ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

Model Syllabus for 4-Year UG Honours in B.Sc. (Mathematics) as Major in consonance with Curriculum framework w.e.f. AY 2025-26

COURSE STRUCTURE (for Semester I to VI)

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
I	I	1	Differential Equations	4	5
		2	Solid Geometry	4	5
	II	3	Group Theory	4	5
		4	Elementary Real Analysis	4	5
II	III	5	Ring Theory	4	5
		6	Advanced Real Analysis	4	5
		7	Theory of Matrices	4	5
	IV	8	Linear algebra	4	5
		9	Vector Calculus	4	5
		10	Linear Programming Program	4	5
III	V	11	Special Functions	4	5
		12 A	Laplace Transforms	4	5
		OR			
		12 B	Foundations of Automata Theory	4	5
		13 A	Numerical Methods	4	5
		OR			
		13 B	Mathematical Methods using MatLab	4	5

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
	VI	**14 A**	Integral Transforms	**4**	**5**
		OR			
		14 B	Statistical Analysis using R	**4**	**5**
		15 A	Advanced Numerical Methods	**4**	**5**
		OR			
		15 B	Mathematical Computations using Python	**4**	**5**

Note: In the III Year (during the V and VI Semesters), students are required to select a pair of electives from one of the **Two** specified domains. **For example: if set 'A' is chosen, courses 12 to 15 to be chosen as 12 A, 13 A, 14 A and 15 A.** To ensure in-depth understanding and skill development in the chosen domain, students must continue with the same domain electives in both the V and VI Semesters.

SEMESTER-I

COURSE 1: DIFFERENTIAL EQUATIONS

Theory	**Credits: 4**	**5 hrs/week**

Course Objectives

1. To introduce the concepts and methods for solving first-order differential equations, including exact, linear, and Bernoulli equations.
2. To understand special types of first-order differential equations such as Clairaut's equations and those solvable for p, x or y.
3. To develop techniques for solving higher-order linear differential equations with constant coefficients.
4. To apply the operator method for finding particular integrals of non-homogeneous differential equations with various types of right-hand side functions.
5. To learn the method of variation of parameters for solving non-homogeneous differential equations.

Course Outcomes

After successful completion of the course, the student will be able to

1. Solve exact differential equations, linear equations, Bernoulli's equations, and equations reducible to exact form using integrating factors.
2. Analyze and solve first-order differential equations that are solvable for p, , and y, including Clairaut's equations.
3. Solve homogeneous and non-homogeneous linear differential equations of higher order with constant coefficients using operator methods.
4. Compute particular integrals for non-homogeneous equations when the right-hand side is a polynomial, exponential, or trigonometric function.
5. Solve non-homogeneous differential equations using the method of variation of parameters and other applicable techniques.

Unit – 1

Exact Differential Equations - Integrating factors - Equations reducible to Exact Equations by Integrating Factors **(i)** $\frac{1}{Mx+Ny}$ **(ii)** $\frac{1}{Mx-Ny}$ - Linear Differential Equations – Bernoulli's Equations

Unit – 2

Equations solvable for p, Equations solvable for y, Equations solvable for x – Clairaut's equation

Unit – 3

Solutions of homogeneous linear differential equations of second and higher order with constant coefficients *f(D)y = 0* - Solutions of non-homogeneous linear differential equations *f(D)y = Q(x)* of second order with constant coefficients by means of polynomial operators (i) $Q(x) = b\,e^{ax}$ where b is a real constant - (ii) $Q(x) = Sin\ ax$ (or) $Cos\ ax$ where a is a real constant.

Unit – 4
Solution to a non-homogeneous linear differential equations of second order with constant coefficients by means of polynomial operators $Q(x) = b\,x^k$, $Q(x) = e^{ax}\,V$, where V is a function of x.

Unit – 5
Solution of the non-homogeneous linear differential equations of second order with constant coefficients by means of polynomial operators $Q(x) = x\,V$, where V is a function of x – Problems on Method of Variation of parameters to find solutions of linear differential equations with variable coefficients.

Activities
The activities planned throughout the Differential Equations course include a variety of interactive and evaluative methods such as quizzes, assignments, seminars, and student presentations. Students will also engage in a mini project, prepare concept flowcharts, and participate in operator method chart activities. Peer teaching sessions, LMS-based online quizzes, and board work challenges will foster collaborative and digital learning. Additionally, poster presentations on applications and visual aids like chalk talks will be incorporated to support diverse learning styles and deepen conceptual clarity.

Text Book

Differential Equations and Their Applications by Zafar Ahsan, published by Prentice-Hall of India Pvt. Ltd, New Delhi-Second edition.

Reference Books

1. Ordinary and Partial Differential Equations by Dr. M.D. Raisinghania, published by S. Chand & Company, New Delhi.
2. Differential Equations with applications and programs – S. Balachandra Rao & HR Anuradha- Universities Press.
3. Differential Equations -Srinivas Vangala & Madhu Rajesh, published by Spectrum University

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SEMESTER-I

COURSE 2: SOLID GEOMETRY

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce fundamental concepts of planes, lines, and spheres in 3D geometry.
2. To develop analytical skills for deriving equations of planes, lines, and spheres in different forms.
3. To analyze geometric relationships, including angles, distances, and intersections between lines, planes, and spheres.
4. To study advanced properties of spheres, such as tangents, polar planes, and orthogonality conditions.
5. To apply geometric principles to solve problems involving coplanarity, shortest distances, and sphere-line/plane interactions.

Course Outcomes

After completing this course, students will be able to

1. Derive and interpret equations of planes and lines in various forms.
2. Compute angles, distances, and intersection conditions between geometric elements (lines, planes, spheres).
3. Determine coplanarity of lines and solve problems involving shortest distances in 3D space.
4. Analyse sphere-related problems, including tangents, intersections, and circle equations in 3D.
5. Apply advanced concepts like polar planes, conjugate points, and orthogonality conditions of spheres.

Course Content

Unit – 1
Equation of plane in terms of its intercepts on the axis - Equations of the plane through the given points - Length of the perpendicular from a given point to a given plane - Bisectors of angles between two planes - Combined equation of two planes

Unit – 2
Equation of a line in various forms - Angle between a line and a plane - The condition that a given line may lie in a given plane - The condition that two given lines are coplanar - Number of arbitrary constants in the equations of straight line - Sets of conditions which determine a line

Unit – 3
The shortest distance between two skew lines - The length and equations of the line of shortest distance between two skew lines - Length of the perpendicular from a given point to a given line.

