**Holy Cross College (Autonomous), Nagercoil**

**Kanyakumari District, Tamil Nadu.**

**Accredited with A$^{++}$ by NAAC - V cycle (CGPA 3.53)**

Affiliated to

**Manonmaniam Sundaranar University, Tirunelveli**

# Semester I - VI

# POs, PSOs & COs

## DEPARTMENT OF MATHEMATICS

**2023-2026**

**(With effect from the academic year 2025-2026)**

## Programme Educational Objectives (PEOs)

| PEOs | Upon completion of B.Sc. degree programme, the graduates will be able to | Mission addressed |
|---|---|---|
| **PEO 1** | apply appropriate theory and scientific knowledge to participate in activities that support humanity and economic development nationally and globally, developing as leaders in their fields of expertise. | **M1& M2** |
| **PEO 2** | inculcate practical knowledge for developing professional empowerment and entrepreneurship and societal services. | **M2, M3, M4 & M5** |
| **PEO 3** | pursue lifelong learning and continuous improvement of the knowledge and skills with the highest professional and ethical standards. | **M3, M4, M5 & M6** |

## Programme Outcomes (POs)

| POs | Upon completion of B.Sc. Degree Programme, the graduates will be able to: | PEOs Addressed |
|---|---|---|
| **PO1** | obtain comprehensive knowledge and skills to pursue higher studies in the relevant field of science. | PEO 1 |
| **PO2** | create innovative ideas to enhance entrepreneurial skills for economic independence. | PEO2 |
| **PO3** | reflect upon green initiatives and take responsible steps to build a sustainable environment. | PEO 2 |
| **PO4** | enhance leadership qualities, team spirit and communication skills to face challenging competitive examinations for a better developmental career. | PEO 1&PEO 3 |
| **PO5** | communicate effectively and collaborate successfully with peers to become competent professionals. | PEO 2&PEO 3 |
| **PO6** | absorb ethical, moral and social values in personal and social life leading to highly cultured and civilized personality | PEO 2& PEO 3 |
| **PO7** | participate in learning activities throughout life, through self-paced and self-directed learning to develop knowledge and skills. | PEO1 & PEO 3 |

## Programme Specific Outcomes (PSOs)

| PSO | Upon completion of B.Sc. Mathematics, the graduates will be able to: | Mapping with POs |
|---|---|---|
| **PSO – 1** | acquire good knowledge and understanding, to solve specific theoretical & applied problems in different area of mathematics & statistics. | **PO1** |
| **PSO – 2** | understand, formulate, develop mathematical arguments, logically and use quantitative models to address issues arising in social sciences, business and other context /fields. | **PO6** |
| **PSO - 3** | apply Mathematical theories and principles accurately, precisely and effectively including higher research and extensions | **PO3 &PO7** |
| **PSO – 4** | prepare the students who will demonstrate respectful engagement with other's ideas, behaviors, beliefs and apply diverse frames of references to decisions and actions | **PO5 &PO6** |
| **PSO – 5** | create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations | **PO2 &PO4** |

## Mapping of PO'S and PSO'S

| POs | PSO1 | PSO 2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **PO 1** | **S** | M | M | M | M |
| **PO 2** | M | M | M | M | S |
| **PO 3** | M | M | S | M | M |
| **PO4** | M | M | M | M | S |
| **PO5** | M | M | M | S | M |
| **PO6** | M | S | M | S | M |
| **PO7** | M | M | S | M | M |

Strong -S (3), Medium – M (2), Low – L (1)

**Course Outcomes**
**SEMESTER I**
**CORE COURSE I: ALGEBRA & TRIGONOMETRY**
**Course Code : MU241CC1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1. | know the definitions and properties of the Remainder Theorem, equations with real and rational coefficients, and the transformations of equations | **K1** |
| 2. | find eigen values, eigen vectors, verify Cayley — Hamilton theorem and diagonalize a given matrix | **K1** |
| 3. | expand the powers and multiples of trigonometric functions in terms of sine and cosine | **K2** |
| 4. | classify and solve reciprocal equations | **K2** |
| 5. | determine relationship between circular and hyperbolic functions and the summation of trigonometric series | **K3** |

**K1** - Remember; **K2** - Understand; **K3** - Apply

**SEMESTER I**

**CORE COURSE II: DIFFERENTIAL CALCULUS**

**Course Code: MU241CC2**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | recall the definitions and basic concepts of Differential Calculus. | **K1** |
| 2 | understand the concepts of Differentiation, Partial Differentiation, Envelope & Curvature. | **K2** |
| 3 | determine Partial derivatives of a function of two variables and use Lagrange's method of undetermined multipliers. | **K2** |
| 4 | distinguish between partial and ordinary differential equations. | **K3** |
| 5 | find the radius of curvature using polar co-ordinates. | **K3** |

