COURSE OUTCOMES

MATHEMATICS

B.Sc.(Hons.) Mathematics

Sem	Type of Course	Course Name	Course Outcomes
I	Core	BMATH101: Calculus	CO1: Learn first and second derivative tests for relative extrema and apply the knowledge in problems in business, economics and life sciences. CO2: Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference. CO3: Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas. CO4: Understand the calculus of vector functions and its use to develop the basic principles of planetary motion.
I	Core	BMATH102: Algebra	CO1: Employ De Moivre's theorem in a number of applications to solve numerical problems. CO2: Learn about equivalent classes and cardinality of a set. CO3: Use modular arithmetic and basic properties of congruences. CO4: Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix. CO5: Find eigenvalues and corresponding eigenvectors for a square matrix.
II	Core	BMATH203: Real Analysis	CO1: Understand many properties of the real line R, including completeness and Archimedean properties. CO2: Learn to define sequences in terms of functions from N to a subset of R. CO3: Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence. CO4: Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
II	Core	BMATH204: Differential Equations	CO1: Learn basics of differential equations and mathematical modeling. CO2: Formulate differential equations for various mathematical models.

			CO3: Solve first order non-linear differential equations and linear differential equations of higher order using various techniques. CO4: Apply these techniques to solve and analyze various mathematical models.
III	Core	BMATH305: Theory of Real Functions	CO1: Have a rigorous understanding of the concept of limit of a function. CO2: Learn about continuity and uniform continuity of functions defined on intervals. CO3: Understand geometrical properties of continuous functions on closed and bounded intervals. CO4: Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications. CO5: Know about applications of mean value theorems and Taylor's theorem.
III	Core	BMATH306: Group Theory-I	CO1: Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc. CO2: Link the fundamental concepts of groups and symmetrical figures. CO3: Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups. CO4: Explain the significance of the notion of cosets, normal subgroups and factor groups. CO5: Learn about Lagrange's theorem and Fermat's Little theorem. CO6: Know about group homomorphisms and group isomorphisms.
III	Core	BMATH307: Multivariate Calculus	CO1: Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion. CO2: Understand the maximization and minimization of multivariable functions subject to the given constraints on variables. CO3: Learn about inter-relationship amongst the line integral, double and triple integral formulations. CO4: Familiarize with Green's, Stokes' and Gauss divergence theorems.
III	SEC	SEC-1: LaTeX and HTML	CO1: Create and typeset a LaTeX document. CO2: Typeset a mathematical document using LaTeX. CO3: Learn about pictures and graphics in LaTeX. CO4: Create beamer presentations. CO5: Create web page using HTML.
IV	Core	BMATH408: Partial Differential Equations	CO1: Formulate, classify and transform first order PDEs into canonical form. CO2: Learn about method of characteristics and separation of variables to solve first order

			PDE's. CO3: Classify and solve second order linear PDEs. CO4: Learn about Cauchy problem for second order PDE and homogeneous and non- homogeneous wave equations. CO6: Apply the method of separation of variables for solving many well-known second order PDEs.
IV	Core	BMATH409: Riemann Integration & Series of Functions	CO1: Learn about some of the classes and properties of Riemann integrable functions, and the applications of the Fundamental theorems of integration. CO2: Know about improper integrals including, beta and gamma functions. CO3: Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence. CO4: Know about the constraints for the inter-changeability of differentiability and integrability with infinite sum. CO5: Approximate transcendental functions in terms of power series as well as, differentiation and integration of power series.
IV	Core	BMATH410: Ring Theory & Linear Algebra-I	CO1: Learn about the fundamental concept of rings, integral domains and fields. CO2: Know about ring homomorphisms and isomorphisms theorems of rings. CO3: Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space. CO4: Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.
IV	SEC	SEC-2: Computer Algebra Systems and Related Software	CO1: Use of computer algebra systems (Mathematica/MATLAB/Maxima/Maple etc.) as a calculator, for plotting functions and animations CO2: Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors. CO3: Understand the use of the statistical software R as calculator and learn to read and get data into R. CO4: Learn the use of R in summary calculation, pictorial representation of data and exploring relationship between data. CO5: Analyze, test, and interpret technical arguments on the basis of geometry.
V	Core	BMATH511: Metric Spaces	CO1: 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. CO2: Analyse how a theory advances from a particular frame to a general frame. CO3: Appreciate the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting. CO4: 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. CO5: Learn about the two important topological properties, namely connectedness and compactness of metric spaces.
V	Core	BMATH512: Group Theory-II	CO1: Learn about automorphisms for constructing new groups from the given group. CO2: Learn about the fact that external direct product applies to data security and electric circuits. CO3: Understand fundamental theorem of finite abelian groups. CO4: Be familiar with group actions and conjugacy. CO5: Understand Sylow theorems and their applications in checking nonsimplicity.
V	DSE	DSE-1(i): Numerical Analysis	CO1: 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. CO2: Know about methods to solve system of linear equations, such as Gauss−Jacobi, Gauss−Seidel and SOR methods. CO3: Interpolation techniques to compute the values for a tabulated function at points not in the table. CO4: Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.
V	DSE	DSE-1(iii): C++ Programming for Mathematics	CO1: Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving. CO2: Learn about structured data-types in C++ and learn about applications in factorization of an integer and understanding Cartesian geometry and Pythagorean triples. CO3: Use of containers and templates in various applications in algebra. CO4: Use mathematical libraries for computational objectives.