Unit – 4

Definition and equation of the sphere - Equation of the sphere through four given points - Plane sections of a sphere - Intersection of two spheres - Equation of a circle - Sphere through a given circle - Intersection of a sphere and a line

Unit – 5

Power of a point - Tangent plane - Plane of contact; Polar plane - Pole of a Plane - Conjugate points - Conjugate planes - Angle of intersection of two spheres - Conditions for two spheres to be orthogonal - Radical Plane – Coaxial system of spheres-Limiting Points.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Analytical Solid Geometry by Shanti Narayan and P.K. Mittal, published by S. Chand & Company Ltd. 7th Edition.

Reference Books

1. A text Book of Analytical Geometry of Three Dimensions, by P.K. Jain and Khaleel Ahmed, published by Wiley Eastern Ltd., 1999.
2. Co-ordinate Geometry of two and three dimensions by P. Balasubrahmanyam, K.Y. Subrahmanyam, G.R. Venkataraman published by Tata McGraw - Hill Publishers.
3. Solid Geometry by B. Rama Bhupal Reddy, published by Spectrum University Press.

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SEMESTER-II

COURSE 3: GROUP THEORY

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce students to the foundational concepts of algebraic structures with a focus on groups.
2. To develop an understanding of subgroups, cosets, and their relevance in group theory.
3. To explore the properties and significance of normal subgroups and their role in constructing quotient groups.
4. To study and apply the concepts of group homomorphisms, isomorphisms, and the fundamental theorem of homomorphism.
5. To examine the structure and properties of permutation and cyclic groups, including their role in group classification.

Course Outcomes

After successful completion of this course, the student will be able to

1. Understand the definition and basic properties of groups, including finite and infinite groups, and construct composition tables.
2. Analyze subgroups and cosets, apply Lagrange's Theorem, and understand the structure of a group through its subgroups.
3. Identify and verify normal subgroups, and understand their role in forming quotient groups.
4. Understand and apply homomorphisms and isomorphisms, including the fundamental homomorphism theorem and its applications.
5. Work with permutations, transpositions, and cyclic groups, and understand their properties and significance in group theory, including Cayley's Theorem.

Course Content
Unit – 1
Binary Operation – Algebraic structure – **S**emi group - **M**onoid – Group definition and **its** elementary properties **-** **F**inite and Infinite groups – examples – order of a group **-** Composition tables with examples.

Unit – 2
Definition of Complex – Multiplication of two complexes- Inverse of a complex- Definition of Subgroup - examples-Criterion for a complex to be a subgroup- Criterion for the product of two subgroups to be a subgroup-Union and Intersection of subgroups – Definition of Cosets – Properties of Cosets – Index of a subgroup of a finite group – Lagrange's Theorem.

Unit – 3
Normal Subgroups - Definition of normal subgroup – Proper and improper normal subgroups – Hamilton group- Criterion for a subgroup to be a normal subgroup – Intersection of two normal subgroups - Sub group of index 2 is a normal sub group

Unit – 4

Quotient groups - Definition of homomorphism – Image of a homomorphism- Elementary properties of homomorphisms – Isomorphism – Automorphism- Definitions and elementary properties–Kernel of a homomorphism – Fundamental theorem of Homomorphism and applications.

Unit – 5

Definition of permutation –Multiplication of Permutations– Inverse of a permutation – Cyclic permutations – Transposition – Even and odd permutations – Cayley's theorem - Cyclic Groups - Definition of cyclic group – Elementary properties

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Modern Algebra by A.R.Vasishtha and A.K. Vasishtha, Krishna Prakashan Media Pvt. Ltd., Meerut.

Reference Books

1. Abstract Algebra by J.B. Fraleigh, Published by Narosa publishing house.
2. Modern Algebra by M.L. Khanna, Jai Prakash and Co. Printing Press, Meerut
3. Rings and Linear Algebra by Pundir & Pundir, published by Pragathi Prakashan

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SEMESTER-II

COURSE 4: ELEMENTRAY REAL ANALYSIS

Theory | **Credits: 4** | **5 hrs/week**

Course Objectives

1. To develop a strong foundation in the real number system and its axiomatic structure.
2. To introduce the concepts of order, bounds, completeness, and related foundational properties of real numbers.
3. To explore the properties of sets in real analysis, including neighborhoods, limit points, open and closed sets.
4. To build analytical skills in handling sequences, convergence criteria, and monotonicity.
5. To understand the behavior of infinite series and apply standard convergence tests effectively.

Course Outcomes

After successful completion of this course, the student will be able to

1. Understand the real number system, its axioms, and properties, including completeness, supremum, and infimum.
2. Apply the Archimedean property, denseness, and concepts of neighborhoods, limit points, and derived sets in problem-solving.
3. Analyze sequences for boundedness and convergence using definitions and the Cauchy criterion.
4. Understand the concept of subsequences, apply the Bolzano-Weierstrass theorem, and test convergence using Cauchy's general principle.
5. Determine the convergence of infinite series using various tests and solve related analytical problems.

Course Content

Unit – 1

Real number system - Field axioms – Properties of real numbers - Order axioms – Properties of Order relation - Principal of induction - Extended real number system – Modulus of a real number – Properties of modulus – Triangle property - Aggregates – Finite and infinite aggregates – Boundedness of an aggregate – Least upper bound (supremum) and greatest lower bound (infimum) of an aggregate – Properties of boundedness – Completeness axiom – Dedekind's theorem - Theorem on Dedekind's axiom and completeness axiom.

Unit – 2

Archemedian Property - It's corollaries – Integral part of a real number - Denseness of the real number system – Intervals – Neighbourhood of a point - Limit point of an aggregate – Derived Set - Bolzano - Weierstrass theorem – Interior point of a set - Open and closed Sets – It's properties (without proofs) - Countable and uncountable sets - Properties of countable sets.

Unit – 3

Sequences – Operations of sequences - Subsequences - Range and Boundedness of Sequences - Limit of a sequence and Convergent sequence – Divergent sequence – Uniqueness of a limit – Sandwich theorem on sequences - Monotone sequences - Problems

Unit – 4

Limit Point of a Sequence - Bolzano-Weierstrass theorem on subsequences – Cauchy Sequences – Cauchy's general principle of convergence - Problems

Unit – 5

Infinite Series – Convergence and divergence of series - Cauchy's general principle of convergence for series – Series of non-negative terms - Convergence of geometric series – p series test - comparison test –D'Alemberts's ratio test – Cauchys's n^{th} root test – problems.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

An Introduction to Real Analysis by Robert G.Bartle and Donlad R. Sherbert, John Wiley and sons Pvt. Ltd

Reference Books

1. Elements of Real Analysis by Shanthi Narayan and Dr. M.D. Raisinghania, S. Chand & Company Pvt. Ltd., New Delhi.
2. Principles of Mathematical Analysis by Walter Rudin, McGraw-Hill Ltd.

