BSc. (Hons.) Mathematics

Learning Outcomes

DISCIPLINE SPECIFIC CORE COURSE

SEMESTER -I

DSC-1: ALGEBRA

Learning Objectives

The primary objective of this course is to introduce

- The basic tools of theory of equations, number theory, and group theory.
- Symmetry group of a plane figure, basic concepts of cyclic groups.
- Classification of subgroups of cyclic groups.

Learning Outcomes

This course will enable the students to:

- Determine number of positive/negative real roots of a real polynomial.
- Solve cubic and quartic polynomial equations with special condition on roots and in general.
- Employ De-Moivre's theorem in a number of applications to solve numerical problems.
- Use modular arithmetic and basic properties of congruences.
- Recognize the algebraic structure, namely groups, and classify subgroups of cyclic groups.

DSC-2: ELEMENTARY REAL ANALYSIS

Learning Objectives

The course will develop a deep and rigorous understanding of:

- Real line $\mathbb{R}$ with algebraic.

- Order and completeness properties to prove the results about convergence and divergence of sequences and series of real numbers.

Learning Outcomes

This course will enable the students to:

- Understand the fundamental properties of the real numbers, including completeness and Archimedean, and density property of rational numbers in $\mathbb{R}$.
- Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$ and find the limit.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate the limit superior and limit inferior of a bounded sequence.
- Apply limit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.

DSE 3: PROBABILITY AND STATISTICS

Learning Objectives

The Learning Objectives of this course are as follows:

- To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.
- To render the students to several examples and exercises that blend their everyday experiences with their scientific interests to form the basis of data science.

Learning Outcomes

This course will enable the students to:

- Understand some basic concepts and terminology - population, sample, descriptive and inferential statistics including stem-and-leaf plots, dotplots, histograms and boxplots.

- Learn about probability density functions and various univariate distributions such as binomial, hypergeometric, negative binomial, Poisson, normal, exponential and lognormal.
- Understand the remarkable fact that the empirical frequencies of so many natural populati ons, exhibit bell-shaped (i.e., normal) curves, using the Central Limit Theorem.
- Measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.

SEMESTER-II

DSE-4: LINEAR ALGEBRA

Learning Objectives

- The objective of the course is to introduce:
- The concept of vectors in *RRnn*, and their linear independence and dependence.
- Rank and nullity of linear transformations through matrices.
- Various applications of vectors in computer graphics and movements in plane.

Learning Outcomes

This course will enable the students to:

- Visualize the space *RRnn* in terms of vectors and their interrelation with matrices. Familiarize with basic concepts in vector spaces, linear independence and span of vectors over a field.
- Learn about the concept of basis and dimension of a vector space.
- Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation with application to computer graphics.

DSE-5: CALCULUS

Learning Objectives

- The primary objective of this course is:
- To introduce the basic tools of calculus, also known as 'science of variation'.
- To provide a way of viewing and analyzing the real-world.

Learning Outcomes

- This course will enable the students to understand:
- The notion of limits, continuity and uniform continuity of functions.
- Geometrical properties of continuous functions on closed and bounded intervals.
- Applications of derivative, relative extrema and mean value theorems.
- Higher order derivatives, Taylor's theorem, indeterminate forms and tracing of curves.

DSE-6: ORDINARY DIFFERENTIAL EQUATIONS

Learning Objectives

- The main objective of this course is to introduce the students:
- The exciting world of differential equations.
- Their applications and mathematical modeling.

Learning Outcomes

The course will enable the students to:

- Learn the basics of differential equations and compartmental models.
- Formulate differential equations for various mathematical models.
- Solve first order non-linear differential equations, linear differential equations of higher order and system of linear differential equations using various techniques.
- Apply these techniques to solve and analyze various mathematical models.

GE: INTRODUCTION TO LINEAR ALGEBRA

Learning Objectives:

- The objective of the course is to introduce the concept of vectors in , understanding the nature of solution of system of linear equations, and to view the matrices as a linear function from to and vice versa.
- The concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.

