

Course Outcomes of B.SC Mathematics Honours(CBCS)

Semester	Course	Course Outcome
Semester-1	CC1 (Unit-1 : Calculus, Unit-2 : Geometry, Unit-3 : Vector Analysis)	<p>Unit-1 : Knowledge of derivatives of a function of real variables and its application to determine the curvature of a curve, concavity, convexity, tangent-normal and its properties. It also gives insight in tracking a curve and finding many of its properties. Concept of asymptotes of a polynomial curve and the idea of envelope to a family of curves are included there.</p> <p>Unit-2 :</p> <p>Unit-3 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> ● define scalar and vector triple products and understand their geometrical significance and apply these to various problems of geometry and mechanics ● solve vector equations using the definition of products of two and three vectors ● understand vector functions and vector valued functions and the concept of calculus extended to such functions ● find limit, continuity, derivative and integration of such functions
	CC-2 Algebra	<p>Unit-1 : Knowledge about complex numbers and some functions like exponential functions, logarithmic functions, hyperbolic functions of complex variables. Students can apply De Moivre's theorem to find the sum of a trigonometric series</p>

		<p>and to solve some problems of real functions. This topic gives the detailed idea to solve cubic, biquadratic and some special type of higher order polynomial equations.</p> <p>Unit-2 : This also gives the fundamental ideas of sets, relations, mappings. This unit also gives the preliminary ideas of number theory. It will be very helpful for those students who will read number theory in higher study.</p> <p>Unit-3 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • define rank and inverse of a matrix and characterize invertible matrices • understand row reduction of matrices and define row echelon matrices • apply the method of row-reduction to find inverse of square matrices and solution of linear systems of equations that arises in different applications of science and engineering
Semester-II	CC3 (Real Analysis)	<p>Unit 1: Idea of real numbers and its properties. Idea of countability of sets and examples of countable and uncountable sets. Concept of bounded and unbounded sets in \mathbb{R}. Students will learn about order completeness axiom, Archimedean property of \mathbb{R} and Density property of rational and Irrational numbers in \mathbb{R}. Concept of Neighbourhood of a point, Interior point, limit point and isolated point of a set and sequence of real numbers. Idea of open sets, closed sets and their properties.</p> <p>Unit 2: Bolzano Weierstrass theorem for set and sequence, Sandwich rule, Nested interval theorem for sequence of closed bounded intervals. Cauchy general principle of</p>

		<p>convergence, Cauchy's first and second limit theorems and their applications</p> <p>Unit 3: Concept of convergence, absolute convergence, conditional convergence and non-convergence of infinite series of real numbers. Tests for convergence applying comparison test, ratio test, Cauchy's n-th root test, Kummer's test and Gauss test and Leibniz test.</p>
	CC-4 (Group Theory -I)	<p>Knowledge of group theory and its simple properties.</p> <p>Students can apply group theory to solve some special problems in elementary number theory like Fermat's Theorem, Wilson's Theorem and so on. Students can gain deep knowledge of group theory by learning symmetric group, dihedral group, group of congruence classes modulo some positive integer etc. The ideas of cyclic groups, quotient groups, normal subgroups, homomorphism, isomorphism and related theorems.</p>
Semester-III	CC-5 (Theory of Real Functions)	<p>Unit 1: Concept of limit and continuity of a function at a point. Sequential criterion for limit and continuity of a function. Continuity of a function on a set and important properties such as neighbourhood properties, boundedness properties, intermediate value theorem of continuous functions. Discontinuity of functions and two kinds of discontinuity of bounded functions. The property that a monotone function can have at most countably many points of discontinuity and the property that a monotone bijective function from an interval to an interval is</p>

		<p>continuous and its inverse is also continuous.</p> <p>Uniform continuity of a function on a set. Theorems such as 'Functions continuous on a closed and bounded interval are uniformly continuous' and 'A necessary and sufficient condition under which a continuous function on a bounded open interval I will be uniformly continuous on I'. Lipschitz condition and the condition is a sufficient condition for uniform continuity.</p> <p>Unit 2: Concept of differentiability of a function at a point and in an interval. Darboux theorem, Rolle's theorem and prove Lagrange and Cauchy Mean Value theorem using Rolle's theorem. Taylor's theorem and its application: infinite series expansion of exponential function, $\log(1+x)$, $\sin x$, $\cos x$ with their range of validity. L' Hospital's rule and its applications. Concept of Maxima and minima. Application of the principle of maximum and minimum in geometrical problems.</p>
	CC-6 Ring Theory & Linear Algebra-I)	<p>Unit-1 : Knowledge of rings, integral domains, fields, ideals and classifications of ideals. Students can acquire the knowledge to generalise the homomorphism theorems, isomorphism theorems, correspondence theorems and</p>