**K1** - Remember; **K2** - Understand; **K3** - Apply

**SEMESTER I**

**ELECTIVE COURSE I: ALLIED MATHEMATICS-I**

**ALGEBRA AND DIFFERENTIAL EQUATIONS**

**Course Code : MU231EC1**

| On the successful completion of the course, student will be able to**:** | | |
|---|---|---|
| 1 | recall the methods of finding the solutions of algebraic equations, differential equations and various formulae of laplace transform | **K1** |
| 2 | understand the theory of algebraic equations, eigen values, differential equations and laplace transform | **K2** |
| 3 | simplify algebraic expressions using various methods, find eigen values, solve initial value problems for odes and find inverse laplace transform | **K2** |
| 4 | analyse various types of first-order odes, relate laplace transform and inverse laplace transform and formulate algebraic equations from real world problems. | **K4** |

**K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze;

**SEMESTER – I**

**NON-MAJOR ELECTIVE NME - I**

**MATHEMATICS FOR COMPETITIVE EXAMINATIONS I**

**Course Code : MU231NM1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| **1** | understand the problems and remember the methods to solve problems. | **K1 & K2** |
| **2** | grasp the simplest method to solve problems. | **K2** |
| **3** | apply suitable mathematical method and get solutions to simple real life problems. | **K3** |

**K1** - Remember; **K2** - Understand; **K3** - Apply

**SEMESTER – I**

**FOUNDATION COURSE - BRIDGE MATHEMATICS**

**Course Code: MU231FC1**

| On the successful completion of the course, student will be able to**:** | | |
|---|---|---|
| **1** | prove the binomial theorem and apply it to find the expansions of any $(x + y)^n$ and also, solve the related problems. | **K2 & K3** |
| **2** | find the various sequences and series and solve the problems related to them. Explain the principle of counting. | **K1 &K3** |
| **3** | find the number of permutations and combinations in different cases. Apply the principle of counting to solve the problems on permutations and combinations. | **K2 & K3** |
| **4** | explain various trigonometric ratios and find them for different angles, including sum of the angles, multiple and submultiple angles, etc. Also, they can solve the problems using the transformations. | **K2 & K3** |
| **5** | find the limit and derivative of a function at a point, the definite and indefinite integral of a function. Find the points of min/max of a function. | **K3** |

**K1**-Remember**K2**- Understand K**3** - Apply

**SEMESTER – I**

**SPECIFIC VALUE-ADDED COURSE –WEB DESIGNING USING HTML**
**Course Code : MU231V01**

| On the successful completion of the course, student will be able to**:** | | |
|---|---|---|
| 1 | define modern protocols and systems used on the web (such as HTML, HTTP) | **K2** |
| 2 | employ fundamental knowledge on web designing with makeup language | **K3** |
| 3 | gain strong knowledge in HTML | **K2** |
| 4 | use critical thinking skills to design and implement an interactive websites with regard to issues of usability, accessibility and internationalism | **K4** |
| 5 | to pursue future courses in website development and design | **K3** |

**K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze

**SEMESTER II**

**CORE COURSE IV: INTEGRAL CALCULUS**

**Course Code : MU232CC2**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1. | determine the integrals of algebraic, trigonometric and logarithmic functions and to find the reduction formulae. | **K1** |
| 2. | evaluate double and triple integrals and problems using change of order of integration. | **K2** |
| 3. | solve multiple integrals and to find the areas of curved surfaces and volumes of solids of revolution. | **K3** |
| 4. | explain beta and gamma function sand to use them in solving problems of integration. | **K2** |
| 5. | explain Geometric and Physical applications of integral calculus. | **K2** |

**K1** - Remember; **K2** - Understand; **K3** – Apply

**SEMESTER – II**

**ELECTIVE COURSE – II : VECTOR CALCULUS AND FOURIER SERIES**

**Course Code : MU232EC1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | remember the formulae of vector differentiation, integration and Fourier series | **K1** |
| 2 | understand various theorems related to vector differentiation, integration and Beta, Gamma functions | **K2** |
| 3 | solve problems on vector differentiation, integration, Beta, Gamma functions and Fourier series | **K3** |
| 4 | compare double and triple integrals, line, surface integrals, Beta, Gamma functions and Fourier series for Even and odd functions | **K2** |

**K1**–Remember **K2** - Understand **K3** - Apply

**SEMESTER - II**

**Non-Major Elective Course II**

**Mathematics for Competitive Examinations II**

**Course Code : MU232NM1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1. | understand the problems and remember the methods to solve problems. | **K2** |
| 2. | identify the appropriate method to solve problems. | **K1** |
| 3. | apply the best mathematical method and obtain the solution in short. | **K3** |
| 4. | apply fundamental mathematical concepts to calculate simple interest, compound interest | **K3** |
| 5. | develop problem-solving skills and critical thinking by effectively solving real-world scenarios involving financial calculation | **K2** |

**K1** - Remember; **K2** - Understand; **K3** - Apply

**SEMESTER – II**

**SKILL ENHANCEMENT COURSE -SEC-I:**

**INTRODUCTION TO COMPUTATIONAL MATHEMATICS**

**Course Code : MU232SE1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| CO1 | gain an appreciation for the role of computers in mathematics, science, and engineering as a complement to analytical and experimental approaches. | **K1 & K2** |
| CO2 | acquire a strong foundation in numerical analysis, enabling students to evaluate and analyze numerical solutions for mathematical problems. | **K2** |
| CO3 | use and evaluate alternative numerical methods for the solution of systems of equations. | **K3** |
| CO4 | foster critical thinking skills in assessing computational methods for problem solving. | **K3** |
| CO5 | apply mathematical concepts to practical problems through computational approaches. | **K3** |

