Department of Mathematics
(Bhatter College,Dantan)

Course outcomes for (CBCS Honours)

Semester-I

CC1: ***Calculus, Geometry & Differential Equation*****.**

Course outcomes upon completion of this course, students should be able to:

- **CO1:** Understand the ideas of derivatives and higher order derivatives and double and triple integral.
- **CO2:** Expand functions using Leibnitz theorem and their application.
- **CO3:** Understanding the ideas of comics and their various applications.
- **CO4:** Apply the ideas of conics to explain many natural phenomena.
- **CO5:** Identify, analyse and subsequently solve physical situation whose behaviour can be described by ordinary differential equations.
- **CO6:** Evaluate and apply linear differential equations of second order (and higher).

CC2: ***Algebra.***

Course outcomes upon completion of this course, students should be able to:

- **CO1:** Explain the fundamental ideas of sets and functions.
- **CO2:** Determine equivalence relations on sets and corresponding equivalence classes.
- **CO6:** Formulate equations from available data and find solutions to real life problem.
- **CO6:** Explain different methods like Descartes method, Cardan's method, Ferrari's method in theory of equations.
- **CO6:** Understand various application of the theory of matrices to a wide variety of problems.
- **CO6:** Acquire knowledge of invertible matrices and their properties.

Semester-II

CC3: *Real Analysis*

Course Outcomes Upon completion of this course, students should be able to:

- **CO6:** Explain continuity and discontinuity of various functions in different contexts.
- **CO6:** Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
- **CO6:** Describe the terms limit and limit points of a set.
- **CO6:** Explain the idea about sequence and monotone property.
- **CO6:** Apply various theorems on the existence of limits of sequences and their evaluation.
- **CO6:** Comprehend vigorous arguments developing the theory underpinning real analysis.

CC4: *Differential Equations & Vector Calculus*.

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Determine solutions to second order linear homogeneous differential equations with constant coefficients.
- **CO2:** Determine solutions to second order linear non-homogeneous differential equations with constant coefficients.
- **CO3:** Obtain power series solutions of differential equations.
- **CO4:** Develop the ability to apply differential equations to significant applied and/or theoretical problem.
- **CO5:** Apply vector algebra techniques to analyse problems involving two- and three-dimensional entities-lines, curves, planes and surface.
- **CO6:** Employ the techniques of higher dimensional differential calculus in problems of physical interest.

Semester-III

CC5: *Theory of real functions and Introduction to Metric Space*.

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Understand different indeterminate forms of limit
- **CO2:** Understand the maximum and minimum behaviour of a function of two variables.
- **CO3:** To have full knowledge of calculus involving the fundamental tools such as continuity and differentiability.
- **CO4:** Develop the ability to reason rigorously in mathematical arguments. They can follow abstract mathematical arguments and write their own proofs.
- **CO5:** Understand the basic concepts of open sets, closed sets cantor sets and metric spaces.

- **CO6:** Explore various properties of compute metric spaces and relate them with convergence of sequences.

CC6- ***Group Theory I***

Course Outcomes Upon completion of this course, students should be able to:

1. **CO1:** Demonstrate understanding of and the ability to verify relationships between operations satisfying various properties
2. **CO2:** Demonstrate understanding of and the ability to work with in various algebraic structures.
3. **CO3:** Acquire the basic knowledge and the structure of group, subgroup and cyclic group.
4. **CO4:** Explain the significance of the notion of a normal sub group and simple group.
5. **CO5:** Analyse and demonstrate examples of subgroup, normal sub groups and quotient groups.
6. **CO6:** Use Lagrange's theorem to analyse the cyclic subgroups of a group.

CC7- ***Numerical Methods and numerical methods lab (using C).***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Developing approximate numerical methods to solve algebraic and transcendental equations.
- **CO2:** Understand numerical methods to solve linear system of equations.
- **CO3:** Developing various numerical root finding methods.
- **CO4:** Develop the ability of effective usage of arrays, structures, functions and pointers.
- **CO5:** Understand and execution of programs written in c language.
- **CO6:** Develop the ability to solve algebraic and transcendental equations using C language.