Learning Outcomes:

This course will enable the students to:

- Visualize the space in terms of vectors and the interrelation of vectors with matrices. Understand important uses of eigenvalues and eigenvectors in the diagonalization of matrices.
- Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces.
- Learn about linear transformation and its corresponding matrix.

SEMESTER-III

DSE-7: GROUP THEORY

Learning Objectives

The primary objective of this course is to introduce:

- Symmetric groups, normal subgroups, factor groups, and direct products of groups.
- The notions of group homomorphism to study the isomorphism theorems with applications.
- Classification of groups with small order according to isomorphisms.

Learning Outcomes

This course will enable the students to:

- Analyse the structure of 'small' finite groups, and examine examples arising as groups of permutations of a set, symmetries of regular polygons.
- Understand the significance of the notion of cosets, Lagrange's theorem and its consequences.
- Know about group homomorphisms and isomorphisms and to relate groups using these mappings.
- Express a finite abelian group as the direct product of cyclic groups of prime power orders.
- Learn about external direct products and its applications to data security and electric circuits.

DSE-8: RIEMANN INTEGRATION

Learning Objectives

The primary objective of this course is to:

- Understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration.
- Learn some of the properties of Riemann integrable functions, its generalization and the applications of the fundamental theorems of integration.
- Get an exposure to the utility of integration for practical purposes.

Learning Outcomes

This course will enable the students to:

- Learn about some of the classes and properties of Riemann integrable functions, and the applications of the Riemann sums to the volume and surface of a solid of revolution.
- Get insight of integration by substitution and integration by parts.
- Know about convergence of improper integrals including, beta and gamma functions

DSE-9: DISCRETE MATHEMATICS

Learning Objectives

The primary objective of the course is to:

- Make students embark upon a journey of enlightenment, starting from the abstract concepts in mathematics to practical applications of those concepts in real life.
- Make the students familiar with the notion of partially ordered set and a level up with the study of lattice, Boolean algebra and related concepts.
- Culminate the journey of learning with practical applications using the knowledge attained from the abstract concepts learnt in the course.

Learning Outcomes

This course will enable the students to:

- Understand the notion of partially ordered set, lattice, Boolean algebra with applications.
- Handle the practical aspect of minimization of switching circuits to a great extent with the methods discussed in this course.
- Apply the knowledge of Boolean algebras to logic, set theory and probability theory.

SEMESTER-IV

DSE-10: SEQUENCES AND SERIES OF FUNCTIONS

Learning Objectives

The objective of the course is to introduce:

- The sequences and series of real-valued functions as a generalization to the sequences and series of real numbers.
- The situations under which the process of convergence of a sequence and series of real valued functions may commute with the processes of calculus while taking differentiation, or integration.
- An important class of series functions (i.e., power series), and the elementary functions exponential, logarithmic and trigonometric.

Learning Outcomes

This course will enable the students to:

- Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence of series of real-valued functions.
- Know about the constraints for the inter-changeability of differentiation, and integration with infinite sum of a series of functions.
- Handle the convergence of power series and properties of the limit function, including
- differentiation and integration of power series.
- Appreciate utility of polynomials in the space of continuous functions.

DSE-11: MULTIVARIATE CALCULUS

Learning Objectives

The primary objective of this course is to introduce:

- The extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
- The geometry and visualisation of curves and surfaces in two dimensions (plane) and three dimensions (space).
- The techniques of integration to functions of two and three independent variables.
- The applications of multivariate calculus tools to physics, economics, optimization etc.

Learning Outcomes

This course will enable the students to:

- Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
- Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
- Learn about inter-relationship amongst the line integral, double, and triple integral formulations.
- Familiarize with Green's, Stokes' and Gauss divergence theorems, and learn applications.

DSE-12: NUMERICAL ANALYSIS

Learning Objectives

The main objective of this course is to introduce:

Various computational techniques to find approximate value for possible root(s) of algebraic and non-algebraic equations.