**K1** - Remember; **K2** - Understand; **K3** - Apply

**SEMESTER I & II**

**Life Skill Training I: Catechism**

| **Course Outcome** | **Upon completion of this course the students will be able to** |
|---|---|
| CO-1 | understand the aim and significance of value education |
| CO-2 | develop individual skills and act confidently in the society |
| CO-3 | learn how to live lovingly through family values |
| CO-4 | enhance spiritual values through strong faith in God |
| CO-5 | learn good behaviours through social values |

**SEMESTER I & II**

**Life Skill Training I: Moral**

**Course Code: UG232LM1**

| **Course Outcome** | **Upon completion of this course the students will be able to** |
|---|---|
| CO-1 | understand the aim and significance of value education |
| CO-2 | develop individual skills and act confidently in the society |
| CO-3 | learn how to live lovingly through family values |
| CO-4 | enhance spiritual values through strong faith in God |
| CO-5 | learn good behaviours through social values |

**SEMESTER I**

**SPECIFIC VALUE- ADDED COURSE- VEDIC ALGEBRA**

**Course Code: MU231V02**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1. | remember mathematical concepts and solutions using Vedic algebra terminology and notation, ensuring clarity and precision in their explanations. | **K1** |
| 2. | understand the mathematical concepts and principles underlying Vedic algebra techniques, fostering a comprehensive grasp of the subject matter. | **K2** |
| 3. | apply Vedic algebra techniques proficiently to solve equations and mathematical problems, demonstrating precision and accuracy. | **K3** |
| 4. | analyze the applicability of Vedic algebra methods in various mathematical contexts, discerning their strengths and limitations through critical examination. | **K4** |
| 5. | evaluate the effectiveness of Vedic algebra in enhancing problem-solving skills and mathematical reasoning, employing rigorous assessment criteria and methodologies. | **K5** |

**K1 -** Remember; **K2 -** Understand; **K3** – Apply; **K4 -** Analyze; **K5** – Evaluate

**SEMESTER I**

**SPECIFIC VALUE - ADDED COURSE - SAMPLING TECHNIQUES**

**Course Code: MU231V03**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1. | recall and list different sampling methods such as simple random sampling, systematic sampling, and stratified sampling. | K1 |
| 2. | understand appropriate sampling methods to create survey designs or experimental setups based on specific research objectives and population characteristics. | K2 |
| 3. | apply knowledge of sampling errors to distinguish between biased and unbiased errors and assess their potential impact on survey outcomes. | K3 |
| 4. | analyse survey designs by evaluating the suitability and effectiveness of sampling methods. | K4 |
| 5. | evaluate the best sampling strategies based on understanding sampling principles to ensure accurate and reliable survey outcomes. | K5 |

**K1**– Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate;

**SEMESTER III**

**CORECOURSE V :VECTOR CALCULUS AND ITS APPLICATIONS**

**Course Code: MU233CC1**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | remember the formulae of vector differentiation, integration and the basic principles of vectors, including their properties, operations, and geometric interpretations | K1 |
| 2 | understand the concepts of divergence and curl and their applications in physics and engineering | K2 |
| 3 | apply Green's, Gauss', and Stokes' theorems to solve problems involving line and surface integrals, demonstrating their understanding of vector calculus principles | K3 |
| 4 | gain proficiency in differentiating vectors and interpreting their gradients geometrically | K4 |
| 5 | learn how to integrate vectors to calculate work done by forces and solve related problems | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** – Evaluate:

**SEMESTER III**
**CORECOURSE VI: DIFFERENTIAL EQUATIONS AND APPLICATIONS**
**Course Code: MU233CC2**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | learn Exact differential equations and Bernoulli's equations | K1 |
| 2 | learn methods of forming and solving partial differential equations | K2, K4 |
| 3 | apply the concepts to solve problems in physical sciences and engineering | K3 |
| 4 | solve linear differential equations with constant coefficients | K5 |
| 5 | solve linear differential equations with variable coefficients | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate;

**SEMESTER III**
**ELECTIVE COURSE III: MATHEMATICAL STATISTICS**
**Course Code: MU233EC1**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | calculate and interpret correlation coefficients and regression lines, and their applications in analyzing relationships between variables. | K1 |
| 2 | understand Theory of Attribute in statistics, including concepts like consistency of data, independence, and association | K2 |
| 3 | acquire knowledge of index numbers and learn how to apply index numbers in economic analysis | K3 |
| 4 | learn about rank correlation and understand when and how to use them to assess monotonic relationships between variables. | K4 |
| 5 | develop proficiency in interpolation methods and apply these techniques to estimate values within a set of data points with precision. | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate;

**SEMESTER III**
**SKILL ENHANCEMENT COURSE SEC-II: SPHERICAL TRIGONOMETRY**
**Course Code: MU233SE1**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| | explain the concepts great and small circles, axis and poles of great circles | K2 |
| | define spherical angle and also the angle of intersection between two great circles | K2 |
| | calculate the arc length between two points on a sphere using the cosine rule for sides | K3 |
| | distinguish between plane trigonometry and spherical trigonometry | K4 |

| | | |
|---|---|---|
| | discuss and derive the spherical cosine, sine, supplemental cosine and cotangent rules | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate;