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SEMESTER-III

COURSE 5: RING THEORY

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. The course aims to:
2. Introduce the fundamental concepts and properties of rings, fields, and integral domains.
3. Explain the structure and significance of subrings and ideals, including prime and maximal ideals.
4. Construct quotient rings and develop composition tables for finite rings.
5. Explore ring homomorphisms, isomorphisms, and apply the fundamental theorems of ring homomorphisms.
6. Study polynomial rings, including operations, division algorithm, irreducibility, and ideal structures.

Course Outcomes

1. Upon successful completion of this course, students will be able to:
2. Understand and differentiate between rings, integral domains, and fields, and describe their algebraic properties.
3. Identify and construct subrings and various types of ideals, and determine when a ring qualifies as a field.
4. Analyze quotient rings, build composition tables for finite rings, and distinguish between prime and maximal ideals.
5. Apply ring homomorphisms and isomorphisms effectively, and interpret the fundamental homomorphism theorems.
6. Solve problems involving polynomial rings over fields, including division algorithms, factorization, and irreducibility criteria.

Course Content

Unit – 1
Definition of a Ring and Examples –Basic properties – Commutative ring - Boolean ring – Zero Divisors of a ring - Cancellation Laws – Integral Domain – Division ring – Field - Idempotent and nilpotent elements in a ring and integral domain.

Unit – 2
The Characteristic of a Ring - The characteristics of integral domain, filed, Boolean ring - Definition and examples of Subrings – Necessary and sufficient condition for a nonempty subset to be a subring – Algebra of Subrings – Centre of a ring – Ideals – Algebra of ideals – A commutative ring with unity and without proper ideals is a filed.

Unit – 3
Principal ideal – Principal ideal ring: definition and theorems Cosets in ring structure - Quotient ring : definition, examples and theorems– Euclidean rings : definition, examples and theorems.

Unit – 4
Homomorphism of Rings – Definition and Elementary properties – Kernel of a homomorphism – Isomorphism – Fundamental theorem of homomorphism of rings – Maximal and prime Ideals.

Unit – 5
Polynomials over a ring – Algebra of polynomials –Degree of a polynomial and related problems -- The Division Algorithm in $F[x]$ – Remainder and Factor Theorems– Irreducible Polynomials – Ideal structure in F[x] – Uniqueness of Factorization in F[x].

Activities
The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text book
Modern Algebra by A.R.Vasishta and A.K.Vasishta, Krishna Prakashan Media Pvt. Ltd.

Reference books
1. A First Course in Abstract Algebra by John. B. Farleigh, Narosa Publishing House.
2. Linear Algebra by Stephen. H. Friedberg and Others, Pearson Education India

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SEMESTER-III

COURSE 6: ADVANCED REAL ANALYSIS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

This course is designed to:

1. Develop a deep understanding of infinite series with non-negative terms and apply various convergence tests.
2. Introduce the concepts of limits and continuity, including their behavior at finite and infinite points.
3. Explore types of discontinuities and apply fundamental theorems related to continuous functions.
4. Understand differentiability and apply Mean Value Theorems in problem-solving.
5. Introduce Riemann integration and explore key properties and theorems of integrable functions.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. Apply convergence tests such as P-test, Cauchy's root test, D'Alembert's ratio test, and Leibnitz test to analyze series.
2. Understand and evaluate limits of real-valued functions, including one-sided and infinite limits, and solve problems involving indeterminate forms.
3. Demonstrate knowledge of continuity, identify types of discontinuities, and apply theorems like Heine's, Borel's, and Bolzano's in analysis.
4. Understand and analyze differentiability, distinguish it from continuity, and apply Rolle's, Lagrange's, and Cauchy's Mean Value Theorems.
5. Evaluate Riemann integrals, verify conditions for integrability, and apply the Fundamental Theorem of Calculus in integration problems.

Unit – 1

Alternating Series – Leibnitz Test – Absolute and conditional convergence – Theorems and problems relating to them – Dirichlet's test – Abel's test (Problems only)

Unit – 2

Real valued Functions - Boundedness of a function - Monotone functions - Limit of a function - Algebra of limits - Sandwich theorem on limit point – Limits of some standard functions – forms – Infinite limits – Limits at infinity.

Unit – 3

Continuity and discontinuity of a function and examples - Heine's theorem- Modulus of a continuous function is a continuous function - Borel's theorem- Every continuous function is bounded - Every continuous and bounded function defined on [a,b] attains its bounds -Bolzano's theorem - Bolzano's intermediate value theorem – Uniform continuity – Every continuous function on closed interval is uniformly continuous.

Unit – 4

The derivability of a function at a point and on an interval - Derivability and continuity of a function - Darboux's theorem (statement only) - Darboux's intermediate value theorem - Mean value Theorems : Rolle's theorem, Lagrange's theorem, Cauchy's Mean value theorem – Problems

Unit – 5

Riemann Integration – Upper and lower Riemann sums, and integrals - Riemann integrable functions - Necessary and sufficient condition for integrability – Continuous function on closed interval is integrable - Monotonic function on closed interval is integrable - Properties of integrable functions - Fundamental theorem of integral calculus – Problems

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

An Introduction to Real Analysis by Robert G.Bartle and Donlad R. Sherbert, John Wiley and sons Pvt. Ltd

Reference Books

1. Elements of Real Analysis by Shanthi Narayan and Dr. M.D. Raisinghania, S. Chand & Company Pvt. Ltd., New Delhi.
2. Principles of Mathematical Analysis by Walter Rudin, McGraw-Hill Ltd.

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SEMESTER-III

COURSE 7: THEORY OF MATRICES

Theory	**Credits: 4**	**5 hrs/week**

Course Objectives

This course aims to:

1. Develop an understanding of special matrices such as symmetric, Hermitian, orthogonal, and unitary matrices and their properties.
2. Explain the computation and properties of determinants and how they are used in matrix operations.
3. Teach methods to find the rank and inverse of matrices using elementary transformations.
4. Provide techniques to analyze and solve systems of linear equations using matrix methods.
5. Introduce the concepts of eigenvalues and eigenvectors, and highlight their significance in linear algebra and applications.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. Compute the determinant of a matrix using expansion and apply various properties for simplification.
2. Perform elementary row and column operations to simplify determinants and matrix expressions.
3. Determine the rank of a matrix using echelon and normal forms, and compute matrix inverses via transformations.
4. Analyze systems of linear equations (homogeneous and non-homogeneous) for consistency, and solve them using methods such as matrix inversion, Cramer's Rule, Gauss elimination, and LU decomposition.
5. Define and compute eigenvalues and eigenvectors of square matrices, and use characteristic equations in applications.

