line and normal plane to the line in space; tangent plane and normal to the surface. Geometric content of the complete differential of the function of two variables.	Practical lesson 13	Geometric applications of functions of several variables.		Execution of individual calculation a nd graphic homework on the top ic: "Differential calculus of a function of several variables".	
Lecture 14	Definition of the double integral, its properties and geometric content. Calculation of the double integral over a rectangular domain.	Practical lesson 14	Calculation of the double integral in the Cartesian coordinate system.		Problems leading to the concept of dou le integral.	
Lecture 15	Calculation of the double integral over an arbitrary domain. Double integral in the polar coordinate system.	Practical lesson 15	Calculation of the double integral in the polar coordinate system. Finding the volumes of bodies using a double integral.		Some geometric and physical applications of double integrals.	
Lecture 16	Curvilinear integral of the second kind (coordinates). Definition, properties and physical content. Vector and scalar form.	Practical lesson 16	Calculation of the curvilinear integral. Application to the calculation of the variable force along a curvilinear path.		The first and second forms of the condit on of independence of the integral from he path of integration. Finding the function of two or three variables by its full differenti l.	
Lecture 17	Integral on a closed loop. Independence of the curvilinear integral from the line of integration. Green-Riemann formula.	Practical lesson 17	Application of the Green-Riemann formula.		Execution of individual calculation a nd graphic homework on the topic: "Integ ral calculus of a function of several variables' .	
Lecture 18	Differential equations, basic concepts. Ordinary differential equations. Differential equations with separated variables. Homogeneous functions of two variables and homogeneous differential equations.	Practical lesson 18	Methods for solving homogeneous differential equations and some types of equations that are reduced to homogeneous.		Problems that lead to the solution of differential equations.	
Lecture 19	Differential equations "in complete differentials". Integrating factor. Cauchy problem, Cauchy theorem.	Practical lesson 19	Solving differential equations "in complete differentials".		Differential equations that are reduced to separate variables by replacing an unkno vn function.	
Lecture 20	Linear first-order differential equations and Bernoulli equations.	Practical lesson 20	Solving first-order linear differential equations.			

Lecture 21	Types of singular points of differential equations: node, center, focus. Secondary differential equations, basic concepts.	Practical lesson 21	Differential equations of the second and higher orders, which involve a decrease in order.			
Lecture 22	Linear homogeneous differential equations of the second and higher orders, their general properties. Linear inhomogeneous differential equations and their properties.	Practical lesson 22	Linear homogeneous differential equations with constant coefficients. Method of variation of arbitrary constants.		Euler and Bessel differential equations.	
Lecture 23	The principle of superposition of solutions. Linear dependence and independence of functions. Fundamental system of solutions of differential equations. Theorem on the structure of the general solution of a linear homogeneous differential equation of the second and higher orders.	Practical lesson 23	Linear inhomogeneous differential equations with right parts of special form.		Vronsky's determinant. Theorem on the existence of a fundamental system of solutions. Theorem on nonsingular linear transformation of a fundamental system of solutions.	
Lecture 24	Systems of linear differential equations with constant coefficients.	Practical lesson 24	Improving the technique of solving differential equations and systems of differential equations of different types.		Work on individual calculation and graphic homework to deepen the knowledge, skills and abilities to solve differential equations and systems of differential equations.	
Lecture 25	Numerical sign series, basic concepts. A necessary sign of convergence. Properties of convergent series. Sufficient features based on the comparison of series. D'Alembert sign, radical and integral Cauchy signs.	Practical lesson 25	Numerical series. Research on the convergence of sign-constant series.			
Lecture 26	Intermittent series, a sign of Leibniz. Alternate series. Absolute and conditional convergence.	Practical lesson 26	Research on absolute and conditional convergence of alternating series.			
Lecture 27	Functional series, basic concepts. Power series, Abel's theorem. Interval and radius of convergence of power series. Properties of power series.	Practical lesson 27	Functional series. Finding the area of convergence. Power series. Finding the convergence interval.		Uniform convergence, a sign of Weierstrass. Basic properties of uniformly convergent functional series.	
Lecture 28	Development of functions in Taylor and McLaren power series. Approximation of calculation of	Practical lesson 28	Development of functions in power series.		Fourier series.	

	functions and integrals by means of power series.					
Lecture 29	Elements of the theory of functions of a complex variable.	Practical lesson 29	Differentiation and integration of functions of a complex variable.		Calculation of integrals by Cauchy integral formulas. Laurent series functions of a complex variable. Finding special points of functions and surpluses. Application of the theory of surpluses to the calculation of integrals.	
Lecture 30	Operating calculus. Laplace transform, basic concepts and properties (linearity theorem, similarity theorem, shift theorem and delay theorem).	Practical lesson 30	Finding images of functions. Duhamel integral. Finding the original by its image.		Table of images of the main functions.	
Lecture 31	Theorems of differentiation and integration of the original and the image. Convolution of two functions. Image multiplication theorem.	Practical lesson 31	Application of the Duhamel integral to the solution of differential equations.		Development formula.	
Lecture 32	Solving differential equations and their systems by the operational method.	Practical lesson 32	Solve linear differential equations with constant coefficients using operational calculus.		Work on individual calculation and graphic homework on the topic: "Operational calculus".	

RECOMMENDED READING

Compulsory	1. Zavalo, S. T. (1985). Course of algebra. Kyiv: Higher School. 2. Demidovich, B. P. (1997). Collection of problems and exercises in mathematical analysis. Москва: ЧеРо. 3. Ilyin, V. A., Poznyak, E. G. (2007). Linear algebra. Москва: Физматлит. 4. Fichtenholtz, G. M. (2019). Course of differential and integral calculus: a textbook. In (Vol. 1-3) s. Vol. 1. St. Petersburg: Doe. 5. Fichtenholtz, G. M. (2020). Course of differential and integral calculus. (Vol. 1-3) s. Vol. 2. St. Petersburg: Doe.	**Recommended**	1. Arkhipov, G. I., Sadovnichy, G. I. (2004). Lectures on mathematical analysis. Москва: Дрофа. 2. Demidovich, B. P. (2001). A short course of higher mathematics. Москва: Астрель. 3. Gevorkyan, Yu. L., Grigoriev, A. L. (2002). Fundamentals of linear algebra and its applications in engineering. Kharkiv, NTU "KhPI". 4. Kletenik, D. V. (2018). Collection of problems in analytical geometry. Санкт Петербург: Лань. 5. Shipachev, V. S. (2005). Higher Mathematics. Санкт-Петербург: Лань.

Academic integrity

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to show discipline, politeness, friendliness, honesty, responsibility.

The syllabus in content fully corresponds to the work program of the course.