**SEMESTER III**
**SPECIFIC VALUE-ADDED COURSE –BASIC FUZZY ALGEBRA**
**Course Code: MU233V01**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| | learn fuzzy versus crisp, fuzzy sets and definition | K1 |
| 2 | understand general definitions and properties of Fuzzy sets, general properties: Fuzzy versus crisp | K2 |
| 3 | study Extension principles of Fuzzy sets, fuzzy compliments | K2 |
| 4 | learn Binary operations of two Fuzzy numbers | K2, K3 |
| 5 | apply the Fuzzy logic concepts to truth values and truth table | K3 |

**K1**– Remember; **K2** - Understand; **K3** – Apply;

**SEMESTER III**
**SPECIFIC VALUE-ADDED COURSE –STATISTICAL SURVEY**
**Course Code: MU233V02**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1. | recall the main steps involved in planning a survey and identifying sources of primary and secondary data. | K1 |
| 2. | understand the purpose of survey planning, the nature of information required, and the importance of selecting appropriate data collection techniques | K2 |
| 3. | apply survey planning principles to design effective surveys and select suitable methods for data collection | K3 |
| 4. | analyze survey data to identify patterns, trends, and potential sources of error or bias. | K4 |
| 5. | create comprehensive survey reports that present survey findings clearly and effectively, drawing conclusions and making recommendations based on the analysis of the data collected | K6 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

**SEMESTER III**
**SPECIFIC VALUE-ADDED COURSE – DATA STRUCTURES**
**Course Code: MU233V03**

| On the successful completion of the course, student will be able to: | | |
|---|---|---|
| 1 | recall the definitions and properties of elementary data structures like arrays, stacks, queues, and linked lists. | K1 |
| 2 | explain the principles underlying these data structures and their applications in problem-solving. | K2 |
| 3 | utilize appropriate data structures to represent rooted trees and demonstrate the relationships between nodes within these structures. | K3 |
| 4 | analyze the properties of red-black trees and their role in maintaining balance in dynamic data structures. | K4 |
| 5 | evaluate the efficiency and scalability of disjoint-set data structures for solving problems involving dynamic connectivity. | K5 |

**K1** – Remember; **K2** – Understand; **K3 –** Apply; **K4-** Analyze; **K5** – Evaluate

**SEMESTER III/V**
**SELF LEARNING COURSE: SET/NET ALGEBRA ESSENTIALS**
**Course Code: MU235SL1**

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1 | demonstrate the ability to compute line integrals over rectifiable arcs and apply Cauchy's Theorem to evaluate integrals in various domains. | K2, K3 |
| 2 | interpret and apply advanced concepts such as Jensen's Formula and Hadamard's Theorem to analyze the behavior of entire functions and infinite products. | K3, K4 |
| 3 | apply the calculus of residues to evaluate definite integrals and utilize harmonic functions to solve boundary value problems using Poisson's Formula and Schwarz's Theorem. | K3, K5 |
| 4 | construct power series expansions using Weierstrass's Theorem and apply partial fractions and factorization techniques to manipulate complex functions. | K3, K6 |
| 5 | analyze the local properties of analytic functions, including removable singularities, zeros, poles, and the Maximum Principle. | K4 |

**K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate; **K6**– Create

**SEMESTER IV**
**CORE COURSE VII: GROUPS AND RINGS**
**Course Code: MU234CC1**

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1 | recall the definitions of groups, rings, functions and also examples of groups and rings | K1 |
| 2 | explain the properties of groups, rings and different types of groups and rings | K2 |
| 3 | develop proofs of results on Permutation groups, Cyclic groups, Quotient group, Subgroups, sub rings, quotient rings | K3 |
| 4 | test the homomorphic and isomorphic properties of groups and rings | K4 |
| 5 | examine the properties of Ideals – Maximal and Prime ideals – Cosets - order of an element | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate;

**SEMESTER IV**
**CORE COURSEVIII: ELEMENTS OF MATHEMATICAL ANALYSIS**
**Course Code: MU234CC2**

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1 | recall the basic concepts of real numbers, definitions on sequences and series of real numbers | K1 |
| 2 | explain the primary concepts of sequences and series of real numbers | K2 |
| 3 | calculate limit of the sequences and determine the convergence of the series by applying Cauchy's principles, root test and ratio tests | K3 |
| 4 | analyse the properties of real numbers, nature of sequences and series | K4 |
| 5 | evaluate the behavior of sequences and the convergence of series using different types of tests | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate;