SEC-1 ***Logic & Sets***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Apply the logic theory of practical situations for drawing conclusions.
- **CO2:** Analyse statements using truth table
- **CO3:** Apply the logical structure of proofs and work symbolically with connections and quantifies to theory of sets, perform set operations.
- **CO4:** Determine equivalence relations on sets and corresponding equivalence classes.
- **CO5:** Explain the fundamental ideas of sets and functions.
- **CO6:** Produce logically valid, correct and clear arguments.

Semester-IV

CC8- ***Riemann Integration and series of function*****:**

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Understanding Integrability and theorems on integrability.
- **CO2:** Acquire the idea about Riemann Integrability and Riemann Integration
- **CO3:** Develop a knowledge about Riemann Integration and applies into problems.
- **CO4:** Explain convergence of a series.
- **CO5:** Develop skill in checking the uniform convergence of series using various tests of convergence.
- **CO6:** Distinguish between pointwise convergence and Uniform convergence.

CC9-*Multivariate Calculus:*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Develop competency in applying the idea of partial derivatives
- **CO2:** Acquire the basic ideas of double and triple integrals ideas of double and triple integrals.
- **CO3:** Apply the techniques of double and triple integral to various problems of finding length of plane curves of surface areas and volumes of surface of revolution.
- **CO4:** Apply the chain rule for functions of several variables.
- **CO5:** Use the Lagrange multiplier method to find extrema of function with constraints.
- **CO6:** Apply the knowledge of Lagrange's multipliers in finding the extreme values of functions.

CC10- ***Ring theory and Linear Algebra-I***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Describe the characteristics of a ring, quotient rings.
- **CO2:** Understanding Quotient Ring Ideals with their existence with examples.
- **CO3:** Familiarize with Rings, Integral Domain, fields and divisor of zero.
- **CO4:** Recognize the concepts of the terms span, linear independence basis, dimension and apply these concepts to various vector spaces and subspaces.
- **CO5:** Solve a system of linear equations using the inverse of a matrix.
- **CO6:** Use the definition and properties of linear transformations and change of basis, including range and isomorphism.

SEC-2 ***Graph Theory:***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Acquire a basic idea of graph, various terms associated and matrix representation of graphs.
- **CO2:** Familiarize with different type of graph, connectivity and properties.
- **CO3:** Illustrate the fundamental applications of graph theory in different walks of life.
- **CO4:** Understand trees and their properties.
- **CO5:** Identify vertices, edges and paths with specific such as bridges, Eulerian etc.
- **CO6:** Check for solutions of famous basic problems in graph theory, such as transportation problem, assignment problem, travelling salesman problem.

Semester-V

C11T: ***Partial Differential equations & Applications***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Describe the origin of partial differential equation and distinguish the integrals of first order linear partial differential equation into complete, general and singular integrals.
- **CO2:** Acquire the idea of Lagrange's method for solving the first order linear partial differential equation.
- **CO3:** Recognize the major classification of PDE's and the qualitative difference between the classes of equations.
- **CO4:** Acquire the idea of derivation of Heat equation, Wave equation and Laplace equation.
- **CO5:** Acquire the knowledge of second order Homogenous equation for solving the Heat Conduction problem.
- **CO6:** Be complement in solving second order PDE using classical solution methods.

C12T: ***Group Theory II***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Develop an idea about Isomorphism, homomorphism and automorphism.
- **CO2:** Acquire the basic knowledge and the structure of direct product, characteristic subgroup, commutator subgroup.
- **CO3:** Develop an idea about Group Actions, Applications of group actions.
- **CO4:** Prove Cayley's theorem, Index theorem.

- **CO5:** Develop an idea about class equation, conjugacy in S_n.
- **CO6:** Understand Sylow's theorem, Cauchy's Theorem.

