UG Semester III

Paper 5: Ordinary Differential Equations

Credit: 4   T:04

Course Outcomes:

1. Formulate Differential Equations for various Mathematical models.
2. Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.
3. Apply these techniques to solve and analyze various mathematical models.

UNIT I

Differential Equations of first order and first degree, variable separable equations and equations reducible to this form, linear equations and Bernoulli equations, Exact differential equations and integrating factors, special integrating factors and transformations. Differential Equations of first order and higher degree, Clairaut equation, singular solutions. Orthogonal trajectories.

UNIT II

Linear Differential Equations with constant coefficients, homogeneous linear equation with constant coefficients, Wronskian, its properties and applications. Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters,

UNIT III

Systems of first order equations, linear systems, homogeneous linear systems with constant coefficients, Volterra's prey predator equations,

Existence and uniqueness of solutions, method of successive approximations, Picard's theorem, Application to systems of first order equations.

UNIT IV

Series solutions of differential equations, Power series method. Bessel, Legendre and Hypergeometric functions and their properties, recurrence and generating relations.

References Text Books:

1. B. Rai, D.P. Choudhary & H.J. Freedman, A Course in Differential Equations.
2. S. L Ross, Differential Equations, 3rd Edition, Wiley

Suggested Readings:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org

https://openlearninglibrary.mit/edu/courses

http://heecontent.upsdc.gov.in/SearchContent.aspx https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 6: Mechanics

Credit: 4   T:04

Course Outcomes:

1. The significance of mathematics involved in physical quantities andtheir uses.
2. To understanding the various concepts of basic mechanics like simple harmonic motion, motion under other laws and forces.
3. To study and to learn the cause-effect related to these.
4. The applications in observing and relating real situations/structures.

UNIT I

Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and planes.

UNIT II

Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform strength.

UNIT III

Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves.

UNIT IV

Motion of particles of varying mass, Rocket motion, Central orbit, Kepler's laws of motion, Motion of particle in three dimensions, Rotating frame of reference, Rotating Earth, Acceleration in terms of different coordinatessystems.

References Text Books:

1. R.C. Hibbeler, Engineering Mechanics-Statistics
2. Nelson, Engineering Mechanics- Dynamics, Tata McGraw Hill

Suggested Readings:

1. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org

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(For students with Mathematics as a minor subject)

Applicable Mathematics– III

Credit: 4   T:04

Course Outcomes:
1. To know the basic concepts of complex analysis including Cauchy's integral formula, derivative of analytic functions, Taylor's and Laurent's series.
2. To understand various methods for numerical solutions of equations.
3. To know how to do numerical differentiation and integration.
4. To solve systems of linear equations by standard methods.

UNIT I

Functions of complex variables - analytic functions, Cauchy - Riemann equations, harmonic functions, Cauchy's integral theorem, Cauchy's integral formula, derivatives of analytic functions, formulae for first, second and nth derivatives, Taylor's and Laurent's series, singularities, zeroes and poles of order n.

UNIT II

Numerical solutions of equations - bisection method, secant method, regula -falsi method, Newton - Raphson method and interpolation with equispaced points.

UNIT III

Finite differences, Newton's forward and backward interpolation formula, Lagrange interpolation formula, divided differences and Newton's formula, numerical differentiations and integration - trapezoidal and Simpson's rules, Newton-Cotes integration formula, Ramberg integration, Gaussian quadrature.

UNIT IV

Systems of linear equations - Gauss elimination method, Gauss-Jordan method, LU decomposition, Jacobi method, Gauss - Seidel method, the algebraic eigenvalue problem - Jacobi's method and power method.

References:
Textbooks

1. J.W. Brown & R.V. Churchill : Complex Variables and Applications, Mc Graw Hill.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain : Numerical methods for scientific and engineering mathematics, New Age International, New Delhi

Suggested Books:

1. S.S. Sastry : Introductory Methods of Numerical Analysis, Prentice Hall of India.
2. Complex Variables, Schaum's Outline Series

Elements of Discrete Mathematics

Credit: 04   T: 04

UNIT I

Integers, Division algorithm, Divisibility, Prime Numbers, Set theory Set operations: union, Intersection, set difference, de Morgan's rule.

UNIT II

Relation, Functions, Principle of inclusion and exclusion, Mathematical induction, sequences: A.P., G.P. and H.P., The pigeonhole principle, Fundamental principle of counting, Permutations, Combinations, Repetitions, dearrangement.

UNIT III

Binomial theorem, Binomial coefficient properties, Recurrence relations & general functions.

UNIT IV

Arithmetic or number theoretic functions, multiplicative functions, Euler ϕ-function, $\tau(n)$, $\sigma(n)$, $\sigma k(n)$, Partition of numbers, Ferrer's diagram.

Recommended Books
1. Richard A. Brualdi, Introductory Combinatorics, Pearson.
2. David M. Burton, Elementary Number Theory.

