Government General Degree College Chapra
Department of Mathematics
PO and CO (NEP)
Third Semester

Programme Outcome:
Upon successful completion of the B.Sc. Mathematics Major/Minor/MDC 3rd Semester, students will be able to:

1. Acquire a comprehensive understanding of fundamental mathematical principles, including algebra, calculus, analysis, differential equations, vector spaces, and abstract structures such as groups.

2. Apply logical reasoning and mathematical techniques to analyze and solve both theoretical and real-life problems involving pure and applied mathematics.

3. Demonstrate proficiency in mathematical modeling and problem-solving using differential equations to address problems in science, engineering, and economics.

4. Develop computational skills and algorithmic thinking, including proficiency in C programming for mathematical computation, data handling, and simulation of mathematical models.

5. Understand and apply real analysis concepts, including convergence, continuity, differentiability, and infinite series, supported by rigorous proofs and geometric intuition.

6. Interpret results through graphical and numerical approaches, using plotting and visualization techniques to study the behavior of sequences, series, and solutions of differential equations.

7. Demonstrate the ability to communicate mathematical ideas clearly and effectively, both in written and verbal form, and construct sound logical proofs across diverse topics.

8. Foster a research-oriented mindset and prepare for higher studies in mathematics or related interdisciplinary fields by cultivating critical thinking and a strong theoretical base.

9. Appreciate the historical development and societal relevance of mathematics, understanding its evolution and utility in the digital age.

10. Uphold ethical practices and responsibility in the application of mathematics, ensuring accuracy, integrity, and respect for the broader impacts of mathematical work.

Course Outcome:

Course code & title	Syllabus	Course Outcome
MATH-M-T-03: Real Analysis-I	**Unit 1. [10L]** Review of algebraic and order properties of R. Idea of countable sets, uncountable sets and uncountability of R. Countability of Q. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima. Completeness property of R and its equivalent properties. The Archimedean property, density of rational (and irrational) numbers in R, intervals. Intervals, ε-neighbourhood of a point in R, interior points, limit points, isolated points, open set, closed set, union and intersection of open and closed sets. Derived set, closure of a set, interior of a set. Illustrations of Bolzano-Weierstrass theorem for sets. **Unit 2. [15L]** Sequences, bounded sequence, convergent sequence, limit of a sequence, lim inf, lim sup. Limit theorems. Sandwich theorem. Nested interval theorem Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only). Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion, Cauchy's 1st and 2nd limit theorem **Unit 3. [15L]** Infinite series, convergence and divergence of infinite series, Cauchy criterion. Tests for convergence: comparison test, limit comparison test, ratio test: D'Alembert's ratio test, Raabe's test, Cauchy's root test, Gauss test, integral test, Cauchy's condensation test with examples.	Upon successful completion of the course, students will be able to: **CO1**: Explain the algebraic and order properties of real numbers and differentiate between countable and uncountable sets. **CO2**: Understand bounds, supremum, infimum, and the completeness and Archimedean properties of R; analyze open, closed, and derived sets. **CO3**: Analyze the convergence and divergence of sequences, apply limit theorems, and use criteria like Bolzano-Weierstrass and Cauchy's convergence. **CO4**: Determine convergence of series using various tests such as ratio test, root test, Raabe's test, etc.; classify series as absolutely or conditionally convergent. **CO5**: Apply the definition of limits and continuity; analyze the behavior of continuous functions on intervals and understand uniform continuity. **CO6**: Apply mean value theorems, Taylor's theorems, and related results to study differentiability and analyze functions. **CO7**: Use graphical tools to explore convergence properties of sequences and series, and to visualize key theorems like Bolzano-Weierstrass and tests for convergence.

	Alternating series, Leibnitz test. Absolute and conditional convergence. **Unit 4: [15L]** Limits of functions (ε - δ approach). Sequential criterion for limits. Divergence criteria. Limit theorems, one sided limit. Infinite limits and limits at infinity. Continuous functions, neighbourhood property. Sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, Bolzano's Theorem, intermediate value theorem. Location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem. Differentiability of a function at a point and in an interval, Caratheodory's theorem, ● Algebra of differentiable functions. ● Darboux's theorem. **Unit 5. [15L]** Rolle's theorem. Lagrange's and Cauchy's mean value theorems. Taylor's theorem with Lagrange's and Cauchy's forms of remainder. Application of Taylor's theorem to convex functions. Applications of mean value theorem to inequalities and approximation of polynomials. Relative extrema, interior extremum theorem. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\log(1+x)$,$1/(ax+b)$,$(1+x)^n$. Application of Taylor's theorem to inequalities. **Graphical Demonstration (Teaching aid) [5L]**	

	1. Plotting of recursive sequences. 2. Study the convergence of sequences through plotting. 3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. 4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum. 5. Cauchy's root test by plotting nth roots. 6. Ratio test by plotting the ratio of nth and $(n+1)_{th}$ term.	
MATH-SEC-T-03 Programming in C	**Unit 1. [15L]** Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: Binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc. Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems. **Unit 2. [30L]** ● Programming language and importance of 'C' programming. ● Constants, variables and data type of 'C'-Program: Character set. Constants and variables data types, expression, assignment statements, declaration. ● Operation and expressions: Arithmetic operators, relational operators, logical operators. ● Decision making and branching: Decision making with if statement, if-else statement, nesting if statement, switch statement, break and continue statement. ● Control statements: While statement, do-while statement, for statement. ● Arrays: One-dimension, two-dimensional and multidimensional arrays, declaration of arrays,	By the end of the course, students will be able to: **CO1**: Describe the history, classification, and basic components of computer systems including hardware and software. **CO2**: Understand and convert between binary, decimal, octal, and hexadecimal number systems and perform binary arithmetic. **CO3**: Define and use terms like bit, byte, word, and understand coding standards like ASCII and EBCDIC. **CO4**: Develop algorithms and draw flowcharts for simple problems, analyzing basic time and space complexity. **CO5**: Write simple programs in C using variables, data types, operators, and expressions. **CO6**: Implement conditional statements (if, if-else, switch) and looping constructs (for, while, do-while) effectively. **CO7**: Use arrays and user-defined functions in C for