Course Content

Unit I

Matrix – Algebra of Matrices – Matrix Multiplication – Transpose and trace of a matrix - Symmetric and Skew symmetric matrices - Hermitian and Skew Hermitian matrices - Orthogonal and Unitary matrices - Idempotent matrix - Nilpotent Matrix – Involutory Matix – examples and related problems – Every square matrix can be expressed as a sum of a symmetric and a skew symmetric matrix – countable and uncountable sets - If $AB = A$ and $BA = B$, then A and countable and uncountable sets are idempotent.

Unit – 2

Determinant of a square matrix (of order 3) - Minors and Cofactors - Properties of determinants - Product of two determinants of the same order - Adjoint and Inverse of a matrix – Orthogonal matrix - Problems

Unit -3
Rank of a matrix - Elementary row and column operations on a matrix – Properties of elementary matrices – Reduction to Echelon form and Normal form - Inverse of a non-singular matrix by elementary transformations – Related problems – The rank of product of matrices cannot exceed the rank of either.

Unit -4
System of homogeneous linear equations – Conditions for trivial and non-trivial solutions – Solving methods of homogeneous linear equations system - System of non-homogeneous linear equations – Conditions for consistency and inconsistency – Matrix Inversion method – Cramer's Rule – Gauss method- LU decomposition method.

Unit - 5
Characteristic (Eigen) Values and Characteristic vectors of a square matrix - Characteristic polynomial and Characteristic equation of a matrix – Finding eigenvalues and eigen vectors of a square matrix.

Activities
The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text book

Matrices , by A.R.Vasishtha and A.K.Vasishtha, published by Krishna Prakashan Media (P) Ltd.

Reference books

1. S. H. Friedberg, A.L.Insel and L.E.Spence, Linear Algebra, Prentice Hall of India (P) Ltd, New Delhi, 2004.
2. R D Sharma and Umash Kumar Basic Applied Mathematics for physical sciences, pearson Education India (P) Ltd
3. Richard Bronson, Theory and problems of Matrix operations, Tata Mc Graw Hill 1989.

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SEMESTER-IV

COURSE 8: LINEAR ALGEBRA

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the fundamental concepts of vector spaces, subspaces, and their algebraic structure.
2. To develop an understanding of basis and dimension of vector spaces and their associated theorems.
3. To explore linear transformations and their properties, including rank, nullity, and the Rank-Nullity Theorem.
4. To apply the Cayley-Hamilton Theorem to compute powers and inverses of matrices without using direct methods.
5. To understand the structure of inner product spaces and study orthogonality and related geometric properties.

Course Outcomes

After successful completion of this course, the student will be able to

1. Understand and apply the definitions and properties of vector spaces, subspaces, linear combinations, and linear span.
2. Determine the basis and dimension of vector spaces and subspaces, and apply related theorems including those on quotient spaces.
3. Define linear transformations and operators, compute rank and nullity, and apply the Rank-Nullity Theorem.
4. Use the Cayley-Hamilton Theorem to verify matrix equations and to compute matrix inverses and higher powers.
5. Understand inner product spaces, verify orthogonality, and apply key inequalities such as Schwarz's and Triangle inequalities.

Course Content

Unit –1

Vector Spaces - General properties of vector spaces - n-dimensional Vectors - Addition and scalar multiplication of Vectors - Vector subspaces -Algebra of subspaces - Linear Sum of two subspaces - linear combination of Vectors- Linear Span - Linear independence and Linear dependence of Vectors.

Unit-2

Basis of a Vector space –Problems on basis of a vector space - Finite Dimensional Vector spaces - Basis existence theorem – Extension and uniqueness theorems and problems on them
-Dimension of a Vector space - Dimension of a subspace - Quotient space and Dimension of Quotient space – Theorems on dimensions

Unit –3

Linear transformations - linear operators- Properties of L.T- Sum and product of L.Ts - Algebra of Linear Operators - Range and null space of linear transformation - Rank and Nullity of linear transformation - Rank- Nullity Theorem.

Unit –4

Cayley Hamilton Theorem – Verification Problems – Finding inverse using Cayley Hamilton Theorem - Inner product spaces- Euclidean and Unitary spaces- Norm or length of a Vector - Problems

Unit –5

Schwartz inequality- Triangle Inequality- Parallelogram law- Orthogonal and Orthonormal sets and problems on them – Gram Schmidt orthogonalization Process(Only problems).

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Linear Algebra by J.N. Sharma and A.R. Vasishtha, published by Krishna Prakashan Media (P) Ltd.

Reference Books

1. Linear Algebra by Stephen H. Friedberg et. al. published by Prentice Hall of India Pvt. Ltd. 4th Edition, 2007
2. Linear Algebra by Kenneth Hoffman and Ray Kunze, published by Pearson education low priced edition), New Delhi.
3. Matrices by Shanti Narayana, published by S. Chand Publications

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SEMESTER-IV

COURSE 9: VECTOR CALCULUS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the concept of vector differentiation and the use of vector operators such as gradient, divergence, and curl.
2. To extend the concept of definite integrals to functions of multiple variables through double and triple integrals.
3. To apply double and triple integrals in evaluating areas and volumes in different coordinate systems.
4. To provide knowledge on evaluating line, surface, and volume integrals using vector calculus techniques.
5. To understand and apply major vector integration theorems like Gauss's Divergence Theorem, Green's Theorem, and Stokes's Theorem.

Course Outcomes

After successful completion of this course, students will be able to

1. Understand and compute vector derivatives, including gradient, divergence, and curl, and apply vector identities in problem-solving.
2. Evaluate double integrals over various regions and use polar coordinates when appropriate.
3. Compute triple integrals in Cartesian and polar coordinates, and apply them to find volumes of solids.
4. Evaluate line, surface, and volume integrals using the appropriate vector calculus methods and geometric interpretations.
5. Apply Gauss's, Green's, and Stokes's theorems to relate different types of integrals and solve physical and geometrical problems

Course Content

Unit – 1

Vector differentiation – ordinary derivatives of vectors – Differentiability – Gradient –Divergence - Curl operators - Relations involving the operators - Problems

Unit – 2

Introduction to double integrals - Evaluation of double integrals – Properties of double integrals - Region of integration - double integration in Polar Co-ordinates – Jacobian and change of variables.

Unit – 3

Triple integral - Region of integration - Change of variables – Evaluation of triple integrals both in Cartesian and polar coordinates – Jacobian and change of variables.