Paper 7: Mathematical Methods

Credit: 4   T:04

Course Outcomes:
1. To develop mathematical skills in calculus and analysis.
2. To get knowledge of Laplace Transforms and Fourier series.
3. To get acquainted with the essentials of calculus of variations.

UNIT I

Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence.

UNIT II

Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.

UNIT III

Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

UNIT IV

Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form.

References:
Text Books:
1. T.M. Apostol. Mathematical Analysis, Pearson
2. RG Bartle, Introduction to Real Analysis, Wiley India

Suggested Readings:
1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata-McGraw Hill
2. A.S. Gupta, Calculus of Variations with Applications Prentice Hall India.

Web References:
Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
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https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 8: Linear & Abstract Algebra

Credit: 4   T:04

Course Outcomes:

1. The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.
2. The concept of linear independence of vectors over a field, the idea of basis and the dimension of a vector space.
3. Basic concepts of linear transformations, the Rank-Nullity Theorem, matrix of a linear transformation and the change of basis.
4. Automorphisms for constructing new groups from the given group.
5. Group actions, Sylow theorems and their applications to check nonsimplicity.
6. Compute inner products and determine orthogonality on vector spaces.

Unit I

Automorphism, inner automorphism, automorphism groups and their computations, Conjugacy relations, Normaliser, Counting principle and the class equation of a finite group, Center of group of prime power order, simple groups, Group action, Burnside lemma, Sylow theorems and its applications.

Unit II

Prime and maximal ideals, Euclidean Rings, Principal ideal rings, Polynomial Rings, Polynomial over the Rational Field, The Eisenstein Criterion, Polynomial Rings over Commutative Rings, unique factorization domain.

Unit III

Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and dimension, Quotient space, Linear transformations, Direct sums, The Algebra of linear transformations, rank nullity theorem, their representation as matrices, Linear functionals, Dual space, Characteristic values, Cayley Hamilton Theorem.

Unit IV

Inner product spaces, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process, Bilinear and Quadratic forms.

References:

Text books:

1. Topics in Algebra by I. N. Herstein.
2. Algebra by V. Sahai and V. Bist
3. Linear Algebra by V. Sahai and V. Bist

Suggested Readings:
1. Linear Algebra by K. Hoffman and R. Kunze.

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org

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http://heecontent.upsdc.gov.in/SearchContent.aspx https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

(For students with Mathematics as a minor subject)

Applicable Mathematics– IV

Credit: 4   T:04

Course Outcomes:
1. To understand application and techniques of solving various types of ordinary differential equations.
2. To understand the Laplace transforms and its applications in solving differential equations.
3. To understand Fourier series and Fourier transforms.
4. To understand standard techniques for finding numerical solution of ordinary differential equations.

UNIT I

Ordinary differential equations - Bernoulli's equation, exact differential equations and integrating factors, special integrating factors and transformations, differential equations of order one and degree more than one, Clairaut's equation, singular solutions and orthogonal trajectories, Linear differential equations with constant coefficients, homogeneous Linear differential equations, series solutions of Legendre's, Bessel's and hypergeometric equations and their basic properties.

UNIT II
Laplace transforms - existence theorem, Laplace transforms of derivatives and integrals, inverse Laplace transform, convolution theorem, applications to simple linear differential equations.

UNIT III
Periodic functions, Fourier series, Fourier expansion of piecewise monotonic functions, half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

UNIT IV
Numerical solution of ordinary differential equations - Taylor series method, Euler's method, Runge - Kutta method, Milne's method, Adam's method.

References:
Textbooks
1. G. F. Simmons : Differential Equations with Applications and Historical Notes, Tata McGraw Hill.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain : Numerical methods for scientific and engineering computations, New Age International, New Delhi.
3. T. M. Apostol : Mathematical Analysis.

Vocational Course in Mathematics
For B.A./B.Sc. Semester IV

Elementary Cryptography

Credit: 4   T:04

Course Outcomes:
1. Use modern symmetric key algorithms for cryptography
2. Use modern asymmetric key algorithms for cryptography
3. To examine the issues and structure of modern stream and block ciphers

UNIT I
Congruence, system of linear congruence, Chinese remainder theorem, discrete logarithm

UNIT II
Field, finite field, construction of Galois finite fields, modulo polynomial arithmetic, finding inverse of an element in finite fields, extended Euclidean algorithm for finding inverse

UNIT III
General structure of modern stream and block cipher, RC-4 stream cipher, AES block cipher

UNIT IV
Asymmetric key cryptography, Discrete log problem, Diffee Hellmen key exchange protocol, Factorization problem, RSA and EL Gaml asymmetric key cryptosystem and their cryptanalysis.

Recommended Books:
1. Cryptography and network security by Behrouz A. Forouzan
2. Cryptography and network security: principles and practice by Stalling William