B. Sc. (HONS.) MATHS LEARNING OUTCOMES (2022-23)				
Semester	**Course Type (Core/AECC/GE /DSE/Language AEEC)***	**Name of the Paper**	**Paper Number**	**Learning Outcome**
1	Core	ALGEBRA	DSC-1	• 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.
1	Core	ELEMENTARY REAL ANALYSIS	DSC-2	• 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.

1	Core	PROBABILITY AND STATISTICS	DSC-3	• 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.
2	Core	LINEAR ALGEBRA	DSC-4	● Visualize the space R^ 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.
2	Core	CALCULUS	DSC-5	● 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.

2	Core	DINARY DIFFERENTIAL EQUATI	DSC-6	● 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.
3	Core	THEORY OF REAL FUNCTIONS	BMATH 305	•Rigorous understanding of the concept of limit of a function, continuity and uniform continuity of functions defined on the intervals.
				•Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.
				•Know about applications of Mean Value theorem and Taylor's theorem.
3	Core	GROUP THEORY-I	BMATH 306	•Recognize the mathematical objects that are groups, and classify them as Abelian, cyclic and permutation groups, etc.
				• Link the fundamental concepts of groups and symmetrical figures as well as to classify subgroups of cyclic groups.
				•Learn about Lagrange's theorem and Fermat's Little theorem. Also, to know about group homomorphisms and group isomorphisms.
3	Core	MULTIVARIATE CALCULUS	BMATH 307	•Upon successful completion the students have appropriate knowledge of functions of more than one variable.
				•The learning outcomes specify the knowledge with skills of understanding the theories and applications of derivatives,multiple integral and line integral .
3	SEC-1	LATEX AND HTML	SEC 1	•By attending this programming language course, the students acquire all necessary skills to be able to prepare a moderate scientific paper and a short mathematical presentation using LaTeX.

				•Create beamer presentations and web page using HTML.
4	Core	PARTIAL DIFFERENTIAL EQUATIONS	BMATH 408	• Formulate, classify and transform first order PDEs into canonical form.
				• Classify and solve second order linear PDEs and to solve homogenuous and non-homogenuous wave equations.
				• Apply the method of separation of variables for solving second order PDEs.
4	Core	RIEMANN INTEGRATION AND SERIES OF FUNCTIONS	BMATH 409	•They learn the theory and applications of Riemann integration of bounded real valued functions defined on closed and bounded interval.
				•Also they learn the improper integration with Beta and gamma integrals.
				•Special type of series of functions, power series and the convergence is understood.
4	Core	RING THEORY & LINEAR ALGEBRA-I	BMATH 410	•Learn about the fundamental concept of rings, integral domains, fields and isomorphism theorems of rings.
				• Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.
				•Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.
4	SEC-2	COMPUTER ALGEBRA SYSTEMS AND RELATED SOFTWARES	SEC 2	•Use of Mathematica software as a calculator, for plotting functions and animations.
				•Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.

				• Use of software R in summary calculation, pictorial representation of data and exploring relationship between data.
5	Core	C11 METRIC SPACES	C11	•Analyse how a theory advances from a particular frame to a general frame.
				•They have the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting.
				•Learn about the two important topological properties, namely connectedness and compactness of metric spaces.
5	Core	C12 GROUP THEORY-II	C12	•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 group actions, Sylow theorems and their applications in checking nonsimplicity.
5	DSE1 (i)	NUMERICAL ANALYSIS	DSE1 (i)	•Learn some numerical methods to find the zeroes of nonlinear functions of a single variable.
				•Interpolation techniques to compute the values for a tabulated function at points not in the table.
				•Applications of numerical differentiation and integration to convert differential equations into difference equations.
5	DSE1 (ii)	C++ Programming	DSE1 (ii)	•Understand and apply the programming concepts of C++ which is important for problem solving.
				•Use of containers and templets in various applications in algebra.
5	DSE2 (i)	Discrete Mathematics	DSE2 (i)	•Learn about lattices, modular and distributive lattices, sublattices and homomorphisms between lattices.

				•Learn about basics of graph theory, including Eulerian graphs, Hamiltonian graphs.
				•Learn about the applications of graph theory in the study of shortest path algorithms.
5	DSE2 (ii)	Cryptography and network security	DSE2 (ii)	Understand the fundamentals of cryptography and computer security attacks.
				Understand about advanced encryption standards and fundamentals of RSA.
6	Core	COMPLEX ANALYSIS	C13	•Students learn the basic ideas of analysis for complex functions in complex variables with visualization through relevant practicals.
				•They learn to 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.
6	Core	RING THEORY AND LINEAR ALGEBRA-II	C14	•They learn the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields with applications in cryptography.
				•Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.
				•It also enables students to apply the techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.
6	DSE	PROBABILITY THEORY AND STATISTICS	DSE3(i)	•Students learn the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.