			CO5: Represent the outputs of programs visually in terms of well formatted text and plots.
V	DSE	DSE-2(i): Probability Theory and Statistics	CO1: Learn about probability density and moment generating functions. CO2: Know about various univariate distributions such as Bernoulli, Binomial, Poisson, gamma and exponential distributions. CO3: Learn about distributions to study the joint behavior of two random variables. CO4: 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. CO5: Understand central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell-shaped curve, i.e., a normal distribution.
V	DSE	DSE-2(ii): Discrete Mathematics	CO1: Understand the notion of ordered sets and maps between ordered sets. CO2: Learn about lattices, modular and distributive lattices, sublattices and homomorphisms between lattices. CO3: Become familiar with Boolean algebra, Boolean homomorphism, Karnaugh diagrams, switching circuits and their applications. CO4: Learn about basics of graph theory, including Eulerian graphs, Hamiltonian graphs. CO5: Learn about the applications of graph theory in the study of shortest path algorithms.
VI	Core	BMATH613: Complex Analysis	CO1: Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations. CO2: Learn some elementary functions and valuate the contour integrals. CO3: Understand the role of Cauchy−Goursat theorem and the Cauchy integral formula. CO4: 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.
VI	Core	BMATH614: Ring Theory and Linear Algebra-II	CO1: Appreciate the significance of unique factorization in rings and integral domains. CO2: 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.

			CO3: Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis. CO4: Find the adjoint, normal, unitary and orthogonal operators.
VI	DSE	DSE-3(i): Mathematical Finance	CO1: Know the basics of financial markets and derivatives including options and futures. CO2: Learn about pricing and hedging of options, as well as interest rate swaps. CO3: Learn about no-arbitrage pricing concept and types of options. CO4: Learn stochastic analysis (Ito formula, Ito integration) and the Black−Scholes model. CO5: Understand the concepts of trading strategies and valuation of currency swaps.
VI	DSE	DSE-4 (ii): Linear Programming and Applications	CO1: Learn about the graphical solution of linear programming problem with two variables. CO2: Learn about the relation between basic feasible solutions and extreme points. CO3: Understand the theory of the simplex method used to solve linear programming problems. CO4: Learn about two-phase and big-M methods to deal with problems involving artificial variables. CO5: Learn about the relationships between the primal and dual problems. CO6: Solve transportation and assignment problems. CO7: Apply linear programming method to solve two-person zero-sum game problems.

GENERIC ELECTIVE (GE) Courses for Honours Courses (For students other than B.Sc. (Hons.) Mathematics)

Sem	Type of Course	Course Name	Course Outcomes
I	GE	GE-1: Calculus	CO1: Sketch the curves in Cartesian and polar coordinates as well as learn techniques of sketching the conics. CO2: Visualize three dimensional figures and calculate their volumes and surface areas. CO3: Understand limits, continuity and derivatives of functions of several variable and vector-valued functions.
II	GE	GE-2: Linear Algebra	CO1: Visualize the space $\mathbb{R}$ in terms of vectors and the interrelation of vectors with matrices, and their application to computer graphics.