**SEMESTER IV**
**ELECTIVE COURSE IV: TRANSFORM TECHNIQUES**
**Course Code: MU234EC1**

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| | recall basic knowledge about Laplace transforms, inverse Laplace transforms, Fourier series, Fourier transform, and Z-transforms, including their definitions, properties, and fundamental concepts. | K1 |
| | demonstrate a solid understanding of the principles and concepts | K2 |

| | | |
|---|---|---|
| | underlying Laplace transforms, inverse Laplace transforms, Fourier series, Fourier transform, and Z-transforms, including their applications in mathematical analysis and signal processing. | |
| | apply Fourier sine and cosine transforms to solve difference equations. | K3 |
| | apply transform techniques to evaluate integrals, and solve ordinary and partial differential equations with constant and variable coefficients. | K3, K4 |
| | analyze and decompose periodic functions using the Fourier series, including expansion of periodic functions of period $2\pi$, expansion of even and odd functions, and representation of functions over half intervals. | K5 |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** – Evaluate

**SEMESTER IV**
**SELF LEARNING COURSE II: ANALYSIS AND FORECASTING**
**Course Code: MU236SL1**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | identify the different components of a time series, including trend, seasonal variations, and cyclical patterns | K1 |
| 2 | understand the importance of time series analysis in various fields and how it aids in making informed decisions | K2 |
| 3 | assessing the effectiveness and reliability of the chosen forecasting technique | K2 |
| 4 | differentiate between stationary and non-stationary time series data and analyze autocorrelation functions | K4 |
| 5 | evaluate forecasting procedures to predict future values of a time series with accuracy and reliability | K5 |

**K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate;

**SEMESTER V**
**CORE COURSE IX: LINEAR ALGEBRA**
**Course Code: MU235CC1**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1. | recall the definitions and fundamental concepts of vector spaces, subspaces, linear transformations, basis, eigenvalues, inner product spaces, quadratic forms, and lattices. | **K1** |
| 2. | describe the span of a set, linear independence, rank and nullity, properties of eigenvalues, and orthogonality in inner product spaces. | **K2** |
| 3. | apply the Cayley-Hamilton theorem to compute characteristic equations and eigenvalues, and perform matrix transformations. | **K3** |
| 4. | analyse the orthogonal complement, bilinear forms, and quadratic form reduction techniques to diagonal form. | **K4** |
| 5. | evaluate lattice structures, modular and distributive lattices, and Boolean algebra for mathematical reasoning and logical deductions. | **K5** |

**SEMESTER V**
**CORE COURSE X: REAL ANALYSIS**
**Course Code** : **MU235CC2**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | define fundamental concepts of metric spaces, including open sets, bounded sets, open balls, subspaces, interior, closure, limit points, dense sets, complete metric spaces, continuity, homeomorphism, connectedness, compactness. | **K1** |
| 2 | describe the properties and relationships of closed sets, limit points, dense sets, complete metric spaces, continuity, connectedness, compactness, and their significance in metric space theory. | **K2** |
| 3 | apply the concepts of open and closed sets, continuity, homeomorphism, connectedness, compactness and complete metric space to solve problems and verify the conditions required for these properties. | **K3** |
| 4 | analyze the properties of metric spaces, continuity, connectedness, completeness and compactness by classifying examples, comparing key theorems, and interpreting their implications in mathematical problem-solving. | **K4** |
| 5 | evaluate the fundamental concepts of metric spaces, continuity, connectedness, completeness and compactness by analyzing key theorems, constructing rigorous proofs, and identifying counterexamples to demonstrate mathematical concepts. | **K5** |

**K1**-Remember;**K2** -Understand; **K3**– Apply;**K4** -Analyze; **K5**-Evaluate

**SEMESTER V**
**CORE COURSE XI: GRAPH THEORY**
**Course Code: MU235CC3**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall fundamental concepts, definitions, and properties of graphs, subgraphs, trees, matchings, planarity, and colorability. | **K1** |
| 2 | explain the structural properties of graphs, including connectedness, Eulerian and Hamiltonian graphs, trees, and chromatic characteristics. | **K2** |
| 3 | apply graph theory principles to solve problems related to connectivity, matchings, planar graphs, and chromatic polynomials. | **K3** |
| 4 | analyze the characteristics of different types of graphs, identify structural properties, and examine their applications in real-world problems. | **K4** |
| 5 | evaluate various graph properties, justify theoretical results such as Euler's formula and the five-color theorem, and assess different graph algorithms. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** – Evaluate.

**SEMESTER V**
**CORE RESEARCH PROJECT**
**Course Code: MU235RP1**
**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | apply mathematical concepts and theories to formulate and analyze real-world problems through project-based learning. | **K1** |
| 2 | demonstrate the ability to conduct literature reviews, identify research gaps, and select appropriate mathematical tools for investigation. | **K2** |
| 3 | develop skills in mathematical modeling, computation, or theoretical analysis to solve complex problems. | **K3** |
| 4 | communicate mathematical ideas effectively through written reports, presentations, and visual aids using appropriate mathematical language. | **K4** |
| 5 | exhibit independent thinking, teamwork, time management, and ethical responsibility during the process of completing the project work. | **K5** |