Unit – 4

Line Integrals with examples - Surface Integral with examples - Volume integral with examples.

Unit – 5

Gauss theorem and applications of Gauss theorem - Green's theorem in the plane and applications of Green's theorem - Stokes's theorem and applications of Stokes theorem.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

A text Book of Higher Engineering Mathematics by B.S. Grawal, Khanna Publishers, 43^{rd} Edition

Reference Books

1. Vector Calculus by P.C. Matthews, Springer Verlag publications.
2. Vector Analysis by Murray Spiegel, Schaum Publishing Company, NewYork

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SEMESTER-IV

COURSE 10: LINER PROGRAMMING PROBLEMS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the concept of convex sets and the foundational principles of linear programming.
2. To develop the ability to formulate real-life problems into linear programming models.
3. To provide graphical and algebraic techniques for solving linear programming problems.
4. To equip students with the knowledge of the simplex method, artificial variables, and special cases in LPP.
5. To explore issues such as degeneracy, alternative solutions, unboundedness, and infeasibility in linear programming problems.

Course Outcomes

After successful completion of this course, students will be able to

1. Understand the structure of convex sets, convex combinations, and apply the fundamental theorem of linear programming to real-world problem formulation.
2. Solve LPPs graphically and represent LP problems in standard, canonical, and matrix forms.
3. Apply the simplex method to solve linear programming problems and interpret unbounded or multiple solutions.
4. Use artificial variable techniques such as the Big M-method and the two-phase method to handle constraints with equality and greater-than conditions.
5. Identify and resolve issues in LPP such as degeneracy, alternative and unbounded solutions, and apply the simplex method to solve systems of simultaneous equations.

Course Content

UNIT-I

Convex Set- Extreme points of a convex set- Convex combination- Convex hull- Convex polyhedron- Fundamental theorem of linear programming - Formulation of linear programming of problems (LPP)

UNIT-2

Graphical solution of linear programming problems- General formulation of LP problems-Standard form and matrix form of LP problems-Standard from and Canonical form of LP Problems

UNIT-3

Introduction of Simplex method - Definitions and notations - Computational procedure of simplex algorithm- Simple way for simplex computations – Unbounded and Alternative solutions

UNIT -4

Artificial variables- Big M-Method and its applications and Two-phase method- Alternative method of two-phase simplex method

UNIT - 5

Degeneracy in LPP and method to resolve degeneracy- Alternative solutions- Unbounded solutions- Non-existing feasible solutions- Solution of simultaneous equations by Simplex method.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text book

Scope as in “Operations Research” by S.D. Sharma, Kedar Nath, Ram Nath & Co- Meerut.

Reference Book

“Operation Research” by Kanthi Swarup- R.K. Gupta and Manmohan- S. Chand publications, New Delhi

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SEMESTER-V

COURSE 11: SPECIAL FUNCTIONS

Theory	**Credits: 4**	**5 hrs/week**

Course Objectives

1. To introduce Euler's integrals and explore the definitions, properties, and relationships between Beta and Gamma functions.
2. To study Chebyshev polynomials, their orthogonality, recurrence relations, and generating functions.
3. To analyse Hermite differential equations, understand Hermite polynomials, their orthogonal properties, and related recurrence formulas.
4. To understand Legendre's differential equation and Legendre polynomials, including their orthogonal properties and generating functions.
5. To solve Bessel's differential equation and study the properties, generating functions, and orthogonality of Bessel functions.

Course Outcomes

After successful completion of this course, the student will be able to

1. Define Beta and Gamma functions, understand their fundamental properties, and derive the relationship between them.
2. Analyse Chebyshev polynomials and demonstrate their orthogonality, recurrence relations, and generating functions.
3. Solve Hermite's differential equation, construct Hermite polynomials, and apply their recurrence and orthogonality properties.
4. Solve Legendre's equation, construct Legendre polynomials, and apply their generating functions and orthogonal properties.
5. Solve Bessel's equation, evaluate Bessel functions of the first and second kind, and use their recurrence relations and orthogonality.

Course Content

Unit – 1

Euler's Integrals-Beta and Gamma Functions, Elementary properties of Gamma Functions, Transformation of Gamma Functions. Another form of Beta Function, Relation between Beta and Gamma Functions.

Unit – 2

Chebyshev polynomials, orthogonal properties of Chebyshev polynomials, recurrence relations, generating functions for Chebyshev polynomials.

Unit – 3

Hermite Differential Equations, Solution of Hermite Equation, Hermite polynomials, generating function for Hermite polynomials. Other forms for Hermite Polynomials, Rodrigues formula for Hermite Polynomials, to find first few Hermite Polynomials. Orthogonal properties of Hermite Polynomials, Recurrence formulae for Hermite Polynomials.

Unit – 4

Definition, Solution of Legendre's equation, Legendre polynomial of degree n, generating function of Legendre polynomials. Definition of $P_n(x)$ and $Q_n(x)$, General solution of Legendre's Equation (derivations not required) to show that $P_n(x)$ is the coefficient of h^n, in the expansion of $(1 - 2h + h^2)^{-1/2}$ Orthogonal properties of Legendre's polynomials, Recurrence formulas for Legendre's Polynomials.

Unit – 5

Definition, Solution of Bessel's equation, Bessel's function of the first kind of order n, Bessel's function of the second kind of order n.
Integration of Bessel's equation in series form, Definition of Jn(x) recurrence formulae for Jn(x) Generating function for Jn(x), orthogonality of Bessel functions.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Special Functions by J.N.Sharma and Dr.R.K.Gupta, Krishna Prakashan,

Reference Books

1. Dr.M.D.Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Company Pvt. Ltd., Ram Nagar, New Delhi-110055.
2. Shanti Narayan and Dr.P.K.Mittal, Integral Calculus, S. Chand & Company Pvt. Ltd., Ram Nagar, New Delhi-110055.
3. George F.Simmons, Differential Equations with Applications and Historical Notes, Tata McGRAW-Hill Edition, 1994.

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SEMESTER-V

COURSE 12 A: LAPLACE TRANSFORMS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the concept, definition, and properties of Laplace Transforms for solving mathematical problems.
2. To explain the use and applications of the first and second shifting theorems, change of scale property, and Laplace transforms of derivatives.
3. To compute Laplace Transforms of standard special functions such as Bessel functions, error functions, sine and cosine integrals.
4. To develop an understanding of the inverse Laplace Transform and its properties using algebraic and analytical methods.
5. To provide knowledge of the convolution theorem, its proof, and applications including Heaviside's expansion theorem.