6	DSE	MECHANICS	DSE3 (ii)	•Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.
				•Learn about conservation of mechanical energy and work-energy equation.
				• Students learn translational and rotational motion of rigid bodies.
6	DSE	NUMBER THEORY	DSE4 (i)	•Learn about some fascinating discoveries related to the properties of prime numbers, and some of the open problems in number theory.
				•Learn about public key crypto systems, in particular, RSA.
				•Students get familiar with simple number theoretic techniques, to be used in data security.
6	DSE	LINEAR PROGRAMMING AND THEORY OF GAMES	DSE4 (ii)	• It develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operation Research.
				•Learn to apply linear programming with applications to transportation, assignment and game problem. Such problems arise in manufacturing resource planning and financial sectors.

Generic (Maths) Papers Learning Outcomes (2022-23)

Semester	Course Type (Core/AECC/GE	Name of the Paper	Paper Number	Learning Outcome
1	GE	FUNDAMENTALS OF CALCULUS	1	• Understand continuity and differentiability in terms of limits. • Describe asymptotic behavior in terms of limits involving infinity. • Understand the importance of mean value theorems and its applications. • Learn about Maclaurin's series expansion of elementary functions. • Use derivatives to explore the behavior of a given function, locating and classifying its extrema, and graphing the polynomial and rational functions.

1	GE	THEORY OF EQUATIONS AND SYMMETRIES	1	• Understand the nature of the roots of polynomial equations and their symmetries. • Solve cubic and quartic polynomial equations with special condition on roots and in general. • Find symmetric functions in terms of the elementary symmetric polynomials.
2	GE	ANALYTIC GEOMETRY	GE-2(i)	● Learn concepts in two-dimensional geometry. ● Identify and sketch conics namely, ellipse, parabola and hyperbola. ● Learn about three-dimensional objects such as straight lines and planes using vectors, spheres, cones and cylinders.
2	GE	Discrete Mathematics	GE-2(ii)	•Learn about lattices, modular and distributive lattices, sublattices and homomorphisms between lattices.
3	GE	Differential Equations	3	• Students learn to solve the variety of methods to solve •Formulate and solve various types of first and second • It provides a solid foundation
3	GE	Linear Programming and game theory	3	• It develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operation Research. •Learn to apply linear programming with applications to transportation, assignment and game problem. Such problems arise in manufacturing resource planning and financial sectors.

4	GE	Numerical Methods	4	•Students learn to find the appropriate numerical methods to solve algebraic and transcendental equations. •Learn to solve first order initial value problems of ODE's numerically using Euler methods. •Appropriate numerical methods to solve algebraic and transcendental equations.
4	GE	Elements of Analysis	4	• It has developed a deeper and more rigorous understanding of defining terms and proving results about convergence of sequences and series of real numbers, having wide applications in real-world problems. •Understand the concepts of pointwise and uniform convergence, Riemann integrability of continuous and monotone functions.

B. A. PROGRAMME (MATHS PAPERS) LEARNING OUTCOMES (2020-21)

	Course Type	Name of the Paper	Paper Number	Learning Outcome
1	Core	ELEMENTS OF DISCRETE MATHEMATICS	DSC-1	• Understand the basic concepts of sets, relations, functions, and induction. • Understand mathematical logic and logical operations to various fields. • Understand the notion of order and maps between partially ordered sets. • Minimize a Boolean polynomial and apply Boolean algebra techniques to decode switching circuits.

