(University of Delhi)
Shyam Lal College

Programme Specific Outcomes and Course Outcomes

B.Sc. (H) Mathematics

Programme Specific Outcomes

Programme	Programme Specific Outcomes
B.Sc.(H) Mathematics	**PSO-1:** Students will be enabled to communicate mathematics effectively by written, computational and graphic means.
	PSO-2: Students will be enabled to create mathematical ideas from basic axioms.
	PSO-3: Students will be enabled to gauge the hypothesis, theories, techniques and proofs provisionally.
	PSO-4: Students will learn to utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
	PSO-5: Students will 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.
	PSO-6: Course will empower the students with the skills and together with the liberty of exploring their interests within the main subject.
	PSO-7: Students will be capable to use ICT tools in solving problems or gaining knowledge and to use appropriate softwares and programming skills to solve problems in mathematics.
	PSO-8: Students will acquire knowledge and skills through self- learning that helps in personal development and skill development for changing demands of work place.
	PSO-9: Students develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life.
	PSO-10: Students will be equipped with knowledge of basic concepts and ideas in mathematics and its subfields and will be able to apply the applications of the subject to other disciplines.
	PSO-11: It would also help in making responsible citizens and facilitate character building.

Course Outcomes

Semester 1

Course Name	Learning Outcomes	Programme Specefic Outcomes are Attained by
DSC-1 Algebra	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.	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	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.	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.
DSC-3 Probability and Statistics	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	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.

	interests to form the basis of data science.	• 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. • 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.
SEC-Statistics with R	The Learning Objectives of this course are as follows: • To enable students to handle data in the R software thereby helping them to • understand meaningful statistical analysis performed on the data. • To enable students to extract data, and perform basic statistical operations entailing data analysis such as – data cleaning, data visualisation, data summarisation, and regression amongst others.	The Learning Outcomes of this course are as follows: • After studying this course, students will be able to extract and Read data into R, manipulate, and analyse it • After studying this course, students will be able Tto debug, organize, and comment R code • After studying this course, students will be able to understand the R environment for downloading, installing, and using packages • After studying this course, students will be able to do basic programming to write own functions • ☐After studying this course, students will be able to use loops • After studying this course, students will be able to create standard and customized graphics • After studying this course, students will be able to perform basic statistical operations and regression.
VAC-Vedic Mathematics 1	The Learning Objectives of the course are: • Foster love for maths and remove its fear through Vedic Mathematics • Enhance computation skills in students through Vedic Mathematics1 • Develop logical and analytical thinking • Promote joyful learning of mathematics • Discuss the rich heritage of mathematical temper of Ancient India	The Learning Outcomes of the course are • Overcome the fear of maths • Improved critical thinking • Familiarity with the mathematical underpinnings and techniques • Ability to do basic maths faster and with ease. • Appreciate the Mathematical advancements of Ancient India.
GE-Fundamental of Calculus	The Learning Objectives of this course is as follows:	Upon completion of this course, students will be able to:

	• Understand the quantitative change in the behaviour of the variables and apply them on the problems related to the environment.	• 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.

Semester 2

Course Name	Learning Outcomes	Programme Specific Outcomes are Attained by
DSC-4 Linear Algebra	The objective of the course is to introduce: • The concept of vectors in RR_{nn}, 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.	This course will enable the students to: • Visualize the space RR_{nn} 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.
DSC-5 Calculus	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.	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.
DSC-6 Ordinary Differential Equations	The main objective of this course is to introduce the students: • The exciting world of differential equations. • Their applications and mathematical modeling.	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.
SEC-Statistics with R	The Learning Objectives of this course are as follows:	The Learning Outcomes of this course are as follows:

