	ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

Model Syllabus for Mathematics (Minor) in consonance with Curriculum framework w.e.f. AY 2025-26

COURSE STRUCTURE

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
II	III	1	Differential Equations	4	5
	IV	2	Group Theory	4	5
III	V	3	Ring Theory	4	5
		4	Elementary Real Analysis	4	5
	VI	5	Linear Algebra	4	5
		6	Advanced Real Analysis	4	5

SEMESTER-III

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-IV

COURSE 2: 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 - Finite 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-V

COURSE 3: RING THEORY

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

Course Objectives

The course aims to:

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

Course Outcomes

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

1. Understand and differentiate between rings, integral domains, and fields, and describe their algebraic properties.
2. Identify and construct subrings and various types of ideals, and determine when a ring qualifies as a field.
3. Analyze quotient rings, build composition tables for finite rings, and distinguish between prime and maximal ideals.
4. Apply ring homomorphisms and isomorphisms effectively, and interpret the fundamental homomorphism theorems.
5. 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-V

COURSE 4: ELEMENTARY 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-VI

COURSE 5: 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 Proses(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-VI

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.

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