Course Outcomes – Program Outcomes (COPO) Mapping

Program Outcomes (PO): B.Sc.(Hons.) Mathematics

Undergraduate Curriculum Framework (UGCF)

National Education Policy (NEP)

The Preamble of the Undergraduate Curriculum Framework-2022 underlines the historical perspective, philosophical basis, and contemporary realities of higher education as enshrined in the National Education Policy 2020 and endeavours to synchronize these cornerstones while charting the road ahead for the state of higher education.

ABBREVIATIONS / NOMENCLATURE

Sno.	Nomenclature	Description	Aggregate Courses
1	PO	Program Outcome	PO1, PO2,PO3, PO4, PO5
2	CO	Course Outcome	CO1, CO2, CO3, CO4, CO5, CO6, CO7
3	DSC	Core Courses	DSC1,DSC2, DSC3, DSC4, DSC5, DSC6, DSC7, DSC8, DSC9, DSC10, DSC11, DSC12
4	DSE	Discipline Specific Electives	DSE1
5	GE	General Electives	GE1 , GE2, GE3, GE4
6	BAP	B.A(Prog.)	BAP1, BAP2, BAP3, BAP4

Sno.	Program Outcomes (PO): B.Sc.(Hons.) Mathematics	Statements
1.	**PO1**	Communicate mathematics effectively by written computational and graphic means.
2.	**PO2**	Create mathematical ideas from basic axioms.
3.	**PO3**	Gauge the hypothesis, theories, techniques and proofs provisionally.
4.	**PO4**	Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
5.	**PO5**	Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.

Course Outcomes (CO): B.Sc.(Hons.) Mathematics

SEMESTER 1: **DSC1: Algebra**			
Unique Paper Code	**Name of the Paper**	**Course Outcome: CO**	**Statement**
2352012101	**DSC1:Algebra**	CO1	Determine number of positive/negative real roots of a real polynomial.
		CO2	Solve cubic and quartic polynomial equations with special condition on roots and in general.
		CO3	Employ De-Moivre's theorem in a number of applications to solve numerical problems.
		CO4	Use modular arithmetic and basic properties of congruences.
		CO5	Recognize the algebraic structure, namely groups, and classify subgroups of cyclic groups.
DSC2: Elementary Real Analysis			
		CO1	Understand the fundamental properties of the real numbers, including completeness and Archimedean, and density property of rational numbers in $\mathbb{R}$.

2352012102	**DSC2:Elementary Real Analysis**	CO2	Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$ and find the limit.
		CO3	Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate the limit superior and limit inferior of a bounded sequence.
		CO4	Apply limit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.
DSC3: Probability and Statistics			
2352012103	**DSC3:Probability and Statistics**	CO1	Understand some basic concepts and terminology - population, sample, descriptive and inferential statistics including stem-and-leaf plots, dotplots, histograms and boxplots.
		CO2	Learn about probability density functions and various univariate distributions such as binomial, hypergeometric, negative binomial, Poisson, normal, exponential and lognormal.
		CO3	Understand the remarkable fact that the empirical frequencies of so many natural populations, exhibit bell-shaped (i.e., normal) curves, using the Central Limit Theorem.
		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.
GE1 (FOR HONOURS): **GE1:Fundamentals of Calculus**			
2354001001	**GE1: Fundamentals of Calculus**	CO1	Understand continuity and differentiability in terms of limits.
		CO2	Describe asymptotic behavior in terms of limits involving infinity.
		CO3	Understand the importance of mean value theorems and its applications.

		CO4	Learn about Maclaurin's series expansion of elementary functions.
		CO5	Use derivatives to explore the behavior of a given function, locating and classifying its extrema, and graphing the polynomial and rational functions.
BA PROGRAM: Topics in Calculus			
2352571101	**BAP1:Topics in Calculus**	CO1	Understand continuity and differentiability in terms of limits and graphs of certain functions.
		CO2	Describe asymptotic behaviour in terms of limits involving infinity.
		CO3	Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function.
		CO4	Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves.
		CO5	Compute the reduction formulae of standard transcendental functions with applications.