	• To enable students to handle data in the R software thereby helping them to understand meaningful statistical analysis performed on the data. • To enable students to extract data, and perform basic statistical operations entailing data analysis such as – data cleaning, data visualisation, data summarisation, and regression amongst others.	• After studying this course, students will be able to extract and Read data into R, manipulate, and analyse it • After studying this course, students will be able to debug, organize, and comment R code • After studying this course, students will be able to understand the R environment for downloading, installing, and using packages • After studying this course, students will be able to do basic programming to write own functions • After studying this course, students will be able to use loops • After studying this course, students will be able to create standard and customized graphics • After studying this course, students will be able to perform basic statistical operations and regression.
SEC-Document Preparation and Presentation System Latex	• To develop proficiency in the use of document preparation software such as document LaTeX, LibreOffice. • To make a presentation using LaTeX, LibreOffice. • To serve as a tool for conveying/communicating one's ideas, views, and observations.	On completion of the course, a student will be able to • Create a text document using LaTeX using a standard template. • Incorporate well-formatted mathematical equations, algorithms, figures, tables and references in a document. Use Zotero for reference management. Format text, including alignment, emphasis and fonts. Handle basic aspects of document structure, including sections, subsections, paragraphs, and bulleted and enumerated lists. Page set a document including header, footer, and page numbering. Make a presentation.
VAC-Vedic Mathematics 1	The Learning Objectives of the course are: • Foster love for maths and remove its fear through Vedic Mathematics • Enhance computation skills in students through Vedic Mathematics1 • Develop logical and analytical thinking • Promote joyful learning of mathematics	The Learning Outcomes of the course are • Overcome the fear of maths • Improved critical thinking • Familiarity with the mathematical underpinnings and techniques • Ability to do basic maths faster and with ease. • Appreciate the Mathematical advancements of Ancient India.

	• Discuss the rich heritage of mathematical temper of Ancient India	
GE-Introduction to Linear Algebra	The objective of the course is: • To introduce the concept of vectors in RR_{nn}. • Understand the nature of solution of system of linear equations. • To view the $mm \times nn$ matrices as a linear function from RR_{nn} to RR_{mm} and vice versa. • To introduce the concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.	This course will enable the students to: • Visualize the space RR_{nn} 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 3

Course Name	Learning Outcomes	Programme Specific Outcomes are Attained by
BMATH 305: Theory of Real Functions	• Have a rigorous understanding of the concept of limit of a function. • Learn about continuity and uniform continuity of functions defined on intervals. • Understand geometrical properties of continuous functions on closed and bounded intervals. • Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications. Know about applications of mean value theorems and Taylor's theorem.	• Students are equipped with a matured perspective of the concepts of calculus • Students learn more applications of limits, continuity, differentiability.
BMATH 306: Group Theory-I	• 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. Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups. • Explain the significance of the notion of cosets, normal subgroups and factor groups. • Learn about Lagrange's theorem and Fermat's Little theorem. • Know about group homomorphisms and group isomorphisms.	• Students learn about the fundamental theorem of groups and homomorphism • Students get to know about symmetric groups and symmetries, an important concept in group theory. • Consequences of Lagrange's theorem are learned by them and their applications.

BMATH 307: Multivariate Calculus	- 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.	Students were made aware of applications of multivariate calculus tools in physics, economics, optimization and understanding the architecture of curves and surfaces in plane and space.
SEC 1: LaTeX and HTML	- Create and typeset a LaTeX document. - Typeset a mathematical document using LaTex. - Learn about pictures and graphics in LaTex. - Create beamer presentations. - Create web page using HTML	- Students were able to typeset mathematical equations - They were equipped with skill of making presentations involving long mathematical equations, a number of symbols. - They learned to design their own webpage.
GE 3: Differential equation	- Solve the exact, linear and Bernoulli equations and find orthogonal trajectories. - Apply the method of variation of parameters to solve linear differential equations. - Formulate and solve various types of first and second order partial differential equations.	- The students get introduced to differential equations. - Different methods were discussed to solve differential equations.
GE 3:Linear programming and game theory	- Learn about the simplex method used to find optimal solutions of linear optimization problems subject to certain constraints. - Write the dual of a linear programming problem. - Solve the transportation and assignment problems. - Learn about the solution of rectangular games using graphical method and using the solution of a pair of associated prima-dual linear programming problems.	- Students are able to construct a linear programming problem for a given situation. - Simplex method helps them to get the optimal value of the problem - Transportation problem and assignment problems are learned by them and they are able to apply them to day-to-day life - Students learn to solve two-person-zero-sum game using different methods.

Semester 4

Course Name	Learning Outcomes	Programme Specefic Outcomes are Attained by
BMATH 408: Partial Differential Equations	- Formulate, classify and transform first order PDE's into canonical form. - Learn about method of characteristics and separation of variables to solve first order PDE's. - Classify and solve second order linear PDE's. - Learn about Cauchy problem for second order PDE and homogeneous and nonhomogeneous wave equations. - Apply the method of separation of variables for solving many well-known second order PDE's.	Students learn to solve partial differential equations and use of them in physical problems

