Mathematics

(12 Core + 3 Optional = 15x4Cr = 60Cr)

Majors in Mathematics are offered with an objective of preparing the students to take up higher studies in Mathematics in international reputed institutes including IITs, IISc, Delhi University, Central Universities, JNU etc. in India. This course will develop the ability to think logically, critically and analytically in dealing with real life situations. After doing this course, the students will also be able to choose carrier in mathematics related fields in education, government/corporate sectors, finance and insurance sectors etc.

A set of twelve core courses will be offered to the students who are opting this major in II and II years of their Bachelor's program. Four courses per semester will be offered in first three semester and in fourth semester, student will be asked to choose at least three courses from the basket of six to seven courses.

In first semester of Majors, four foundational courses (Calculus, Algebra, Differential Equations and Real Analysis) will be offered. During this semester, student will learn to solve complicated system of equations, modeling of physical phenomena, and understanding of real number system. Second semester of Majors (Group Theory, Metric spaces, Mathematical methods and Linear Algebra) will provide in depth knowledge of pure mathematical courses and prepare students for learning mathematical methods like Laplace and Fourier transforms etc. and it will also introduce the definition of space and dimensions in mathematical terms. In third semester of Majors, in addition to pure mathematics courses, student will learn some numerical techniques (using MATLAB) to solve the problems which are not solvable analytically. A course on complex analysis having wide range applications in string and quantum field theory will also be introduced. In fourth semester, the elective courses from various applied fields like Mechanics, Optimization, Graph theory, Probability and Statistics will be offered and students will be asked to three elective courses. Certain course will include computational lab components also.

In brief, the above program covers broad range of topics related to pure and applied mathematics: Linear algebra, Metric spaces, Group and Ring theory, Numerical analysis, Calculus along with relevant applicable computational laboratory components (using MATLAB, Mathematics SPSS etc.

Course Scheme

12 Core Courses + 3 Electives= 15 Courses

Semester	Course	Credit
1		
2	Introduction to Mathematical Thinking	2 (Foundation Course)
3	Calculus	4 (Core Courses until Sem 5)
	Algebra	4
	Differential Equations	4
	Real Analysis	4
4	Group Theory	4
	Metric Spaces	4
	Mathematical Methods	4
	Linear Algebra	4
5	Ring Theory	4
	Complex Analysis	4
	Partial Differential Equations	4
	Numerical Analysis	4
6	**Electives (Any 3)**	
	Optimization Techniques	4
	Mechanics	4
	Discrete Mathematics	4

	Graph Theory	4
	Probability and Statistics	4
	Advanced Numerical Analysis	4
	Computational Linear Algebra	4
	Financial Mathematics	4

Algebra

Course-I

L	T	P	Cr
4	0	0	4.0

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Matrices and its Applications: Symmetric, skew-symmetric, Hermition and skew-Hermition, Systems of linear equations, Row reduction and echelon forms, The matrix equation $A\mathbf{x} = \mathrm{b}$, Solution sets of linear systems, Linear independence, The rank of a matrix and applications, Matrix operations, The inverse of a matrix, Characterizations of invertible matrices, Eigenvectors and eigenvalues, The characteristic equation and the Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Theory of Equations: The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations in one variable, solution of polynomial equations having conditions on roots, common roots and multiple roots, Transformation of equations, Nature of the roots of an equation, Descarte's rule of signs, Solutions of cubic equations (Cardon's method), Biquadratic equations and their solutions.

Complex Numbers: Review of complex numbers, Transcendental functions, hyperbolic functions, Polar representation of complex numbers, Imaginary roots, the *n*th roots of unity, De Moivre's theorem and its applications.

Recommended Books:

1. Shanti Narayan: A Text Books of Matrices.

2. Dickson, Leonard Eugene (1922). *First Course in The Theory of Equations*. John Wiley & Sons, Inc. New York. The Project Gutenberg EBook.

3. Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.

CALCULUS

Course-II

L T P Cr.

4 0 0 4.0

Course objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion.

Derivatives and Applications: Review of Limits, Continuity of functions, differentiability, the first-derivative test for relative extrema, concavity and inflection points, second-derivative test for relative extrema, Curve tracing using first and second derivative test, limits to infinity and infinite limits.

Sketching and Tracing of Curves: Asymptotes in Cartesian coordinates, intersection of curve and its asymptotes, asymptotes in polar coordinates, Curvature, radius of curvature for Cartesian curves, parametric curves, polar curves, Newton's method, radius of curvature for pedal curves, Tangential polar equations, centre of curvature, circle of curvature, chord of curvature, evolutes, multiple points, Cusp, nodes, conjugate points, types of cusps.

Multivariable Functions: Limits and continuity for functions of several variables, partial derivatives, the chain rule, directional derivatives, gradient vectors, tangent planes, extreme values and saddle points.

Multiple Integrals and Applications: Double integrals, triple integrals, Jacobian, substitutions in multiple integrals, Green's theorem, Stoke's theorem and the divergence's theorem, Quadrature (area) section area, area bounded by closed curves, Volume and surfaces of Revolution, Hyperbolic functions, Reduction formulas.

Recommended Books:

1. George B. Thomas, Maurice D. Weir and Joel R. Hass, Thomas'Calculus,

   12th Ed., Pearson Education, New Delhi, 2014.