COPO MAPPING

	SEMESTER I : COPO MAPPING					
Papers	Program Outcome : PO					
	Course Outcome: CO	PO1	PO2	PO3	PO4	PO5
DSC1	CO1		✓	✓		
	CO2			✓	✓	
	CO3	✓			✓	
	CO4			✓	✓	✓
	CO5		✓	✓		
DSC2	CO1		✓	✓		
	CO2			✓	✓	
	CO3			✓	✓	
	CO4			✓	✓	✓
DSC3	CO1		✓	✓		
	CO2			✓	✓	
	CO3			✓	✓	
	CO4	✓		✓	✓	
	CO1		✓	✓	✓	

GE1	CO2			✓	✓	
	CO3			✓	✓	
	CO4				✓	✓
BAP1	CO1		✓	✓	✓	
	CO2			✓	✓	
	CO3			✓	✓	
	CO4				✓	✓
	CO5			✓	✓	

SEMESTER II: **DSC4: Linear Algebra**			
Unique Paper Code	**Name of the Paper**	**Course Outcome: CO**	**Statement**
2352011201	**DSC4: Linear Algebra**	CO1	Visualize the space R^n in terms of vectors and their interrelation with matrices.
		CO2	Familiarize with basic concepts in vector spaces, linear independence and span of vectors over a field.
		CO3	Learn about the concept of basis and dimension of a vector space.
		CO4	Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation with application to computer graphics.
DSC5: Calculus			
2352011202	**DSC5:Calculus**	CO1	The notion of limits, continuity and uniform continuity of functions.
		CO2	Geometrical properties of continuous functions on closed and bounded intervals.
		CO3	Applications of derivative, relative extrema and mean value theorems.
		CO4	Higher order derivatives, Taylor's theorem, indeterminate forms and tracing of curves.
DSC6: Ordinary Differential Equations			
		CO1	Learn the basics of differential equations and compartmental models.
		CO2	Formulate differential equations for various

2352011203	**DSC6: Ordinary Differential Equations**		mathematical models.
		CO3	Solve first order non-linear differential equations, linear differential equations of higher order and system of linear differential equations using various techniques.
		CO4	Apply these techniques to solve and analyze various mathematical models.
GE2 (FOR HONOURS): Introduction to Linear Algebra			
2354001202	**GE2: Introduction to Linear Algebra**	CO1	Visualize the space R^n in terms of vectors and the interrelation of vectors with matrices.
		CO2	Understand important uses of eigenvalues and eigenvectors in the diagonalization of matrices.
		CO3	Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces.
		CO4	Learn about linear transformation and its corresponding matrix.
BA PROGRAM: Elementary Linear Algebra			
2352571201	**BAP2: Elementary Linear Algebra**	CO1	Visualize the space R^n in terms of vectors and the interrelation of vectors with matrices
		CO2	Familiarize with concepts of bases, dimension and minimal spanning sets in vector Spaces.
		CO3	Learn about linear transformation and its corresponding matrix.

COPO MAPPING

	SEMESTER II : COPO MAPPING					
Papers	Program Outcome : PO					
	Course Outcome: CO	PO1	PO2	PO3	PO4	PO5
DSC4	CO1		✓	✓		
	CO2				✓	
	CO3			✓		
	CO4			✓	✓	

DSC5	CO1	✓		✓	✓	
	CO2			✓	✓	
	CO3		✓	✓	✓	
	CO4			✓		✓
DSC6	CO1	✓		✓	✓	
	CO2			✓	✓	
	CO3		✓	✓	✓	
	CO4			✓		✓
GE2	CO1		✓	✓		
	CO2				✓	
	CO3			✓		
	CO4			✓	✓	
	CO5		✓	✓		
BAP2	CO1		✓	✓		
	CO2				✓	✓
	CO3			✓		
	CO4			✓	✓	✓
	CO5		✓	✓		

SEMESTER III:

DSC7: Group Theory

Unique Paper Code	Name of the Paper	Course Outcome: CO	Statement
2352012301	**DSC7: Group Theory**	CO1	Analyse the structure of 'small' finite groups, and examine examples arising as groups of permutations of a set, symmetries of regular polygons.
		CO2	Understand the significance of the notion of cosets, Lagrange's theorem and its consequences.
		CO3	Know about group homomorphisms and isomorphisms and to relate groups using these mappings.
		CO4	Express a finite abelian group as the direct product of cyclic groups of prime power orders.
		CO5	Learn about external direct products and its applications to data security and electric circuits.
DSC8: Riemann Integration			
		CO1	Learn about some of the classes and properties of Riemann integrable functions, and the

2352012302	**DSC8: Riemann Integration**		applications of the Riemann sums to the volume and surface of a solid of revolution.
		CO2	Get insight of integration by substitution and integration by parts.
		CO3	Know about convergence of improper integrals including, beta and gamma functions.
DSC9: Discrete Mathematics			
2352012303	**DSC9: Discrete Mathematics**	CO1	Understand the notion of partially ordered set, lattice, Boolean algebra with applications.
		CO2	Formulate differential equations for various mathematical models.
		CO3	Apply the knowledge of Boolean algebras to logic, set theory and probability theory.
GE3(FOR HONOURS): Differential Equations			
2354002001	**GE3: Differential Equations**	CO1	Solve the exact, linear, Bernoulli equations, find orthogonal trajectories and solve rate problems.
		CO2	Apply the method of undetermined coefficients and variation of parameters to solve linear differential equations.
		CO3	Solve Cauchy-Euler equations and System of linear differential equations.
		CO4	Formulate and solve various types of first and second order partial differential equations.
DSE1: Number Theory			
2353012003	**DSE1:Number Theory**	CO1	Use modular arithmetic in solving linear and system of linear congruence equations.
		CO2	Work with the number theoretic functions, their properties and their use.
		CO3	Learn the forms of positive integers that possess primitive roots and the Quadratic Reciprocity Law which deals with the solvability of quadratic congruences.
		CO4	Understand the public-key cryptosystems, in particular, RSA.
BA PROGRAM: Differential Equations			
	BAP3:Differential Equations	CO1	Solve the exact, linear, Bernoulli equations, find orthogonal trajectories and solve rate