		<p>one-one correspondence between the sets of ideals and the set of congruences in rings.</p> <p>Unit-2 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • define vector spaces, subspaces and quotient spaces and understand the algebra and geometry of such spaces • understand the concept of linear span and linear independence of vectors and its use in the definition of basis and dimension of vector spaces • understand the concept of linear transformation and its algebra and find the matrices of linear transformation • calculate the rank and nullity of a linear operator • define isomorphism of two vector spaces and understand the theorems related to isomorphism • understand characteristic equation of a square matrix and the Cayley-Hamilton theorem associated to it and apply this theorem to find the inverse of a square matrix • define eigen-values and eigen-vectors of a square matrix and use in to solve related problems
	CC-7 Ordinary Differential Equation and Multivariate Calculus)	<p>In this course , students learn about the concepts of forming differential equations in case of geometric and mechanical problems. Also the idea of solving higher order linear differential equations using special techniques such as variation of parameters , integrating factors are being taught. Special non-linear differential equations , such as clairaut's</p>

		<p>form and singular solution are being taught also.</p> <p>Solving simultaneous differential equations of two variables using algebraic techniques are also taught.</p> <p>Idea of critical points in case of planar autonomous systems is included which gives the important idea of phase space. Power series solution for nth order linear differential equation is also included. Students get an elaborate idea and concepts of ordinary differential equations so that they can apply it to advanced topics such as mechanics, modelling, and many other branches of higher mathematics.</p> <p>In calculus of several variables the concept of function of more than one independent variable are being taught. The idea of simultaneous limit , iterated limits and partial derivatives are also being taught in this course. Concepts of finding extreme values for the function of two and three variables are also being taught. Students get these ideas useful in various advanced topics of analysis and algebra.</p>
	SEC-A (C-Programming)	Students learn about the constants, variables, loops, library functions, user defined functions, arrays used in c program. Preliminary ideas for writing a c program have been developed by this course.
Semester-IV	CC-8	The Riemann integration gives students the ideas to find the areas of curves. Students can recognize

	(Riemann Integration and Series of Functions)	<p>whether a function is integrable or not. Students also learn about a zero set and its relation with integrability of a function. They can develop the ideas of improper integrations and they learn how to find the values of improper integral and gain the idea to test a function whether it is convergence or not.</p> <p>Learning some special functions such as Beta-function, Gamma-functions. Students can find the values of some complicated integrals easily using these functions. Also this core course helps students to generalise the sequence and series in a broad area.</p>
	CC-9 (Partial Differential Equation & Multivariate Calculus-II)	<p>Unit-1 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • understand the concept and theory of linear and non-linear partial differential equations of first order, and different methods of solving such equations e.g., Lagrange's method and Charpit's method • derive different second order PDE's e.g., heat equation, wave equation and Laplace equation • classify second order linear PDE's and reduce them to canonical forms • understand the Cauchy problem of PDE's and the related theory and learn the method of separation of variables to solve vibration and heat conduction problems.

		<p>Unit-2 : In multivariate calculus II , students get the idea of double and triple integral as well as the very important concept of differentiation under the sign of integral with parametric values. Also the concept of line integral and Stokes Theorem, Green's Theorem, Gauss-Divergence Theorem are included here. Students get these ideas useful in various branches like advanced mechanics, astro-physics and quantum mechanics.</p>
	CC-10 (Mechanics)	<p>This course of mechanics gives the idea of coplanar forces, force system in space, equilibrium in the presence of sliding friction force, virtual work, stability of equilibrium, kinematics of a particle, Newton laws of motion and law of gravitation, dynamics of a particle, planar motion & three dimensional motion of a particle and dynamics of many particles system.</p> <p>This course is useful in various branches of Applied Mathematics like advanced mechanics, fluid mechanics, astro-physics, quantum mechanics, etc.</p>
	SECB1 (Mathematical logic)	
	SEC-B2 (Sage-Math)	<p>SageMath is a computer algebra system (CAS) with features covering many aspects of mathematics, including algebra, combinatorics, graph theory,</p>

		<p>numerical analysis, number theory, calculus and statistics.</p> <p>The goal of this course is to introduce students to the fundamental commands and structure of SageMath. The course covers the basic syntax and semantics of SageMath including basic data types, variables, control structures and functions or similar concepts, and visualization of results and processed data graphically.</p>
Semester-V	CC-11 (Probability & Statistics)	<p>Unit-1 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • learn the concepts of random experiment, σ-field, probability space and the axioms of probability • define conditional probability, understand Bayes theorem and use it to solve real life problems. • understand the concepts of discrete and continuous random variables and distribution functions of one variable, the concepts of probability mass and density function together with important and common examples of such functions • understand the concepts of mathematical expectation and characteristic function of random variables and the common characteristics associated with it <p>Unit-2 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • understand the extension of the concepts of Unit-I to many variables, especially to two random variables

		<ul style="list-style-type: none"> understand the concepts of covariance, correlation coefficient, marginal and conditional distributions and also the concepts of regression lines and curves of two variables <p>Unit-3 : After completing this unit the students will be able to</p> <ul style="list-style-type: none"> understand the Markov and Chebyshev's inequality and the concept of convergence of a sequence of random variables in probabilistic sense understand the weak and strong law of large numbers and the central limit theorem for independent and identically distributed random variables with finite variance <p>Unit-4 & 5 : In statistics, students learn about three central tendencies, mean, median mode, standard deviation, skewness, kurtosis. Also they get the idea of sampling techniques, different sampling distributions such as normal distribution chi-square distribution and t-distribution. They also learn about estimation techniques and the theory of testing hypotheses. The notion of critical regions using Neyman-Pearson lemma is also taught. This helps students to apply in various real life situations.</p>
	CC-12 (Group Theory II and Linear Algebra)	To gain the knowledge of automorphism, automorphism groups, cyclic groups, factor groups and its applications to automorphism groups, external direct products, internal direct products and fundamental theorem of finite abelian groups.

