Силабус освітнього компонента
Програма навчальної дисципліни

Higher Mathematics

Шифр та назва спеціальності
274 - Motor vehicle transport

Інститут
IES in Mechanical Engineering and Transport

Освітня програма
Motor vehicle transport

Кафедра
Applied Mathematics (170)

Рівень освіти
Bachelor

Тип дисципліни
General Education Course, mandatory

Семестр
1-4

Мова викладання
English

Викладачі, розробники

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Candidate of Sci. in Engineering, Associate Professor

With 24 years of work experience, I have authored over 60 scientific and educational-methodological works, including contributions to high-rank international journals indexed in science metrics databases such as Scopus and Web of Science. I have presented reports at distinguished international conferences. My extensive teaching experience encompasses a diverse range of mathematics courses, involving linear algebra, analytic geometry, mathematical analysis, differential equations, series theory, and field theory.

More details on the web-page: Детальніше про викладача на сайті кафедри

Загальна інформація

Анотація

The "Higher Mathematics" course is tailored to form students' theoretical understanding and foster practical skills in the application of mathematical concepts and mathematical methods of specific sections of higher mathematics relevant to engineering disciplines. This course contributes to the development of skills in analyzing and modeling various processes, utilizing information and communication technologies when necessary.

Мета та цілі дисципліни

The purpose of this course is to equip students with the essential mathematical knowledge and skills required for successful professional engagement in the fields of mechanical engineering and electrical engineering. This knowledge serves as a crucial foundation for the subsequent study of disciplines incorporated into the training program within this field. The course fosters the development of logical thinking and the establishment of a solid mathematical groundwork, which is particularly vital for conducting research and solving applied problems.

Формат занять

Lectures, practical classes, individual independent work, consultations. The final control is an exam.

Компетентності

GC01. Ability to abstract thinking, analysis and synthesis.
GC02. Ability to apply knowledge in practical situations.
GC05. Ability to search, process and analyze information from various sources.
GC06 Ability to learn and master modern knowledge.
GC12. The ability to solve practical problems involving the methods of mathematics, physics and engineering.

Результати навчання

LR01. Students are expected to acquire proficiency in linear and vector algebra, analytic geometry, and the theory of limits. Furthermore, they should be adept at applying fundamental concepts and methods from the course to solve specialized problems within the domains of industrial and electric power engineering.

Обсяг дисципліни

570 hours (19 ECTS credits): lectures – 96 hours, practical classes – 144 hours, individual independent work – 330 hours

Передумови вивчення дисципліни (пререквізити)

To successfully pass the course, you need to have knowledge and skills from the elementary mathematics course of high school.

Особливості дисципліни, методи та технології навчання

The 'Higher Mathematics' course is delivered through a combination of lectures, practical classes, and consultations that incorporate multimedia technologies, in particular, Microsoft Office 365 Teams. Additionally, students engage in individual independent study to master the educational material and complete individual educational tasks.

Програма навчальної дисципліни

Теми лекційних занять

Semester 1
Topic 1 – Elements of linear algebra.
Matrices. Matrix operations. Determinats of 2-nd and 3-d order, computation. Solving system of linear algebraic equations (SLAE) by Cramer's rule. Cofactors. Main properties of determinants. Inverse matrix. Solving SLAE using inverse matrix. Basic minors and matrix rank. Matrix elementary transforms. Computing matrix rank. SLAE. Kronecker-Capelli theorem. Gaussian elimination method for solving SLAE. Methods by Jordan-Gauss for solving SLAE. Finding the fundamental system of solutions of homogeneous SLAE.
Topic 2 – Elements of vector algebra.
Concept of vector. Linear operations on vectors. Decomposition of the vector in basis. Projection of vector on axis. Coordinates in Cartesian coordinate system. Vector coordinates. Vector operations in coordinates. Vectors dot product. Condition of perpendicularity. Vector cross product. Condition of collinearity. Vector mixed product. Condition of complanarity.
Topic 3. – Elements of analytic geometry
General equation of plane in Cartesian coordinate system. Different types of planes' equations. Line in space - various types of equations of straight line in space. Mixed problems of plane and line in 3-D space. Line in plane. Canonic equations of second order curve: circle, ellipse, hyperbola, parabola. Reducing of the general second order equations to canonical equations of the curves
Topic 4. Limits and continuity of functions.