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE I: a) NUMERICAL METHODS**
**Course Code: MU235DE1**
**Course Outcomes**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | recall the fundamental concepts of numerical methods, including iteration techniques, finite differences, and interpolation formulas. | **K1** |
| 2 | describe the application of Newton's Interpolation and divided difference methods in data approximation. | **K2** |
| 3 | compute numerical differentiation and integration using Newton's forward, backward, and central difference formulas, as well as quadrature rules.. | **K3** |
| 4 | examine different numerical techniques, including Taylor's series, Picard's, | **K4** |

| | | |
|---|---|---|
| | Euler's, and Runge-Kutta methods, for solving differential equations. | |
| 5 | compare the accuracy and efficiency of various numerical methods for solving algebraic, transcendental, and differential equations. | **K5** |

**K1** - Remember; **K2** - Understand; **K3**– Apply; **K4**-Analysis; **K5**-Evaluate

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE I: b) FUZZY MATHEMATICS**
**Course Code: MU235DE2**

**Course Outcomes**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | recall the basic concepts of crisp sets and fuzzy sets, including their differences, properties, and fundamental operations, the types of fuzzy numbers ,truth tables, logical connectives. | **K1** |
| 2 | explain the various types of fuzzy sets and the significance of operations performed on them and Describe the process of performing fuzzy arithmetic and operations on fuzzy numbers.. | **K2** |
| 3 | solve problems involving basic operations on fuzzy sets such as union, intersection, and complement and to model complex systems such as clustering or decision-making. | **K3** |
| 4 | analyze the role of fuzzy relations in real-world applications like database management, pattern recognition, and fuzzy systems.compare and contrast the properties of operations on fuzzy sets with those on crisp sets | **K4** |
| 5 | assess the practical application of fuzzy sets in real-world problems such as control systems or decision-making processes and the effectiveness and limitations of fuzzy systems in real-world applications such as data mining, optimization, and adaptive systems. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4**-Analysis; **K5**-Evaluate

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE I: c) THEORYOF NUMBERS**
**Course Code: MU235DE3**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall fundamental concepts of divisibility theory, Diophantine equations, the basic properties of congruences, Fermat's Theorem, and Fibonacci numbers to efficiently solve problems in number theory. | **K1** |
| 2 | explain the division algorithm, the distribution of prime numbers, the theory of congruences, pseudo primes, absolute pseudo primes, the properties of Fibonacci numbers, and the Fibonacci sequence. | **K2** |
| 3 | apply the greatest common divisor, the Euclidean algorithm, the Fundamental Theorem of Arithmetic including linear congruences and the Chinese Remainder Theorem, Wilson's Theorem Fibonacci numbers and sequences in solving mathematical and computational problems and applications. | **K3** |
| 4 | explore the Euclidean algorithm to identify patterns and relationships in integers, the structure of Diophantine equations, investigate the properties of congruences, critically assess Fermat's Theorem, and analyze the Fibonacci sequence and its | **K4** |

| | | |
|---|---|---|
| | mathematical properties to identify patterns and relationships in number theory and real-world applications. | |
| 5 | evaluate the Euclidean algorithm in solving integer-related problems, the significance of Diophantine equations, judge the applicability of congruences, compare and validate the use of Fermat's Theorem, and Fermat's Little Theorem, critically evaluate the properties of Fibonacci numbers and sequences, and justify their applications in mathematical and computational contexts. | **K5** |

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE II: a) COMBINATORIAL MATHEMATICS**
**Course Code: MU235DE4**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall fundamental principles of permutations, combinations, principle of inclusion-exclusion, recurrence relations, generating functions and polya's theory of counting | **K1** |
| 2 | explain concepts such as restricted permutations, circular permutations, combinations, principle of inclusion-exclusion, recurrence relations, significance of generating functions and the equivalence classes under a permutation group | **K2** |
| 3 | solve counting problems, including mixed problems on permutation and combinations, inclusion-exclusion, recurrence relations, generating functions,polya's theory of countingand applications of the rook polynomial. | **K3** |
| 4 | interpretcomplex combinatorial problems by identifying appropriate methods such as characteristic roots for recurrence relations, generating functions in counting problems, equivalence classes under a permutation group and principle of inclusion and exclusion | **K4** |
| 5 | develop proficiency in mathematical proofs using combinatorial arguments, including induction and bijective proofs. | **K5** |

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE II: b) DISCRETE MATHEMATICS**
**Course Code: MU235DE5**

**Course Outcomes**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | recall the fundamental concepts in propositions, truth tables, Boolean operations, logic gates and lattices | **K1** |
| 2 | explain methods of proofs, logical equivalence, predicate logic and the working of logic circuits | **K2** |
| 3 | apply techniques like mathematical induction, De Morgan's theorem and Boolean function in problem solving | **K3** |
| 4 | analyze compound propositions, logical statements, fallacies, canonical forms and the structure of partially ordered sets | **K4** |
| 5 | evaluate logical arguments, proof strategies, lattice operations and finite Boolean algebras | **K5** |

**K1** – Remember **K2 -** Understand **K3 -** Apply **K4** – Analyse**K5** – Evaluate **K6 -** Create

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE II: c) AUTOMATA THEORY**
**Course Code: MU235DE6**
**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | acquire the knowledge in mathematical notions of computation,such as computability, decidability and reducibility of the theory of formal languages and automata. | **K1** |
| 2 | perceive the techniques of computations including finite state automata, grammars and regular expressions and their relations | **K2** |
| 3 | design and explain finite state automata, context free grammars, derivation trees. | **K3** |
| 4 | apply mathematical foundations, algorithmic principles and computer science theory to the modelling and design of computer based systems in a way that demonstrates. | **K4** |
| 5 | evaluate different computational models using combinatorial methods. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate

**SEMESTER VI**
**CORE COURSE XII: COMPLEX ANALYSIS**
**Course Code: MU236CC1**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall and understand the fundamental concepts and results, describe transformations and summarize Taylor's and Laurent's series, singularities. | **K1, K2** |
| 2 | compute limits, continuity, and differentiability, determine analyticity using C.R equations, apply transformations to map functions, evaluate complex integrals using Cauchy's theorem, integral formula and residues. | **K3** |
| 3 | analyze the conditions for a function to be analytic or harmonic, conformal, compare different types of singularities, examine the properties of transformations along with their geometric interpretations, and investigate various cases of Cauchy's residue theorem. | **K4** |
| 4 | evaluate definite integrals using contour integration techniques and justify the use of Taylor's and Laurent's series for function expansion. | **K5** |
| 5 | construct analytic functions that satisfy given boundary conditions and design contour integration methods for evaluating definite integrals. | **K6** |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate; **K6**– Create

**SEMESTER VI**
**CORE COURSE XIII: MECHANICS**

**Course Code: MU236CC2**
**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| **1** | recall fundamental concepts related to forces, moments, couples, friction, projectiles, | **K1** |

| | | |
|---|---|---|
| | and motion under central forces. | |
| **2** | explain the principles governing equilibrium, force systems, friction, projectile motion, and central orbits. | **K2** |
| **3** | apply the concepts of forces, friction, projectiles, and central motion to solve real-world problems. | **K3** |
| **4** | analyze various mechanical systems involving forces, equilibrium, motion, and central orbits. | **K4** |
| **5** | evaluate and justify the mathematical formulations and physical interpretations of forces, motion, and mechanical principles. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate

**SEMESTER VI**

**CORE COURSE XIV: THEORY OF CELESTIAL SPHERE AND INDIAN MATHEMATICS**

**Course Code: MU236CC3**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall fundamental concepts of the spherical trigonometry of the celestial sphere, zones of the Earth, Geometry, Combinations, and series. | **K1** |
| 2 | explain the Celestial sphere, Dateline, Duration of Twilight, the method of false assumption in Egyptian mathematics, and Gross estimation of plane figures. | **K2** |
| 3 | apply concepts such as **hour angle, azimuth at rising, terrestrial latitude and longitude**, and **astronomical refraction** to determine celestial positions accurately. It is also important to apply methods for **finding unknowns from sums and differences** and for **constructing rational triangles whose sides differ by unity** in solving geometric problems related to celestial observations. | **K3** |
| 4 | explore the Four systems of coordinates, the Dip of Horizon General effects of refraction,and the geometry of quadrilaterals. | **K4** |
| 5 | evaluate the Diurnal motion and sidereal Time, Cassini's Formula,the Pythagorean theorem, and Constructing 4 x 4 pan-diagonal magic squares. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate;

**SEMESTER VI**

**DISCIPLINE SPECIFIC ELECTIVE III: a) DATA STRUCTURES**

**Course Code: MU236DE1**

Course Outcomes

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall fundamental concepts of data structures, including arrays, strings, pointers, structures, linked lists, stacks, queues, and trees, along with their basic operations, representations, and applications. | **K1** |
| 2 | explain the fundamental concepts of data structures, including arrays, strings, pointers, structures, linked lists, stacks, queues, and trees, and demonstrate their operations, implementations, and applications. | **K2** |
| 3 | apply appropriate data structures such as arrays, strings, pointers, linked lists, stacks, queues, and trees to solve computational problems. | **K3** |
| 4 | analyze various data structures, including arrays, pointers, linked lists, stacks, queues, and trees, to differentiate their characteristics and evaluate their efficiency in problem-solving. | **K4** |

| | | |
|---|---|---|
| 5 | evaluate the efficiency of various data structures, including arrays, pointers, linked lists, stacks, queues, and trees, by applying appropriate algorithms and justifying their suitability for different computational problems. | **K5** |

**K1**-Remember;**K2** -Understand; **K3**– Apply;**K4** -Analyze; **K5**-Evaluate;

## SEMESTER VI
## DISCIPLINE SPECIFIC ELECTIVE III: b) FUNDAMENTALS OF PYTHON PROGRAMMING
## Course Code: MU236DE2
### Course Outcomes

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | explain the fundamental concepts of variables, data types, lists, tuples, dictionaries, conditional statements, loops, and functions in Python. | **K1, K2** |
| 2 | implement Python programs using variables, lists, tuples, dictionaries, conditional statements, loops, and functions to solve basic computational problems. | **K3** |
| 3 | examine and differentiate various data structures, control flow mechanisms, and function implementations to optimize Python code efficiency. | **K4** |
| 4 | assess the correctness, readability, and efficiency of Python programs by analyzing data handling in lists, tuples, and dictionaries, debugging control flow in conditional and looping structures, and promoting structured design and code reusability in function development. | **K5** |
| 5 | develop well-structured Python programs that integrate different programming constructs, such as functions, loops, and data structures, to solve real-world problems effectively. | **K6** |