BMATH 409: **Riemann Integration** **& Series of Functions**	• Learn about some of the classes and properties of Riemann integrable functions, and the applications of the Fundamental theorems of integration. • Know about improper integrals including, beta and gamma functions. Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence. • Know about the constraints for the inter-changeability of differentiability and integrability with infinite sum. • Approximate transcendental functions in terms of power series as well as, differentiation and integration of power series.	• Students learn the integrability of continuous functions on closed and bounded intervals • Applications of integrable functions also learned
BMATH 410: Ring **Theory &** **Linear Algebra-** **I**	• Learn about the fundamental concept of rings, integral domains and fields. • Know about ring homomorphisms and isomorphisms 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	• Students get the knowledge of two important algebraic structures: ring theory and linear algebra • Students are able to apply linear algebra in real life.

	matrix.	
SEC2: Computer Algebra Systems and Related Software	• Use of computer algebra systems (Mathematica/MATLAB/Maxima/M aple etc.) 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. Understand the use of the statistical software R as calculator and learn to read and get data into R. • Learn the use of R in summary calculation, pictorial representation of data and exploring relationship between data. • Analyze, test, and interpret technical arguments on the basis of geometry.	• Students are able to use different computer algebra systems and are able to solve mathematical problems using them.
GE4: Numerical methods	• Find the consequences of finite precision and the inherent limits of numerical methods. • Appropriate numerical methods to solve algebraic and transcendental equations. • Solve first order initial value problems of ODE's numerically using Euler methods.	• Important topics of numerical methods are understood by students

GE 4: Elements of analysis	• Understand the real numbers and their basic properties. • Be familiar with convergent and Cauchy sequences. Test the convergence and divergence of infinite series of real numbers. • Learn about power series expansion of some elementary functions.	• Students get an insight of real number system. • They learned real sequences and series and their sums.

Semester 5

Course Name	Learning Outcomes	Programme Specefic Outcomes are Attained by
BMATH 511: Metric Spaces	- Understand the basic concepts of metric spaces - Correlate these concepts to their - counter parts in real analysis - Appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc. beyond their geometrical imaginations. - Analyze how a theory advances from a particular frame to a general frame - Learn about Banach fixed point theorem-one of the beautiful results in analysis	Students develop an idea of distance into an abstract form on any sets of objects, maintaining its inherent characteristics and the resulting consequences
BMATH 512: Group Theory	- Automorphisms for constructing new groups from the given group - External direct product $Z_2 \square Z_2$ applies to data security and electric circuits. - Group actions, Sylow theorems and their applications to check non simplicity. - Understand fundamental theorem of finite abelian groups - Be familiar with group actions and conjugacy in S_n.	- Students get in-depth understanding of abstract algebra. - Students able to classify all finite Abelian groups.
DSE-1 (i): Numerical Analysis	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	Students get the knowledge computational Techniques to find approximate value for possible root(s) of non-algebraic equations, to find the approximate solutions of system

	certain given level of precision. • 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 for numerical solutions.	of linear equations and ordinary differential equations Students are able to apply linear algebra in real life. • Learn 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.
DSE-2 (i): **Probability Theory** **and Statistics**	• Distributions to study the joint behavior of two random variables • To establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression. • Central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell shaped curve.	• Students get familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness. • Students solve several examples and exercises that blend their everyday experiences with their scientific interests.

Semester 6

Course Name	Learning Outcomes	Programme Specefic Outcomes are Attained by
BMATH 613: Complex Analysis	• Learn the significance of differentiability of complex functions • Understand Cauchy Riemann equations. • Learn some elementary functions and valuate the contour integral • Understand the role of Cauchy-Goursat theorem and the Cauchy integral formula • Expand some simple functions	• Students develop a basic idea of analysis of complex functions in complex variables.
BMATH 614: Ring theory and linear algebra -II	• Appreciate the significance of unique factorization in rings and integral domains • Compute the characteristic polynomials, eigenvectors, eigenspaces. • Compute inner products and determine orthogonality on vector spaces • Find the adjoint, normal and orthogonal operators	• Students 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. • Students get to know the application of techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.
DSE-3 (iii): Biomathematics	• Learn the development, analysis and interpretation of bio mathematical models. • Reinforce the skills in mathematical modeling. • Appreciate the theory of bifurcation and chaos.	• Students do scientific study of normal functions in living systems. • The basic concepts of the probability to understand molecular evolution and genetics have also been discussed.

	• Learn to apply the basic concepts of probability to molecular evolution and genetics.	
DSE-4 (ii): Linear Programming and Applications	• Analyze and solve linear programming models of real-life situations. • The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points. The theory of the simplex method is developed • The relationships between the primal and dual problems and their solutions with applications to transportation, assignment and two- person zero-sum game problem.	• Students understand the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. • Students understand Linear Programming with applications to Transportation, Assignment and Game Problem. Such problems arise in manufacturing resource planning and financial sectors.