1	Core	TOPICS IN CALCULUS	DSC	• Understand continuity and differentiability in terms of limits and graphs of certain functions. • Describe asymptotic behaviour in terms of limits involving infinity. • Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function. • Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves. • Compute the reduction formulae of standard transcendental functions with applications.
2	Core	ANALYTIC GEOMETRY	DSC-2	● Learn concepts in two-dimensional geometry. ● Identify and sketch conics namely, ellipse, parabola and hyperbola. ● Learn about three-dimensional objects such as straight lines and planes using vectors, spheres, cones and cylinders.
2	Core	Elementary Linear Algebra	Discipline A-2	● Visualize the space Rn in terms of vectors and the interrelation of vectors with matrices. ● Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces. ● Learn about linear transformation and its corresponding matrix.
3	Core	Analytic geometry & Applied Algebra	3	• identifying curves and applying mathematical models in daily life problems, studying geometric properties of various conic sections.
				•Understand various applications of algebra in design of experiments, modelling of matching jobs, checking spellings, network reliability and scheduling of meetings.
3				Students get basic knowledge of Mathematica software and their programming language in order to apply them for plotting functions, finding roots to polynomials, computing limits and other mathematical tools.
	SEC-1	Sec-1	SEC1	

4	Core	Analysis	4	•Students learn the basic properties of the field of real number as well as to examine continuity and uniform continuity of functions using sequential criterion. • Also, they learn to distinguish between the notion of integral as anti-derivative and Riemann integral.
4	SEC-2	SEC-2 Mathematical typesetting system: Latex	SEC2	•They learn the typesetting of a mathematical document using LaTex. • Learn about pictures and graphics in LaTex and how to create beamer presentations.
5	SEC-3	SEC-3 Statistical Software : R	SEC3	• Be familiar with R syntax and use R as calculator. • Understand the concepts of objects, vectors and data types. • Visualize distribution of data in R and learn about normality test.
5	DSE-1	Differential Equations	DSE-1	•Students learn to solve ODE's and know about Wronskian and its properties. •They learn method of variation of parameters and total differential equations. • Students use various techniques with the tools needed to model complex real-world situations.
6	DSE-2	Numerical Analysis	DSE-2	•Students learn to find the consequences of finite precision and the inherent limits of numerical methods. •Solve first order initial value problems of ordinary differential equations numerically using Euler methods.

6	SEC-4	SEC-4 Transportation and Network Flow Problems	SEC4	•Formulate and solve transportation problems. • Learn to solve assignment problems using Hungarian method. • Learn about network models and flow problems • Learn about project planning techniques namely, CPM and PERT

B. Sc. MATHEMATICAL SCIENCES LEARNING OUTCOMES (2022-23)

Semester	Course Type	Name of the Paper	Paper Number	Learning Outcomes
1	Core	TOPICS IN CALCULUS	1	• Understand continuity and differentiability in terms of limits and graphs of certain functions. • Describe asymptotic behaviour in terms of limits involving infinity. • Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function. • Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves. • Compute the reduction formulae of standard transcendental functions with applications.
2	Core	Elementary Linear Algebra	2	Visualize the space Rn in terms of vectors and the interrelation of vectors with matrices. ● Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces. ● Learn about linear transformation and its corresponding matrix.
3	Core	Algebra	3	•Students able to recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups etc.

				• Students have understood a major part of abstract algebra, which is an essential tool in number theory, geometry, topology and has applications in cryptography, coding theory, quantum chemistry and physics.
4	Core	Real Analysis	4	• It has developed a deeper and more rigorous understanding of defining terms and proving results about convergence of sequences and series of real numbers, having vide applications in real-world problems.
				•Understand the concepts of pointwise and uniform convergence, Riemann integrability of continuous and monotone functions.
5	Core	Differential equations	DSE1	• It develops skills and knowledge of standard concepts in ordinary and partial differential equations and also provide the standard methods for solving differential equations.
				•Students use various techniques with the tools needed to model complex real-world situations.
6	Core	Numerical Methods	DSE2	•Students learn certain algorithms that uses numerical approximation for the problems of mathematical analysis. Also, the use of Computer Algebra Systems (CAS) by which the intractable problems can be solved both numerically and analytically.
3	SEC-1	COMPUTER ALGEBRA SYSTEMS	SEC1	•Students get basic knowledge of Mathematica software and their programming language in order to apply them for plotting functions, finding roots to polynomials, computing limits and other mathematical tools.

4	Sec-2	Mathematical Typesetting system: LATEX	SEC2	•Students learn the typesetting of a mathematical document using LaTex. •Learn about pictures and graphics in LaTex and how to create beamer presentations.
5	SEC-3	SEC-3 Statistical Software : R	SEC3	• Be familiar with R syntax and use R as calculator. • Understand the concepts of objects, vectors and data types. • Visualize distribution of data in R and learn about normality test.
6	SEC-4	SEC-4 Transportation and Network Flow Problems	SEC4	•Formulate and solve transportation problems. • Learn to solve assignment problems using Hungarian method. • Learn about network models and flow problems • Learn about project planning techniques namely, CPM and PERT