Course Outcomes

After successful completion of the course, the student will be able to

1. Understand and apply the definition and basic properties of Laplace Transforms for a wide class of functions.
2. Utilize shifting theorems, change of scale property, and Laplace Transforms of derivatives in solving problems.
3. Compute Laplace Transforms of standard and special functions including Bessel and error functions.
4. Perform inverse Laplace Transforms using standard techniques, including partial fractions and known properties.
5. Apply the convolution theorem and Heaviside's expansion theorem to solve integral and differential equations.

Course Content

Unit – 1

Definition of Laplace Transform - Linearity Property - Piecewise Continuous Function - Existence of Laplace Transform - Functions of Exponential order and of Class A.

Unit – 2

First Shifting Theorem, Second Shifting Theorem, Change of Scale Property, Laplace transform of the derivative of f(t), Initial value theorem and Final value theorem.

Unit – 3

Laplace Transform of Integrals - Multiplication by t, Multiplication by t^n - division by t - Laplace transform of Bessel Function - Laplace Transform of Error Function - Laplace transform of Sine and Cosine integrals.

Unit – 4

Definition of Inverse Laplace Transform - Linearity Property - First Shifting Theorem - Second Shifting Theorem - Change of Scale property - use of partial fractions - Examples.

Unit – 5

Inverse Laplace transforms of Derivatives - Inverse Laplace Transforms of Integrals - Multiplication by Powers of 'p' - Division by powers of 'p' - Convolution Definition - Convolution Theorem - proof and Applications - Heaviside's Expansion theorem and its Applications.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Laplace Transforms by A.R. Vasishtha, Dr. R.K. Gupta, Krishna Prakashan Media Pvt. Ltd., Meerut.

Reference Books

1. Introduction to Applied Mathematics by Gilbert Strang, Cambridge Press
2. Laplace and Fouries transforms by Dr.J.K. Goyal and K.P. Guptha, Pragathi Prakashan, Meerut.

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SEMESTER-V

COURSE 12 B: FOUNDATIONS OF AUTOMATA THEORY

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the foundational concepts of formal languages, alphabets, strings, and the classification of languages.
2. To explain the construction and working of deterministic and non-deterministic finite automata (DFA and NFA) and their equivalence.
3. To develop understanding of regular expressions and their relation to finite automata, along with algebraic properties.
4. To explore context-free grammars (CFG), parse trees, and the concept of ambiguity in grammars.
5. To introduce pushdown automata (PDA) and establish their equivalence with context-free grammars, including deterministic PDA.

Course Outcomes

Upon successful completion of the course, students will be able to

1. Define formal languages, alphabets, strings, and construct both deterministic and non-deterministic finite automata.
2. Design and analyze regular expressions and establish their equivalence with finite automata using algebraic laws.
3. Examine the properties of regular languages using pumping lemma and demonstrate closure properties.
4. Construct context-free grammars and parse trees, and identify ambiguity in grammars and languages.
5. Design pushdown automata and explain their equivalence with context-free grammars, including deterministic variations.

Unit – 1

Alphabets, strings, and languages. Finite Automata deterministic and non-deterministic finite automata - Properties of transition functions - The equivalence of DFA and NFA. (Sections 1.5, 2.1-2.3)

Unit – 2

Regular expressions, finite automata and regular expressions – algebraic laws for regular expressions. (Sections 3.1,3.2,3.4)

Unit – 3

Regular languages and their relationship with finite automata, pumping lemma for regular languages - closure properties of regular languages. (Sections 4.1,4.2)

Unit – 4

Context Free Grammars - parse trees - ambiguities in grammars and languages. (Sections 5.1.5.2.5.4)

Unit – 5

Pushdown automata - the language of a Pushdown automata – Equivalence of Pushdown automata and context free grammar - deterministic PDA. (Sections 6.1-6.4)

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text book

John E. Hopcroft, Rajeev Motwani and J.D. Ullman, Introduction to Automata Theory Languages and Computation, Third Edition, Pearson Addison-Wesley, 2006.

Reference books

1. J.A. Anderson, Automata theory with modern applications, Cambridge University Press, 2006.
2. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997. 3. K L P Mishra and N Chandrasekaran, Theory of Computer Science Automata, Languages and Computation, Third Edition, Prentice Hall, 2006
3. K L P Mishra and N Chandrasekaran, Theory of Computer Science Automata, Languages and Computation, Third Edition, Prentice Hall India, New Delhi, 2006.

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SEMESTER-V

COURSE 13 A: NUMERICAL METHODS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To understand various numerical methods for solving algebraic and transcendental equations.
2. To introduce the concept of finite difference operators and their interrelations.
3. To develop knowledge of interpolation techniques including Newton-Gregory forward and backward interpolation.
4. To understand and apply central difference interpolation formulas like Stirling's, Bessel's, and Laplace-Everett.
5. To equip students with the basic concepts of curve fitting and its applications in numerical analysis.

Course Outcomes

After successful completion of this course, students will be able to

1. Distinguish between different finite difference operators and explain their interrelationships.
2. Apply Newton-Gregory forward and backward interpolation techniques to solve numerical problems.
3. Use central difference operators and interpolation formulas such as Gauss forward and backward formulas.
4. Solve algebraic and transcendental equations using methods such as Bisection, Regula Falsi, Iteration, and Newton-Raphson.
5. Understand and apply curve fitting techniques using various interpolation formulas including Stirling's, Bessel's, and Laplace-Everett.

Course Content

Unit – 1

Method for finding initial approximate value of the root - Bisection method - to find the solution of given equations by using (i) Regula Falsi method (ii) Iteration method (iii) Newton – Raphson's method and problems on them.

Unit – 2

The operators Δ, ∇, E - Fundamental theorem of difference calculus- properties of Δ, ∇, E and problems on them to express any value of the function in terms of the leading terms and the leading differences - relations between E and D - relation between D and Δ - problems on one or more missing terms

Unit – 3

Derivations of Newton – Gregory Forward and backward interpolation formulae and problems on them - Divided differences - Newton and Lagrange' divided difference formulae and problems on them.

Unit – 4

Central Difference operators δ, μ, σ and relation between them - Gauss forward formula for equal intervals - Gauss Backward formula

Unit – 5

Central Difference Interpolation - Stirlings formula and problems - Bessel's formula and problems – Laplace-Everett formula and problems .

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Introductory Methods of Numerical Analysis by S.S. Sastry, (6th Edition) PHI New Delhi 2012

Reference Books

1. Applied Numerical Analysis by Curtis F. Gerald and Patrick O. Wheatley, Pearson,(2003) 7th Edition
2. Numerical Analysis by G. Shanker Rao, New Age International Publications
3. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S .R. K. Iyengar and R. K. Jain, New Age International Publishers (2012), 6th edition.