Methods to solve system of linear equations and ordinary differential equations.

The use of computer algebra system (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem-solving skills.

Learning Outcomes

This course will enable the students to:

- Learn some numerical methods to find the zeroes of nonlinear functions of a single variable, up to a certain given level of precision.
- Get aware of using interpolation techniques, for example in finding values of a tabulated
- function at points which are not part of the table.
- Learn finding numerical solutions of difference equations which are obtained converting differential equations using techniques from calculus.

GE: ELEMENTS OF REAL ANALYSIS

Learning Objectives:

- The primary objective of this course is to introduce:
- The real line with algebraic, order and completeness properties.
- Convergence and divergence of sequences and series of real numbers with applications.

Learning Outcomes:

This course will enable the students to:

- Understand the basic properties of the set of real numbers, including completeness and Archimedean with some consequences.
- Recognize bounded, convergent, monotonic and Cauchy sequences
- Learn to apply various tests such aslimit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.

SEMESTER-V

BMATH511: Metric Spaces

Course Learning Outcomes:

The course will enable the students to:

- Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
- Analyse how a theory advances from a particular frame to a general frame.
- Appreciate the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting.
- Know about Banach fixed point theorem, whose far-reaching consequences have resulted into an independent branch of study in analysis, known as fixed point theory.
- Learn about the two important topological properties, namely connectedness and compactness of metric spaces.

BMATH512: Group Theory-II

Course Learning Outcomes:

The course shall enable students to:

- Learn about automorphisms for constructing new groups from the given group.
- Learn about the fact that external direct product applies to data security and electric circuits.
- Understand fundamental theorem of finite abelian groups.
- Be familiar with group actions and conjugacy in ._.
- Understand Sylow theorems and their applications in checking nonsimplicity.

DSE-1 (i): Numerical Analysis

Course Learning Outcomes: The course will enable the students to:

- Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.

- Know about methods to solve system of linear equations, such as Gauss−Jacobi, Gauss−Seidel and SOR methods.
- Interpolation techniques to compute the values for a tabulated function at points not in the table.

SEMESTER-VI

BMATH613: Complex Analysis

Course Learning Outcomes:

The completion of the course will enable the students to:

- Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations.
- Learn some elementary functions and valuate the contour integrals.
- Understand the role of Cauchy−Goursat theorem and the Cauchy integral formula.
- Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate
- integrals.

BMATH614: Ring Theory and Linear Algebra-II

Courses Learning Outcomes:

On completion of this course, the student will be able to:

- Appreciate the significance of unique factorization in rings and integral domains.
- Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as
- well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.
- Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.

- Find the adjoint, normal, unitary and orthogonal operators.

DSE-3 (i): Mathematical Finance

Course Learning outcomes:

On completion of this course, the student will be able to:

- Know the basics of financial markets and derivatives including options and futures.
- Learn about pricing and hedging of options, as well as interest rate swaps.
- Learn about no-arbitrage pricing concept and types of options.
- Learn stochastic analysis (Ito formula, Ito integration) and the Black−Scholes model.
- Understand the concepts of trading strategies and valuation of currency swaps.

DSE-4 (i): Number Theory

Course Learning Outcomes:

This course will enable the students to:

- Learn about some fascinating discoveries related to the properties of prime numbers, and some of the open problems in number theory, viz., Goldbach conjecture etc.
- Know about number theoretic functions and modular arithmetic.
- Solve linear, quadratic and system of linear congruence equations.
- Learn about public key crypto systems, in particular, RSA.

DSE-4 (ii): Linear Programming and Applications

Course Learning Outcomes:

This course will enable the students to:

- Learn about the graphical solution of linear programming problem with two variables.

- Learn about the relation between basic feasible solutions and extreme points.
- Understand the theory of the simplex method used to solve linear programming problems.
- Learn about two-phase and big-M methods to deal with problems involving artificial variables.
- Learn about the relationships between the primal and dual problems.
- Solve transportation and assignment problems.
- Apply linear programming method to solve two-person zero-sum game problems.