Elements of theory of sets. Number sequences. Limit of number sequence. Basic elementary functions. Limit of function at point and at infinity. Infinitudes and infinitesimals. Properties of infinitesimals. Main theorems of function limits. Limit exitance tests. Comparing infinitesimals. Properties of equivalent infinitesimals. First and second remarkable limits. Continuous functions. Properties of continuous functions. Classification of discontinuities.

Semester 2

Topic 1 – Derivative. Differentiation technique.

Definition of derivative, its mechanical and geometrical applications. Differentiation rules. Derivatives of basic elementary functions. Differential of function. Higher order derivatives and differentials. Approximate computations using differential.

Topic 2 – Applying derivative of function of single variable for investigating functions and plotting graphs.

Basic theorems of differential calculus: Rolle's, Cauchy's and Lagrange's theorems. L'Hospital's rule. Intervals of monotonicity, extrema. Necessary and sufficient conditions for extrema. Maximum and minimum of function on segment. Convexity and concavity of function graph, inflexion points. Necessary and sufficient conditions. Asymptotes of function graph. General scheme for investigation and plotting of functions.

Topic 3 – Antiderivative and Indefinite Integral.

Notion of primitive and antiderivative. Basic properties of antiderivatives. Table of basic antiderivatives. Simplest integration techniques - direct integration through reduction to standard integrals, integration by parts, and substitution method. Integrating functions containing quadratic polynomial. Notion of rational fractions. Complex numbers and operations with them. Expansion of proper rational fractions in sum of simple fractions. Integrating rational fractions. Integrating trigonometric functions and functions containing irrationality.

Topic 4. – Definite integral and its applications

Definite integral. Classes of integrable functions. Properties of definite integral. Integral with variable lower and upper limit. Newton-Leibniz formula. Integrating by parts and change of variables for definite integral. Integrating even and uneven functions over symmetric interval. Polar coordinate system. Computing areas of plain regions. Length of curve segment. Parametric equation of curve. Computing length of curve segment. Volume of body of revolution. Improper integrals. Basic properties. Convergence tests.

Topic 5. Function of several variables.

Function of two variables. First order partial derivatives. Total differential of function of two variables. Higher order partial derivatives and differentials. Equation of surface tangent plane and normal. Extrema of function of two variables. Scalar field. Directional derivative. Gradient.

Semester 3

Topic 1. Differential equations.

Differential equations of the first order. Integrated types of differential equations of the first order: with separable variables, linear. The fundamental theory of linear differential equations. Linear Homogeneous Differential equations (LHDE). The fundamental system of LHDE. Differential equations of higher orders. General conceptions. Some types of the second order differential equations reducible to the first order equations. Linear differential equations of the second order. The general theorems. Wronskian's determinant. Ostrogradskiy-Liuvill's formula. Homogeneous linear equations of the second order with constant coefficients. Systems of Differential Equations. General Concept and Definition. Systems of Linear Differential Equations. Method of Elimination.

Topic 2. Integral calculus for functions with several variables.

Double integral. Some problems leading to concept of the double integrals. Calculation of the double integrals in the Cartesian coordinate system. Curvilinear coordinates on the plane. Change of the variables in the double integrals. Physical applications of the double integral. Triple integral calculation and applications. Calculation of the triple integral in the Cartesian coordinates system, in cylindrical and spherical coordinate systems. Curvilinear integrals of the I-st kind and II-nd kind (line integrals). Calculation, physical and geometrical properties. Connection between line integrals and curvilinear integrals of the first kind. Green's formula. Surface integrals of the I-st and of the II-nd kind. Physical and geometric properties of these integrals.

Semester 4

Topic 1. Field Theory.

Definitions of scalar and vector fields. Level surfaces and lines, directional derivatives, gradient of scalar fields. Vector lines of vector fields. Concept of the flux of the vector field. The divergence of the field. The theorem by Ostragradsky-Gauss. Linear integral of the vector field. Circulation. Concept of the curl. The theorem by Stokes in vector form. Types of the vector fields. Finding the potential of the potential fields.

Topic 2. Series.

Concepts of the numerical series and the convergence of it. Properties of the convergent series. Necessary condition for convergence. Comparison of the series with positive terms. Two comparison tests for convergence. D'Alembert's ratio test for convergence. Integral and radical tests by Cauchy for convergence. Plus-and-minus series. Absolute and conditional Convergence. Alternating series. Theorem by Leibniz. Functional series. Uniform convergence. Test by Weierstrass. Integration and differentiation of the functional series. Power series. Abel's theorem. Taylor's series and Maclaurin's series. Expansion the functions in Taylor's series and Maclaurin's series.