	initialization of one and multi-dimensional arrays. ● User-defined Functions: Definition of functions, scope of variables, return values and their types, function declaration, function call by value, nesting of functions, passing of arrays to functions, recurrence of function. ● Application to simple problems: Evaluation of functional values, solution of quadratic equations with real coefficients, approximate sum of convergent infinite series, sorting of real numbers.	structured programming and modular problem solving. **CO8**: Apply programming knowledge to real-life problems such as solving quadratic equations, evaluating mathematical functions, sorting, and summing series.
MATH-MI-T-02 Calculus & Differential Equations	Real-valued functions defined on an interval, limit and Continuity of a function (using $\varepsilon-$). Algebra of limits. Differentiability of a function. Successive derivative: Leibnitz's theorem and its application to problems of type e^{ax+b}sinx, $e^{ax+b}cosx$, $(ax+b)sinx$, $(ax+b)^n cosx$. Partial derivatives. Euler's theorem on homogeneous function of two and three variables. Curvature, rectilinear asymptotes. Indeterminate Forms: L'Hospital's Rule (Statement and Problems only). Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Taylor's and Maclaurin's infinite series of functions like e^x, sinx, cosx, $(1+x)^n$, log(1+x) with restrictions wherever necessary. Application of the principle of maxima and minima for a function of a single variable. **Unit 2. [5L]** Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sin^n x\,dx$, $\int cos^n x dx$, $\int tan^n x dx$, $\int sec^n x dx$, $\int (\log x)^n dx$, $\int sin^n x cos^m x dx$. **Unit 3. [20L]** First order equations: (i) Exact equations and those reducible to such	After completing this course, students will be able to: **CO1**: Understand the concept of limit, continuity, and differentiability of real-valued functions using the ε-δ definition. **CO2**: Compute successive derivatives using Leibnitz's theorem and solve related problems involving exponential and trigonometric functions. **CO3**: Evaluate partial derivatives and apply Euler's theorem for homogeneous functions in two and three variables. **CO4**: Apply L'Hospital's Rule to solve indeterminate forms and find curvature and rectilinear asymptotes. **CO5**: State and interpret Rolle's, Lagrange's, and Cauchy's Mean Value Theorems geometrically and algebraically. **CO6**: Use Taylor's and Maclaurin's Theorems (with remainder forms) to expand functions and analyze convergence.

	equations. (ii) Euler's and Bernoulli's equations (Linear). (iii) Clairaut's Equations: General and Singular solutions. Second order differential equation: (i) Method of variation of parameters, (ii) Method of undetermined coefficients. Linear homogeneous equations with constant coefficients, method of variation of parameters, simultaneous differential equations.	**CO7**: Apply differential calculus to identify maxima and minima of single-variable functions. **CO8**: Derive and apply reduction formulas for trigonometric and logarithmic integrals. **CO9**: Solve first-order and second-order differential equations using exact, Bernoulli's, Clairaut's methods, and the method of variation of parameters. **CO10**: Analyze linear differential equations with constant coefficients and apply methods of undetermined coefficients and simultaneous equations.
MATH-MD-T-03 **Basic Mathematics**	**Unit 1. Set Theory: [5L]** • Introduction to sets and their representations. The empty set, finite and infinite sets, equal sets, subsets, power set, and Universal set. • Venn Diagrams, operations on sets, complement of a set, problems on union and intersection of sets. **Unit 2. Complex Numbers: [5L]** • Polar representation of complex numbers. • De Moivre's theorem (without proof) for rational indices and their applications. **Unit 3. Theory of Equations: [10L]** • Introduction and definition of equation. Types of equations. • Relation between roots and coefficients. Descartes's rule of signs. • Linear and quadratic equations and their solution. Nature of the roots of quadratic equations. **Unit 4. Matrix & Determinant: [10L]** • Definition of a Matrix. Types of Matrices. Elementary operations on Matrices. • Determinant of a square matrix (up to third order). Properties of determinants. Cofactors and minor of a determinant.	After completing this course, the student will be able to: **CO1**: Understand the concept of sets, perform set operations using Venn diagrams, and solve problems involving union, intersection, and complement. **CO2**: Represent complex numbers in polar form and apply De Moivre's Theorem to compute powers and roots. **CO3**: Identify and solve linear and quadratic equations; apply Descartes's Rule of Signs and use root-coefficient relationships. **CO4**: Understand the structure and types of matrices, compute determinants, and solve systems of equations using inverse and Cramer's Rule. **CO5**: Grasp the basic concepts of statistics, differentiate between types of data, and represent data effectively using tables and graphs.

	• Transpose and Adjoint of a matrix. Symmetric and Skew Symmetric Matrices. • Inverse of a matrix. Solution of system of linear equations (up to third order) using matrix inversion method and Cramer's Rule. **Unit 5. [5L]** • Definition and scope of statistics, concepts of statistical population and sample. • Data: qualitative and quantitative, discrete and continuous data types, primary and secondary data. • Presentation of data: tabular and graphical. • Frequency distribution, cumulative frequency distribution and their graphical representations: histogram, frequency polygon, frequency curve, and O-gives. **Unit 6. [10L]** • Measures of Central Tendency: mean, weighted mean, median, mode. • Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.	**CO6**: Calculate and interpret measures of central tendency and dispersion, and assess data distribution using skewness and kurtosis.