			CO2: Familiarize with concepts in vector spaces, namely, basis, dimension and minimal spanning sets. CO3: Learn about linear transformations, transition matrix and similarity. CO4: Learn about orthogonality and to find approximate solution of inconsistent system of linear equations
III	GE	GE-3: Linear Programming and Game Theory	CO1: Learn about the simplex method used to find optimal solutions of linear optimization problems subject to certain constraints. CO2: Write the dual of a linear programming problem. CO3: Solve the transportation and assignment problems. CO4: Learn about the solution of rectangular games using graphical method and using the solution of a pair of associated prima-dual linear programming problems.
IV	GE	GE-4: Elements of Analysis	CO1: Understand the real numbers and their basic properties. CO2: Be familiar with convergent and Cauchy sequences. CO3: Test the convergence and divergence of infinite series of real numbers. CO4: Learn about power series expansion of some elementary functions.

MATHEMATICS COURSES FOR B.A. (PROG.)

Sem	Type of Course	Course Name	Course Outcomes
I	Core	Paper I: Calculus	CO1: Understand continuity and differentiability in terms of limits. CO2: Describe asymptotic behavior in terms of limits involving infinity. CO3: Use derivatives to explore the behavior of a given function, locating and classifying its extrema, and graphing the function. CO4: Understand the importance of mean value theorems. CO5: Learn about Maclaurin's series expansion of elementary functions.
II	Core	Paper II: Algebra	CO1: Solving higher order algebraic equations. CO2: Become aware of De Moivre's theorem and its applications. CO3: Solving simultaneous linear equations with at most four unknowns.

			CO4: Get an overview of abstract algebra by learning about algebraic structures namely, groups, rings and vector spaces.
III	Core	Paper III: Analytic Geometry and Applied Algebra	CO1: Learn concepts in two-dimensional geometry. CO2: Identify and sketch conics namely, ellipse, parabola and hyperbola. CO3: Learn about three-dimensional objects such as spheres, conicoids, straight lines and planes using vectors. CO4: Understand various applications of algebra in design of experiments, modelling of matching jobs, checking spellings, network reliability and scheduling of meetings.
III	SEC	SEC-1: Computer Algebra Systems	CO1: Use CAS as a calculator and for plotting functions. CO2: Understand the role of CAS finding roots of polynomials and solving general equations. CO3: Employ CAS for computing limits, derivatives, and computing definite and indefinite integrals. CO4: Use CAS to understand matrix operations and to find eigenvalues of matrices.
IV	Core	Paper IV: Analysis	CO1: Understand basic properties of the field of real numbers. CO2: Examine continuity and uniform continuity of functions using sequential criterion. CO3: Test convergence of sequence and series of real numbers. CO4: Distinguish between the notion of integral as anti-derivative and Riemann integral.
IV	SEC	SEC-2: Mathematical Typesetting System: LaTeX	CO1: Create and typeset a LaTeX document. CO2: Typeset a mathematical document using LaTeX. CO3: Learn about pictures and graphics in LaTeX. CO4: Create beamer presentations.
V	DSE	DSE-1 (i): Statistics	CO1: Determine moments and distribution function using moment generating functions. CO2: Learn about various discrete and continuous probability distributions. CO3: Know about correlation and regression for two variables, weak law of large numbers and central limit theorem. CO4: Test validity of hypothesis, using Chi-square, F and t-tests, respectively in sampling distributions.
V	SEC	SEC-3: Transportation and etwork Flow Problems	CO1: Formulate and solve transportation problems. CO2: Learn to solve assignment problems using Hungarian method. CO3: Solve travelling salesman problem. CO4: Learn about network models and various network flow problems.

			CO5: Learn about project planning techniques namely, CPM and PERT.
VI	DSE	DSE-2 (i): Numerical Methods	CO1: Find the consequences of finite precision and the inherent limits of numerical methods. CO2: Appropriate numerical methods to solve algebraic and transcendental equations. CO3: Solve first order initial problems of ordinary differential equations numerically using Euler methods.
VI	SEC	SEC-4: Statistical Software: R	CO1: Be familiar with R syntax and use R as a calculator. CO2: Understand the concepts of objects, vectors and data types. CO3: Know about summary commands and summary table in R. CO4: Visualize distribution of data in R and learn about normality test. CO5: Plot various graphs and charts using R.