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SEMESTER-V

COURSE 13 B: MATHEMATICAL METHODS USING MATLAB

Theory	Credits: 4	5 hrs/week

Course Objectives

1. To introduce the fundamentals of MATLAB programming and familiarize students with its environment and data handling capabilities.
2. To develop proficiency in matrix operations, array manipulation, and the use of built-in functions for mathematical computations.
3. To train students in writing scripts and functions, and in understanding MATLAB's language-specific features and advanced data types.
4. To apply MATLAB for solving mathematical problems in linear algebra, interpolation, numerical integration, and differential equations.
5. To equip students with skills to create 2D/3D plots, handle graphics, use toolboxes like Symbolic Math, and present mathematical computations visually.

Course Outcomes

Upon successful completion of the course, students will be able to:

1. Demonstrate understanding of the MATLAB interface, basic commands, array operations, and symbolic computation.
2. Perform interactive computations using matrices, vectors, character strings, and generate basic plots and visualizations.
3. Develop and execute MATLAB script and function files for solving computational problems efficiently.
4. Apply MATLAB techniques to solve problems in linear algebra, data analysis, curve fitting, numerical methods, and differential equations.
5. Create and manipulate 2D and 3D graphical representations, use advanced plotting techniques, and utilize MATLAB toolboxes for symbolic and numerical computations.

Unit-I

Basics of MATLAB Programming, Basics of MATLAB, Input-output, File types, General commands, Creating and working with arrays of numbers, Printing simple plots, Creating; saving and executing a script file, Creating and executing a function file, Arrays and matrices, Symbolic computation Importing and exporting data. (Sec: 1.1, 1.6 (1.6.1, 1.6.3-1.6.6), 2.2-2.6, 2.8, 2.9)

Unit–2

Interactive Computation Matrices and vectors, Matrix and array operations, Character strings, A special note on array operations, Command-Line functions, Built-in functions, Saving and loading data, Plotting simple graphs. (3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8)

Unit-3

Scripts and Functions Script files, Function files, Language-specific features, Advanced data objects, Publishing reports. (4.1, 4.2, 4.3, 4.4, 4.5)

Unit-4

Applications in Mathematical Sciences Linear Algebra, Curve fitting and interpolation, Data analysis and statistics, Numerical integration, Ordinary differential equations, Nonlinear algebraic equations, Partial differential equations. (5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7)

Unit–5

Graphics and Toolbox Basic 2-D plots, Using subplot for multiple graphs, 3-D plots, Handle graphics, Saving and printing graphs, Animation, The symbolic math toolbox, Numeric versus symbolic computation, Using MuPAD notebook. (6.1, 6.2, 6.3, 6.4, 6.6, 6.7, 8.1, 8.2, 8.5)

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book:

Rudra Pratap (2010), Getting Started with MATLAB, Oxford University Press.

References:

1. Gilat A (2012), Matlab An Introduction with Applications (4th Edition), John Wiley.
2. R K Bansal, A K Goyal, M K Sharma, MATLAB and its Applications in Engineering, 2 nd Edition, Pearson.
3. S S Alam S N Alam (2019), Understanding MATLAB A Textbook for Beginners, Wiley India.

SEMESTER-VI

COURSE 14 A: INTEGRAL TRANSFORMS

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To enable students to apply Laplace Transforms in solving ordinary and simultaneous differential equations.
2. To introduce students to the application of Laplace Transforms in solving various types of integral equations.
3. To provide foundational knowledge of Fourier Transforms and their various properties.
4. To equip students with the skills to solve problems involving Fourier sine and cosine transforms.
5. To establish the connection between Fourier and Laplace Transforms, and apply these tools to practical problems involving integral and differential equations.

Course Outcomes

After successful completion of this course, the student will be able to

1. Apply Laplace Transform techniques to solve ordinary differential equations with constant and variable coefficients.
2. Solve simultaneous differential equations and partial differential equations using Laplace Transforms.
3. Analyze and solve various forms of integral equations using Laplace Transforms, including convolution-type and integral-differential equations.
4. Understand the definition, types, and properties of Fourier Transforms, including linearity, scaling, shifting, and modulation.
5. Solve problems using finite Fourier sine and cosine transforms and apply Parseval's identity and the convolution theorem for Fourier Transforms

Course Content

Unit – 1

Solutions of ordinary Differential Equations - Solutions of Differential Equations with constant coefficients - Solutions of Differential Equations with Variable coefficients.

Unit – 2

Solutions of Simultaneous Ordinary Differential equations - Solutions of Partial Differential Equations.

Unit – 3

Definitions of Integral Equations - Abel's Integral Equation - Integral Equation of Convolution type - Integral Differential Equations - Application of L.T. to Integral Equations.

Unit – 4

Definition of Fourier Transform - Fourier sine Transform - Fourier cosine Transform - Linear Property of Fourier Transform - Change of Scale Property for Fourier Transform - sine Transform and cosine transform shifting property - Modulation theorem.

Unit – 5

Definition of Convolution - Convolution theorem for Fourier transform - Parseval's Identity - Relationship between Fourier and Laplace transforms - problems related to Integral Equations - Finite Fourier Transforms - Finite Fourier Sine Transform - Finite Fourier Cosine Transform - Inversion formula for sine and cosine transforms only - statement and related problems.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2017.

Reference Books

1. Fourier Series and Integral Transformations by Dr.S. Sreenadh and others, published by S.Chand and Co, New Delhi
2. E.M. Stein and R. Shakarchi, Fourier analysis: An introduction, (Princeton University Press, 2003).
3. R.S. Strichartz, A guide to Distribution theory and Fourier transforms, (World scientific, 2003).

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SEMESTER-VI

COURSE 14 B: STATISTICAL ANALYSIS USING R

Theory **Credits: 4** **5 hrs/week**

Course Objectives

1. To introduce the fundamentals of **R programming** for statistical analysis and data manipulation.
2. To equip students with skills to **handle, clean, and transform data** using R.
3. To develop the ability to apply **statistical modelling techniques** and perform **data visualization** using base R and advanced graphical packages.
4. To foster problem-solving skills through **real-world data analysis** and simulation in R.
5. To introduce students to **advanced R topics**, including interfacing with other languages and package development.