		<p>Students can check whether a finite group has a subgroup corresponding to any divisor of the order of the group. In linear algebra of this core course students can gain the knowledge of inner products, norms, Gram-schmidt orthogonalization process, orthogonal complement, Bessel's inequality, linear operator, dual space, dual basis and transpose of a linear transformation. They can also learn how to diagonalise a symmetric matrix, how to test for critical points of a function of several variables. How to find eigenspace, eigenvalues of a linear operator.</p>
	<p>DSE-A 1 (Group Theory and Ring Theory)</p>	<p>Knowledge of group action and its application to group theory, generalisation of Cayley's theorem, index theorem, class equation. Gain the knowledge to determine all possible subgroups of a group of given order and to check whether a group of finite order can have a subgroup corresponding to each divisor of the order of the group. Students can also learn about principal ideal domain, principal ideal ring, prime element, irreducible element, gcd etc. They can also learn about FD, UFD, PID and their inter-relations and how to embed a ring.</p>

	DSEA1 ()	
	DSE-B(1) (Linear Programming & Game Theory	<p>Unit-1:</p> <p>Unit-2:</p> <p>Unit-3: After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • understand the theory of duality in LPP and construct the dual problem from the primal problem and vice-versa • understand the relation between dual and primal problems and the relation between their optimal solutions and learn to determine the optimal solutions of the primal problem from the simplex table for the dual problem and vice-versa <p>Unit-4: After completing this unit the students will be able to</p> <ul style="list-style-type: none"> • understand the optimization problems popularly known as Transportation problems, Assignment problems and Travelling Salesman problems and learn the methods of solving these problems and use it to work out such problems for optimal solutions • understand the concepts of game theory - especially two-person zero sum games, which may be either deterministic or probabilistic in nature. • find the saddle points for rectangular games with pure strategies and the corresponding value of the games • learn the various methods of solving rectangular games with mixed strategies and the fundamental theorem of rectangular games with the concept of inter-relation between the theory of games and LPP

	DSEB1 ()	
Semester- VI	CC-13(Metric Space and Complex Analysis)	<p>As a generalisation of distance function students learn metric space and they are able to generalise the basic concept of real analysis in this metric space. After gaining knowledge they learn sequence, Cantor's theorem, compactness, Hein-Borel theorem, finite intersection property, continuous function, contraction mapping, Banach fixed point theorem and its application etc. Students learn these things in a generalised form.</p> <p>In complex analysis of this core course students start learning about stereographic projection, regions, limits, continuity, functions of complex variables, derivatives, differentiation formulas, Cauchy-Riemann Equations, analytic functions and some special functions. Students can learn basic theorems of power series in real analysis as a generalised version of complex variables. Students can gain the knowledge to prove some fundamental theorems.</p> <p>Also using contour integration they can determine the values of some special integrations.</p>

	CC-14 (Numerical Methods with Numerical Methods Lab (Practical))	There are three stages of numerical course , polynomial interpolation for both equal difference tabular data as well as unequal difference table using divided difference and lagrange formula , solving simultaneous equations with two variable using different determinant & matrix as well as solving non-linear equations using different iterative methods such as Newton-Raphson method is also included in this course. Solving differential equations using Picard's method , Euler's method as well as numerical integration using computer programmes are included in this course. Students learn these extremely useful techniques to employ in different fields of applied mathematics as well as in real life.
	DSEA2(Point Set Topology)	Basic idea of topological spaces, basis, subbasis for a topological space. Students learn topology as a generalisation of real analysis. Gain the knowledge about separation axioms, connected spaces, compact spaces. They can also learn Hein-Borel Theorem in R^n , the concept of compactness in a metric space, sequential compactness of a metric space.
	DSE-A(2) (Mathematical Modelling)	Unit-1: After completing this unit the students will be able to <ul style="list-style-type: none"> • find the power series solution of Legendre's equation and series solution of Bessel's equation and learn all

		<p>necessary properties of Legendre and Bessel functions together with the reduction formulae</p> <ul style="list-style-type: none"> understand the concepts of Laplace transform and inverse transform with sufficient examples and apply these concepts to solve initial value problems associated with ordinary differential equations up to the second order <p>Unit-2: After completing this unit the students will be able to</p> <ul style="list-style-type: none"> understand the concept of the harbor system in morning rush hour models using Monte Carlo simulation generate random numbers using linear congruence method as well as learn different queueing theory models and their use in different methods of solving real life situations get an overview of optimization modelling and linear programming models and use the algebraic and simplex methods for solving LPP's understand the concepts of sensitivity analysis and apply it to the problems of linear programming
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