2352572301			problems.
		CO2	Apply the method of undetermined coefficients and variation of parameters to solve linear differential equations.
		CO3	Solve Cauchy-Euler equations and system of linear differential equations.
		CO4	Formulate and solve various types of first and second order partial differential equations.

COPO MAPPING

	SEMESTER III : COPO MAPPING					
Papers	Program Outcome : PO					
	Course Outcome: CO	PO1	PO2	PO3	PO4	PO5
DSC7	CO1		✓	✓		
	CO2		✓	✓	✓	
	CO3			✓	✓	
	CO4		✓	✓		
	CO5			✓	✓	✓
DSC8	CO1		✓	✓		
	CO2			✓	✓	
	CO3		✓		✓	
DSC9	CO1	✓	✓			
	CO2		✓	✓	✓	
	CO3			✓	✓	✓
DSE1	CO1		✓	✓		
	CO2			✓	✓	
	CO3			✓	✓	
	CO4			✓	✓	✓
GE3	CO1	✓	✓			✓
	CO2			✓		
	CO3			✓	✓	
	CO4			✓	✓	✓
BAP3	CO1	✓	✓			✓
	CO2			✓		
	CO3			✓	✓	
	CO4			✓	✓	✓

SEMESTER IV:

DSC10: Sequences and Series of Functions			
Unique Paper Code	**Name of the Paper**	**Course Outcome: CO**	**Statement**
2352012401	**DSC10: Sequences and Series of Functions**	CO1	Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence of series of real-valued functions.
		CO2	Know about the constraints for the inter-changeability of differentiation, and integration with infinite sum of a series of functions.
		CO3	Handle the convergence of power series and properties of the limit function, including differentiation and integration of power series.
		CO4	Appreciate utility of polynomials in the space of continuous functions.
DSC11: Multivariate Calculus			
2352012401	**DSC11: 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, and learn applications.
DSC12: Numerical Analysis			
2352012401	**DSC12: Numerical Analysis**	CO1	Learn some numerical methods to find the zeroes of nonlinear functions of a single variable, up to a certain given level of precision
		CO2	Learn Gauss−Jacobi, Gauss−Seidel methods to solve system of linear equations.
		CO3	Get aware of using interpolation techniques, for example in finding values of a tabulated function at points which are not part of the table.
		CO4	Learn finding numerical solutions of difference equations which are obtained converting differential equations using techniques from calculus.

GE4 (FOR HONOURS): Linear Programming			
2354002004	**GE4: Linear Programming**	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 solution of rectangular games using graphical method and dominance.
		CO5	Formulate game to a pair of associated prima-dual linear programming problems.
BA PROGRAM: Introduction to Graph Theory			
2352202402	**BAP4: Introduction to Graph Theory**	CO1	Good familiarity with all initial notions of graph theory and related results and seeing them used for some real-life problems.
		CO2	Learning notion of trees and their enormous usefulness in various problems.
		CO3	Learning various algorithms and their applicability
		CO4	Studying planar graphs, Euler theorem associated to such graphs and some useful applications like coloring of graphs.

COPO MAPPING

	SEMESTER III : COPO MAPPING					
Papers	Program Outcome : PO					
	Course Outcome: CO	PO1	PO2	PO3	PO4	PO5
DSC10	CO1	✓	✓			✓
	CO2			✓		
	CO3			✓	✓	
	CO4			✓	✓	✓
DSC11	CO1	✓	✓			✓
	CO2			✓		
	CO3			✓	✓	
	CO4			✓	✓	✓
DSC12	CO1		✓	✓		
	CO2			✓		
	CO3			✓	✓	
	CO4			✓	✓	✓

GE4	CO1			✓	✓	
	CO2		✓	✓	✓	
	CO3			✓	✓	✓
	CO4				✓	
	CO5			✓	✓	✓
BAP4	CO1		✓	✓	✓	
	CO2			✓	✓	✓
	CO3				✓	
	CO4			✓	✓	✓
	CO5			✓	✓	