DSE-1: ***Linear Programming***

Course Outcomes Upon completion of this course, students should be able to:

- **DSEO1:** Analyse and solve linear programming models of real-life situation.
- **DSEO2:** Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex and extreme points.
- **DSEO3:** Understand the theory of the simplex method.
- **DSEO4:** Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.
- **DSEO5:** Learn about the applications to transportation, assignment problems.
- **DSEO6:** Learn about the two-person zero sum game problems.

DSE-2: ***Probability and Statistics***

Course Outcomes Upon completion of this course, students should be able to:

- **DSEO1:** Define the principal concepts about probability.
- **DSEO2:** Calculate probabilities using conditional probability, rule of total probability and Bayes' theorem.
- **DSEO3:** Define the concept of random variable.
- **DSEO4:** Calculate the expected value, variance of a random variable.
- **DSEO5:** Learn about the Markov chain.
- **DSEO6:** Learn about the random samples, sampling distribution, estimation of parameters.

Semester-VI

C13T: ***Metric Spaces and Complex Analysis***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Understand the significance of differentiability for complex functions and be familiar with the Cauchy-Riemann equations.
- **CO2:** Determine whether a given function is analytic.
- **CO3:** Classify Singularities and Poles.
- **CO4:** Learn basic facts about the cardinality of a set.

- **CO5:** Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano Weierstrass property, compactness and connectedness.
- **CO6:** Identify the continuity of a function defined on metric spaces.

C14T: ***Ring Theory and Linear Algebra II.***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Earn knowledge of specialized rings like principal ideal domains, Unique factorization domains, their conclusions and counter examples.
- **CO2:** Learn in detail about polynomial rings, fundamental properties of finite field extensions and classification of finite fields.
- **CO3:** Learn properties of inner product spaces and determine orthogonality in inner product spaces.
- **CO4:** Explain the Gram-Schmidt orthogonalization process.
- **CO5:** Determine the minimal polynomial for a linear operator.
- **CO6:** Determine minimal solutions to system of linear equations.

DSE-3: ***Number Theory:***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Effectively express the concepts and results of number theory.
- **CO2:** Work effectively as part of a group to solve challenging problems in number theory.
- **CO3:** Understand the logic and methods behind the major proofs in number theory.
- **CO4:** Construct mathematical proofs of statements and find counter examples to false statements in number theory.
- **CO5:** Definition of divisibility and related algorithms.
- **CO6:** Basic congruence results.

DSE-4: ***Mathematical Modelling:***

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Get an idea of power series method to solve differential equations familiar with Legendre equation and Legendre polynomial.
- **CO2:** Understands Laplace transforms and inverse transforms.
- **CO3:** Get an idea of power series solution of Bessel's equation.
- **CO4:** Learn the basics of Monte Carlo simulation method.
- **CO5:** Learn how to create models for decision making.
- **CO6:** The basic of linear programming model and queuing models.

Generic Electives (GE)

GE1: ***Calculus, Geometry & Differential Equation.***

Course Outcomes Upon completion of this course, students should be able to:

- **GEO1:** Understand the ideas of derivatives and higher order derivatives and double and triple integral.
- **GEO2:** Expand functions using Leibnitz theorem and their application.
- **GEO3:** Understanding the ideas of comics and their various applications.
- **GEO4:** Apply the ideas of conics to explain many natural phenomena.
- **GEO5:** Identify, analyse and subsequently solve physical situation whose behaviour can be described by ordinary differential equations.
- **GEO6:** Evaluate and apply linear differential equations of second order (and Higher).

GE2: ***Algebra.***

Course Outcomes Upon completion of this course, students should be able to:

- **GEO1:** Explain the fundamental ideas of sets and functions.
- **GEO2:** Determine equivalence relations on sets and corresponding equivalence classes.
- **GEO3:** Formulate equations from available data and find solutions to real life problem.
- **GEO4:** Explain different methods like Descartes method, Cardan's method, Ferrari's method in theory of equations.
- **GEO5:** Understand various application of the theory of matrices to a wide variety of problems.
- **GEO6:** Acquire knowledge of invertible matrices and their properties.