Теми практичних занять

According with lectures:

Semester 1

Topic 1 – Elements of linear algebra

Matrix operations. Computing determinants of 2-nd and 3-d order. Solving SLAE by Cramer's rule. Computing inverse matrix. Solving SLAE using inverse matrix. Computing matrix rank. Studying consistence of SLAE. Gaussian elimination method for solving SLAE. Solving SLAE by the Jordan-Gauss method. Homogeneous systems.

Topic 2 – Elements of vector algebra.

Linear operations on vectors. Decomposition of vector. Coordinates in new basis. Vectors dot product. Vector cross product. Vector mixed product.

Topic 3. Elements of analytic geometry

Solving the problems on finding the equation of plane in space. Line in space. Mixed problems on a plane and a straight line in space. Problems on finding the equation of straight line in plane. Second order curves, determining curve type (circle, ellipse, hyperbola, parabola), plotting curves. Finding the canonical equations of the second order curves by compliting the full square.

Topic 4. Limits and continuity of functions.

Basic functions. Domain of function. Limit of number sequence. Limit of function. Evaluating indeterminate forms $\left\|\frac{\infty}{\infty}\right\|$, $\|\infty-\infty\|$, $\left\|\frac{0}{0}\right\|$, $\|0\cdot\infty\|$. Computing limits using first and second remarkable limits. Evaluating indeterminate form $\|1^{\infty}\|$. Studying function continuity property.

Semester 2

Topic 1 – Derivative. Differentiation technique

Differentiation technique. Differential of function. Higher order derivatives and differentials.

Topic 2 – Applying derivative of function of single variable for investigating functions and plotting graphs.

L'Hospital's rule. Studying function monotonicity. Extrema of function. Determining minimum and maximum of function on segment. Intervals of convexity and concavity of function graph, inflexion points. Determining function asymptotes. Investigating functions using derivatives and plotting their graphs.

Topic 3 – Antiderivative and Indefinite Integral.

Table of integrals. Simplest integration techniques. Invariability of integration formulae. Integration methods: direct integration through reduction to standard integrals, integration by parts, and substitution method. Integrating functions containing quadratic polynomials. Complex numbers and operations with them. Integrating rational fractions. Integrating trigonometric functions and functions containing irrationality.

Topic 4. Definite integral and its applications

Newton-Leibniz formula. Integrating by parts and change of variables for definite integral. Computing areas of plain regions. Computing length of curve segment. Volume of body of revolution. Studying convergence of first and second kind improper integrals.

Topic 5. Function of several variables.

Domain of functions of several variables. Techniques for computing first and second order partial derivatives of functions of several variables. Equation of surface tangent plane and normal. Extrema of

function of two and more variables. Conditional extremum of function of two and more variables. Methods for solving problems on extremum.

Semester 3

Topic 1. Differential equations.

Integration of the equations with separable variables. Integration of the homogeneous differential equations in Euler's sense. Integration of the linear equations. Integration of the Bernoulli's Equations. Some types of the second order differential equations reducible to the first order equations. Linear differential equations of the second order. Homogeneous linear equations of the second order with constant coefficients. Systems of Differential Equations. Systems of Linear Differential Equations. Method of Elimination.

Topic 2. Integral calculus for functions with several variables.

Calculation of the double integrals in the Cartesian coordinate system. Curvilinear coordinates on the plane. Change of the variables in the double integrals. Physical applications of the double integral. Triple integral calculation and applications. Calculation of the triple integral in the Cartesian coordinates system, in cylindrical and spherical coordinate systems. Curvilinear integrals of the I-st kind and II-nd kind (line integrals). Calculation, physical and geometrical properties. Connection between line integrals and curvilinear integrals of the first kind. Green's formula. Surface integrals of the I-st and of the II-nd kind. Physical and geometric properties of these integrals.

Semester 4

Topic 1. Field Theory.

Definitions of scalar and vector fields. Level surfaces and lines, directional derivatives, gradient of scalar fields. Vector lines of vector fields. Concept of the flux of the vector field. The divergence of the field. The theorem by Ostragradsky-Gauss. Linear integral of the vector field. Circulation. Concept of the curl. The theorem by Stokes in vector form. Types of the vector fields. Finding the potential of the potential fields.

Topic 2. Series.