Course Outcomes

After successful completion of this course, students will be able to

1. Understand the R programming environment, basic syntax, data types, and perform input/output operations using R.
2. Write efficient R scripts and functions using control structures, apply debugging techniques, and follow best practices in reproducible coding.
3. Import, explore, and preprocess data from various sources, manage missing values, and perform data transformation tasks effectively.
4. Perform statistical computations, fit linear and generalized linear models, and create visualizations using both base R and advanced graphics systems.
5. Apply advanced programming concepts including object-oriented features, interface R with other programming environments, and initiate R package development with real-world projects

Course Content

Unit 1

Introduction to data analysis and R's role, Basics of R: Starting R, R console, commands, help features, Data types and structures in R: vectors, lists, matrices, arrays, and data frames, Objects and assignments, Input/output operations in R, Installing and loading packages **Reference:** Chapters 1, 2 from the textbook.

Unit 2

Writing R scripts and functions, Control structures: loops and conditionals, Functional programming basics in R, Debugging and error handling, Best practices for writing reproducible code. **Reference:** Chapters 3, 4 from the textbook

Unit 3
Importing data: CSV, Excel, Text, Exploring and cleaning data, Subsetting and transforming data, Working with missing values, Creating and using packages. **Reference:** Chapters 5, 6

Unit 4
Descriptive statistics and probability distributions, Model fitting: linear models, GLM, Basic simulation using random number generators, Creating plots using base R, Advanced plotting: lattice and grid systems. **Reference:** Chapters 6, 7

Unit 5
Classes and methods in R, Text mining and handling text data, Interfacing R with C, Fortran, and other systems, Overview of R package development, Introduction to project-based analysis using real datasets **Reference:** Chapters 8, 9, 11, 12

Activities
The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Textbook
Chambers, John M. Software for Data Analysis: Programming with R, Springer, 2008.

Reference Book
Dalgaard, Peter. ***Introductory Statistics with R***, Springer, 2nd Edition, 2008.

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SEMESTER-VI

COURSE 15 A: ADVANCED NUMERICAL METHODS

Theory	**Credits: 4**	**5 hrs/week**

Course Objective

1. To introduce the concept of numerical differentiation using finite difference formulas.
2. To familiarize students with various numerical integration techniques and their error analysis.
3. To develop an understanding of solving linear systems using direct and iterative methods.
4. To apply matrix factorization techniques and solve tridiagonal systems numerically.
5. To explore methods for solving ordinary differential equations using numerical techniques like Euler's and Runge-Kutta methods.
6.

Course Outcomes

After successful completion of the course, the student will be able to

1. Apply Newton's forward, backward, and central difference formulas for numerical differentiation.
2. Evaluate definite integrals using numerical integration techniques such as Trapezoidal, Simpson's, and Weddle's rules with error analysis.
3. Solve linear systems using direct methods including matrix inversion, Gaussian elimination, and Gauss-Jordan methods.
4. Implement iterative methods such as Jacobi and Gauss-Seidel to solve tridiagonal and large sparse linear systems.
5. Solve initial value problems of ordinary differential equations using numerical methods such as Taylor series, Picard's, Euler's, and Runge-Kutta methods.

Course Content

Unit – I

Derivatives using Newton's forward difference formula - Newton's backward difference formula- Derivatives using central difference formula - Stirling's interpolation formula - Newton's divided difference formula.

Unit – 2

General quadrature formula on errors - Trapezoidal rule – Simpson's 1/3 rule - Simpson's 3/8 rule- Weddle's rule

Unit – 3

Solution of linear systems - Direct Methods - Matrix inversion method – Gaussian elimination method-Gauss Jordan Method.

Unit – 4

Method of factorization - Solution of Tridiagonal systems - Iterative methods - Jacobi's method - Gauss - Siedal method.

Unit – 5

Introduction – solution of Taylor's series – Picard's method of successive approximations – Euler's method – Modified Euler's method – Runge-Kutta methods.

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text Book

Introductory Methods of Numerical Analysis by S.S. Sastry, (6^{th} Edition) PHI New Delhi 2012

Reference Books

1. Applied Numerical Analysis by Curtis F. Gerald and Patrick O. Wheatley, Pearson Publications.

2. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S .R. K. Iyengar and R. K. Jain, New Age International Publishers.

3. Numerical Analysis by G. Shanker Rao, New Age International Publications

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SEMESTER-VI

COURSE 15 B: MATHEMATICAL COMPUTATIONS WITH PYTHON

Theory	**Credits: 4**	**5 hrs/week**

Course Objectives

1. To introduce mathematical concepts through computational methods.
2. To provide practical experience using Python libraries such as NumPy, Matplotlib, SciPy, and SymPy.
3. To reinforce theoretical mathematical concepts using visualizations and numerical examples.
4. To develop problem-solving skills using Python for analysis
5. To develop problem-solving skills using Python for calculus, differential equations, linear algebra, and abstract algebra.

Course Outcomes

By the end of the course, students will be able to

1. Use Python libraries to perform numerical computations and visualize mathematical functions.
2. Understand and apply core concepts in real analysis including limits, continuity, and convergence.
3. Implement numerical methods for differentiation and integration using Python.
4. Solve ordinary and partial differential equations with computational tools.
5. Apply linear algebra techniques to solve systems of equations and explore eigenvalue problems.

Unit- 1

Basics of NumPy and Matplotlib - Basic concepts in analysis - The ε, N definition of convergence for sequences - Convergence of series -The Harmonic Series - The Fibonacci sequence - The ε, δ definition of continuity - Thomae's function - The Intermediate Value Theorem and root finding - Differentiation - The Mean Value Theorem

Unit - 2

Basic calculus with SciPy - Comparison of differentiation formulae - Taylor series - Taylor's Theorem and the Remainder term - A continuous, nowhere differentiable function - Integration with Trapezium Rule - Integration with Simpson's Rule – Improper Integrals

Unit - 3

Basic concepts - ODE's, PDE's – Basic of Matplolib animation – ODE –I, ODE –II , PDE –I heat equation, PDE –II the wave equation

Unit - 4

Basic of SymPy – Basic concepts in linear algebra – Linear systems in R3 – Four methods for solving Ax=B – Matrices as linear transformations – Eigenvalues and Eigenvectors

Unit - 5

Basic concepts in abstract algebra – Cyclic group – Dihedral Group – Symmetric and alternating groups

Activities

The activities include quizzes, assignments, seminars, and student presentations. Additional tasks involve mini projects, concept flowcharts, operator method charts, peer teaching, LMS-based quizzes, board work challenges, poster presentations, and visual aids like chalk talks to enhance learning and engagement.

Text book

Siri Chongchitnan, Exploring University Mathematics with Python, Springer

Reference books

1. Robert Johansson, *Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib*, Apress.
2. Gilbert Strang, *Introduction to Linear Algebra*, Wellesley-Cambridge Press.
3. Judith Gersting, *Mathematical Structures for Computr Science*, W.H. Freeman.