**K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 – Create**

## SEMESTER VI
## DISCIPLINE SPECIFIC ELECTIVE III: c) OBJECT ORIENTED PROGRAMMING WITH C++
## Course Code: MU235DE3

### Course Outcomes

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | define and differentiate between fundamental OOP concepts such as classes, objects, inheritance, polymorphism, encapsulation, and abstraction. | **K2** |
| 2 | design and implement C++ programs using classes and objects, including defining member functions, attributes, and constructors/destructors. | **K3** |
| 3 | understand and apply inheritance (single, multiple, hierarchical) and polymorphism (function overloading, operator overloading, virtual functions) to create reusable and flexible code. | **K4** |
| 4 | implement exception handling mechanisms in C++ to ensure robust and reliable programs that can gracefully recover from errors. | **K5** |
| 5 | apply their knowledge of object-oriented programming to design and implement solutions for real-world problems, demonstrating the practical application of the concepts learned. | **K6** |

**K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate; **K6** – Create

**SEMESTER VI**
**DISCIPLINE SPECIFIC ELECTIVE IV: a) LINEAR PROGRAMMING**
**Course Code: MU236DE4**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall the fundamental principles, mathematical formulations, and solution methods of LPP, Duality, Transportation, Assignment, and Job Sequencing problems. | **K2** |
| 2 | understand the theoretical concepts, problem structures, and computational techniques of LPP, Duality, Transportation, Assignment, and Job Sequencing problems for optimization analysis | **K3** |
| 3 | apply appropriate optimization techniques, duality concepts, and solution approaches to solve real-world problems related to LPP, Transportation, Assignment, and Job Sequencing | **K4** |
| 4 | analyze different optimization methods, duality strategies, and problem-solving techniques to assess their efficiency, feasibility, and relevance in decision-making. | **K5** |
| 5 | evaluate various optimization models and solution methodologies in LPP, Duality, Transportation, Assignment, and Job Sequencing to determine their effectiveness in achieving optimal solutions | **K6** |

**K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create**

**SEMESTER VI**
**DISCIPLINE SPECIFIC ELECTIVE IV: b) RESOURCE MANAGEMENT TECHNIQUES**
**Course Code: MU236DE5**

**Course Outcomes**

| **On the successful completion of the course, student will be able to:** | | |
|---|---|---|
| 1 | define fundamental concepts of sequencing problems, PERT & CPM, game theory and inventory models. | **K1** |
| 2 | explain the principles of sequencing, project scheduling, game theory strategies and inventory models with real-world applications. | **K2** |
| 3 | apply appropriate techniques to solve sequencing problems, network scheduling, game theory scenarios and inventory-related calculations. | **K3** |
| 4 | analyze the effectiveness of different sequencing rules, scheduling methods, game strategies and inventory models for optimal decision-making. | **K4** |
| 5 | evaluate complex problems in sequencing, project management, game theory and inventory control to determine the most efficient strategies. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyze; **K5** - Evaluate

**SEMESTER VI**
**DISCIPLINE SPECIFIC ELECTIVE IV: c) PROBABILITY THEORY AND DISTRIBUTIONS**
**Course Code: MU236DE6**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | recall and state fundamental concepts of central tendencies, probability, random variables, probability distributions, and statistical functions, list the properties and characteristics of Binomial, Poisson, and Normal distributions. | **K1** |

| | | |
|---|---|---|
| 2 | explain the significance of partition values, measures of dispersion, moments, skewness, and kurtosis, interpret probability concepts, random variables, and probability distributions in various contexts. | **K2** |
| 3 | solve problems related to statistical measures, probability, and probability distributions, use probability distribution, moment-generating functions, and characteristic functions in real-world scenarios. | **K3** |
| 4 | examine the relationships between different statistical measures and probability distributions, compare and contrast various probability models and their impact on data interpretation. | **K4** |
| 5 | assess the appropriateness of statistical techniques and probability models for different datasets, critically evaluate statistical conclusions and validate theoretical results with real-world applications. | **K5** |

**K1** - Remember; **K2** - Understand; **K3** – Apply; **K4** - Analyse; **K5** - Evaluate; **K6**– Create

## SEMESTER VI
## PROFESSIONAL COMPETENCY SKILL II: MATH FOUNDATIONS AND AI TOOLS
**Course Code: MU236PS1**

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | demonstrate proficiency in mathematical concepts and computational techniques, applying them to solve complex problems effectively. | **K1** |
| 2 | improve speed and accuracy in problem solving under time constraints typically found in competitive programming environments. | **K2** |
| 3 | learn common abbreviations and terminology used in the field of Computer Science and Information Technology | **K2** |
| 4 | develop their analytical thinking and problem-solving abilities, preparing them for success in competitive programming contests and technical interviews. | **K3** |
| 5 | master key mathematical concepts, including Discrete Mathematics, Number Theory, and Combinatorics. | **K4** |

**K1** – Remember; **K2** - Understand; **K3** – Apply; **K4** – Analyse; **K5** – Evaluate