GE3: ***Differential Equations & Vector Calculus.***

Course Outcomes Upon completion of this course, students should be able to:

- **GEO1:** Determine solutions to second order linear homogeneous differential equations with constant coefficients.
- **GEO2:** Determine solutions to second order linear non-homogeneous differential equations with constant coefficients.
- **GEO3:** Obtain power series solutions of differential equations.
- **GEO4:** Develop the ability to apply differential equations to significant applied and/or theoretical problem.
- **GEO5:** Apply vector algebra techniques to analyse problems involving two- and three-dimensional entities-lines, curves, planes and surface.
- **GEO6:** Employ the techniques of higher dimensional differential calculus in problems of physical interest.

GE4*: Partial Differential equations & Applications*

Course Outcomes Upon completion of this course, students should be able to:

- **GEO1:** Describe the origin of partial differential equation and distinguish the integrals of first order linear partial differential equation into complete, general and singular integrals.
- **GEO2:** Acquire the idea of Lagrange's method for solving the first order linear partial differential equation.
- **GEO3:** Recognize the major classification of PDE's and the qualitative difference between the classes of equations.
- **GEO4:** Acquire the idea of derivation of heat equation, wave equation and Laplace equation.
- **GEO5:** Acquire the knowledge of second order homogenous equation for solving the heat conduction problem.
- **GEO6:** Be complement in solving second order PDE using classical solution methods.

Course outcomes for Honours (3-tier examination)

PART-III

Paper-VI

Group-A *(Rigid Dynamics)*:

Course Outcomes Upon completion of this course, students should be able to:

- CO1: Solve kinetics problems involving impulse and momentum.
- CO2: The knowledge of work and energy in kinetics by.
- CO3: Understand how to apply the knowledge of kinetics of particles to rigid bodies in two dimensions and three dimensions.
- CO4: Apply the Principle of Work and Energy and the Principle of Impulse and Momentum to mechanical systems.
- CO5: Solve selected 3D rigid body problems using dynamics and kinematics equations presented.
- CO6: Understand the principles and methods used in problems dealing with motion of rigid bodies subjected to external forces.

Group-B *(Hydrostatics)*:

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Solve hydrostatic problem.
- **CO2:** Calculate the pressure distribution for incompressible fluids.

- **CO3:** Describe the principles of motion for fluids.
- **CO4:** Identify how to derive basic equations and know the related assumptions.
- **CO5:** Calculate the hydrostatic pressure and force on plane and curved surfaces.
- **CO6:** Identify derivation of basic equations of fluid mechanics and apply.

Group-C (*Discrete Mathematics*):

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Understand the concepts of Mathematical logic such as Connections, Concepts of Tautology etc.
- **CO2:** Study the concepts of Relations and Functions.
- **CO3:** Create structural designs using patterns of graphs in graph theory.
- **CO4:** Classify the concept of Lattices and Boolean Algebra.
- **CO5:** Gains knowledge in Formal languages and Automata.
- **CO6:** Understand the basic principles of sets and operations in sets.

Group-D (*Mathematical Modelling*)

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Knowledge about basic concepts of mathematical modelling.
- **CO2:** Understand its utility, preliminary concept of stability of differential equation.
- **CO3:** Learn about the mathematical model with their formulation.
- **CO4:** Understand the solution of model, interpretation and limitation.
- **CO5:** Learn about simple epidemic model.
- **CO6:** Solve S.I. Model.

Paper-VII

Group-A (*Elements of Computer Science)*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Knowledge about basic concepts of machine language, assembly language.
- **CO2:** Learn about the application of computer programming.
- **CO3:** Understand computer-oriented algorithm, flowchart.
- **CO4:** Learn about Boolean algebra and applications.
- **CO5:** Understand and apply the programming concepts of C++ which is important for mathematical investigation and problem solving.
- **CO6:** Use mathematical libraries for computational objectives.

Group-B (*Mathematical theory of Probability*)

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Calculate probabilities by applying probability laws and theoretical results.
- **CO2:** Identify an appropriate probability distribution for a given discrete or continuous random variable and use its properties to calculate probabilities.
- **CO3:** Derive probability distributions of functions of random variables.