Necessary condition for convergence. Comparison of the series with positive terms. Two comparison tests for convergence. D'Alembert's ratio test for convergence. Integral and radical tests by Cauchy for convergence. Plus-and-minus series. Absolute and conditional Convergence. Alternating series. Theorem by Leibniz. Functional series. Uniform convergence. Test by Weierstrass. Integration and differentiation of the functional series. Power series. Abel's theorem. Taylor's series and Maclaurin's series. Expansion the functions in Taylor's series and Maclaurin's series.

Теми лабораторних робіт

Not provided

Самостійна робота

The course involves students' engagement with lecture materials, preparation for practical classes, completion of individual tasks, and readiness for tests. Supplementary materials for individual independent study on course topics are also provided to students. Throughout the semester, students are evaluated on their performance in individual home tasks (IHZ), which are composed of assignments aligned with the semester's themes, namely:

1. Studies on revising school material in algebra and geometry.
2. Solving homogeneous systems of linear algebraic equations using Jordan-Gauss method.
3. Double Vector product.
4. Equation of lines in plane in the polar coordinate system.
5. Surfaces in space.
6. Comparison of infinitisemals.
7. Revising lecture contents on limits and continuity of functions.
8. Investigating function using derivative and plotting thier graphs.
9. Integration of functions with quadratic irrationality in the denominator and a polynomial in the numerator, utilizing the Gauss-Ostrogradsky formula.
10. Computing area of plane region, length of plane curve segment, volume of body of revolution in polar coordinates.
11. Equations of surface tangent plane and normal using the gradient definition.
12. Lagrange method for finding conditional extremum of functions of several variables.

13. Equations not solved for derivative. Equations by Lagrange and Clairaut.
14. Fourier's series for even and odd functions. The expansion of a nonperiodic function in a Fourier's series.

Література та навчальні матеріали

Basic references

1. Rudnyeva G.V. Elements of linear algebra and analytic geometry. Second revised and expanded edition: textbook / G.V.Rudnyeva – Kharkiv: Panov A.M., 2020. – 236 p.
2. Higher mathematics. Problem solving and variants of typical calculations. Edited by Dr.Sci.Tech. Kurpa L.V. – Kharkiv: NTU "KhPI", 2004. – Volume 1.
3. Kurpa L.V., Shmatko T.V. Differential and Integral Calculus for One Variable Functions: Textbook. – Kharkiv: NTU KhPI: 2017.-324 pages

Additional references

4. Tolasa F.T. Matrix and Determinant: Matrix, determinant, system of linear equation and methods of solving linear equation. LAP LAMBERT Academic Publishing, 2021. - 52 pages
5. Terri Manthey, College Algebra for the Managerial Sciences.
6. Howard Anton, Calculus with Analytic Geometry, 3rd ed., New York, John Wiley & Sons, 1988
7. Mahmudov E. Single Variable Differential and Integral Calculus: Mathematical Analysis. Atlantis Press, Paris, France, 2013. - 369 pages

Система оцінювання

Критерії оцінювання успішності студента та розподіл балів

The final grade for the semester is determined by combining the points earned during the semester (80 points) and those obtained in the exam (20 points). The exam comprises a written assignment, which includes one theoretical question and two practical problem-solving questions, followed by an oral presentation.
The current evaluation, accounting for 80%, comprises three control works, three individual obligatory tasks, and two tests. During the intervals between modular knowledge assessments, students are engaged in independent work, as outlined in the educational program.

Шкала оцінювання

Сума балів	Національна оцінка	ECTS
90–100	Відмінно	A
82–89	Добре	B
75–81	Добре	C
64–74	Задовільно	D
60–63	Задовільно	E
35–59	Незадовільно (потрібне додаткове вивчення)	FX
1–34	Незадовільно (потрібне повторне вивчення)	F

Норми академічної етики і політика курсу

The student is required to adhere to the Code of Ethics for Academic Relations and Integrity of NTU 'KhPI,' demonstrating discipline, education, benevolence, honesty, and responsibility. Any conflict situations should be openly discussed within study groups with the teacher. If it proves impossible to resolve the conflict at this level, it should be brought to the attention of the institute's directorate employees.
The regulatory and legal support for implementing the principles of academic integrity at NTU 'KhPI' is available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Погодження

Syllabus approved by	Date of approval, signature	Head of the AM Department

Vyacheslav BURLAYENKO

Date of approval, signature

Garantee of EP for Motor vehicle transport
Andrii KOZHUSHKO