- **CO4:** Calculate probabilities for joint distributions including marginal and conditional probabilities.
- **CO5:** For joint distributed random variables calculate their covariance and correlation and determine whether they are independent.
- **CO6:** Derive mean, variance.

Group-C (*Mathematical Statistics)*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Organize, manage and present data.
- **CO2:** Analyse statistical data graphically using frequency distributions and cumulative frequency distributions.
- **CO3:** Analyse statistical data using measures of central tendency, dispersion and location.
- **CO4:** Learn about statistical hypothesis.
- **CO5:** Understand and critically discuss the issues surrounding sampling and significance.
- **CO6:** Conduct basic statistical analysis of data.

Paper-VIII

Group-A (*Numerical Analysis*)

Course Outcomes Upon completion of this course, students should be able to:

- CO1: Identify methods to solve numerical algebraic and transcendental equations.
- CO2: Study the concepts of interpolation for unequal intervals.
- CO3: Gains knowledge about to interpolation for equal intervals.
- CO4: Understands the concepts of finite differences.
- CO5: Computes solutions to simultaneous linear algebraic equations.
- CO6: Identify methods to solve first order ordinary differential equation.

Group-B *(Real Analysis III)*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Explain convergence of a series.
- **CO2:** Develop skill in checking the uniform convergence of series using various tests of convergence.
- **CO3:** Distinguish between pointwise convergence and Uniform convergence.
- **CO4:** Learn about power series and Fourier Series.
- **CO5:** Understand continuity of a function.
- **CO6:** Knowledge about series of function and its convergence test.

Group-C (*Linear Algebra-II)*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Solve systems of linear equations.
- **CO2:** Analyze vectors in $\mathbb{R}^n$ geometrically and algebraically,
- **CO3:** Recognize the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces,

- **CO4:** Use matrix algebra and the related matrices to linear transformations,
- **CO5:** Compute and use eigenvectors and eigen values.
- **CO6:** Compute and use determinants,

Group-D (*Computer Practical)*

Course Outcomes Upon completion of this course, students should be able to:

- **CO1:** Developing approximate numerical methods to solve algebraic and transcendental equations.
- **CO2:** Understand numerical methods to solve linear system of equations.
- **CO3:** Developing various numerical root finding methods.
- **CO4:** Develop the ability of effective usage of arrays, structures, functions and pointers.
- **CO5:** Understand and execution of programs written in c language.
- **CO6:** Develop the ability to solve algebraic and transcendental equations using C language.

Program Outcomes

By the end of a B.Sc. program, a student will:

- **PO1:** Have an appropriate set of professional skills to ensure a productive career.
- **PO2:** Recognize and appreciate the connections between theory and applications.
- **PO3:** Communicate effectively with whom they are interacting and the society to make effective presentations, and give and receive clear instructions.
- **PO4:** Be able to analyze, test, interpret and form independent judgments in both academic and non-academic contexts.
- **PO5:** Be prepared for life-long learning.
- **PO6:** Work effectively in a multi-disciplinary environment.
- **PO7:** Function effectively as an individual, and as a member or leader in diverse teams.

Program Specific Outcomes

By the end of B Sc program in Mathematics, a student will:

- **PSO1:** Construct abstract models using appropriate mathematical and statistical tools.
- **PSO2:** Identify suitable existing methods of analysis, if any, and assess his/her strengths and weaknesses in the context of the problem being considered.
- **PSO3:** Be prepared to use Mathematics, not only in the discipline of Mathematics, but also in other disciplines and in their future endeavors.
- **PSO4:** Develop the skills necessary to formulate and understand proofs and to provide justification.
- **PSO5:** Develop an understanding of the precise language of Mathematics, and be able to integrate mathematical arguments with their critical thinking skills.
- **PSO6:** Be a life-long learner who is able to independently expand his/her mathematical or statistical expertise when needed.
- **PSO7:** Be familiar with different areas of Mathematics.
- **PSO8:** Be able to solve problems using a broad range of significant mathematical techniques