2. Shanti Narayan, Integral Calculus, S. Chand and Company Ltd, 2001.

3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.

4. Osborne, George. A. (1906). *Differential and Integral Calculus with Examples and Applications*. Revised Edition. D. C. Health & Co. Publishers. Boston, U.S.A.

Differential Equations

Course-III

L T P Cr

4 0 0 4.0

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, exhibit the techniques for obtaining solutions to ordinary differential equations and the basic ideas and theory behind those techniques.

First order Linear Differential Equations: Classification of Differential Equations: Their Origin and applications, Nature and method of solutions. Initial and boundary value problem. Existence and uniqueness theorem, Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. Clairaut equation, applications of first order Equations.

Second and Higher order Differential Equations: Higher-Order Linear Differential Equations: Basic Existence Theorem, The Homogeneous Equation, Wronskian, its properties and applications, reduction of order, the non-homogeneous equation, the homogeneous linear equation with constant coefficients, initial-value problem, the Cauchy-Euler equation, theorems on the second-order homogeneous linear equation, the method of undetermined coefficients, method of variation of parameters.

Power Series solution of Differential Equations: Ordinary points and singular points, power series solution about an ordinary point, power series solution about singular points, the method of Frobenius.

Recommended Books:

1. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modelling, Pearson Education India, 2005.

2. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

3. E. A. Coddington, An introduction to ordinary differential equation, Prentice- Hall of India.

4. M. D. Raisinghania, Ordinary and Partial Differential Equations, 19th edition, S. Chand Publisher, 2017.

Real Analysis

Course-IV

L T P Cr.

4 0 0 4.0

Course Objectives: The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications in real life scenario.

Real Number System $\mathbb{R}$ and its properties: Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$, Definition and types of intervals, Nested intervals property, Neighborhood of a point in $\mathbb{R}$, Open and closed sets in $\mathbb{R}$.

Sequences in $\mathbb{R}$: Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, divergent sequence, Subsequences, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion.

Infinite Series: Convergence and divergence of infinite series of real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series**:** Integral test, comparison test, D'Alembert's ratio test, Cauchy's *n*th root test; Alternating series, Leibniz test, Absolute and conditional convergence.

Recommended Books:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., JohnWiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

2. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishing House, Reprint 2002.

3. S. C. Malik and Savita Arora, Mathematical Analysis, (2nd ed.). New Age International.

4. R.R. Goldberg: Real Analysis, Oxford & I.B.H. Publishing Co., New Delhi, 1970.

Mathematics Minor

Algebra and Trigonometry

Course-I

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Nil

Section 1: Sets and their Representations, types of sets, Subsets, Power Set, Universal Set, Venn Diagrams, Operations on Sets, Complement of a Set, Union and Intersection of two Sets, Cartesian product, Applications

Section 2: Ordered pairs, Relations, Domain and Range, types of relation, functions, types of functions, mappings, Composite functions, Binary operations

Section 3: Complex numbers, properties, graphical representation, polar representation, fundamental theorem of algebra, solutions of quadratic equation in complex number system, square root of complex numbers

Section 4: Sequence and Series, Arithmetic Progression, Arithmetic Mean, Geometric Progression, finite and infinite G. P. and its sum, Geometric Mean, Relation between A.M. and G.M.

Section 5: Factorial n, Permutation and Combinations, applications, Binomial Expansion, general and middle term in Binomial expansion, applications

Section 6: Trigonometric functions, angles in radian and degree, trigonometric identities, domain and range of trigonometric functions and their graphs, product and sum formulas, multiple angles formulas

Section 7: Linear Inequalities, algebraic solutions in one variable and their representation on number line, graphical solution of linear inequalities and system, of linear inequalities in two variables

Recommended Books:

1. NCERT 11^{th} and 12^{th} standard books.

Differential Calculus

Course-II

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Algebra

Section 1: Introduction to standard curves (line, circle, parabola, hyperbola, ellipse etc.)

Section 2: Limit of a function, L'Hospital rule, Continuity, Differentiation using first principle, Derivative of some standard functions, trigonometric and inverse trigonometric functions, Chain rule,

Section 3: Differentiation of functions in parametric form and in exponential form, Higher order derivatives, Rolle's theorem, Mean Value theorem

Section 4: Applications of derivatives: Rate of change of quantity, increasing and decreasing, tangents and normals, approximations, Maxima and minima.

Section 5: Introduction of Differential equations, Basic concepts, general and particular solution of D.E., formulation of Differential equation from general solution, Methods of solving first order linear D.E.

Recommended Books:

1. NCERT 11^{th} and 12^{th} standard books.

Integral Calculus

Course-III

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Algebra, Differential calculus

Section 1: Integration of some standard and trigonometric functions, Integration by substitution, Integration by partial fractions, Integration by parts,

Section 2: Definite integral, fundamental theorem of calculus, evolution of definite integrals by substitution, properties of definite integrals

Section 3: Basic applications of integrals: area under a curve, area between two curves,

Recommended Books:

1. NCERT 11^{th} and 12^{th} standard books.

Matrices and determinants

Course-IV

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Algebra

Matrices: Introduction to matrices, types of matrices, operations on matrices, Symmetric and skew symmetric matrices, Hermitian and skew-Hermitian matrices, matrices over complex numbers, Elementary transformations (operations) on matrices, Inverse of a matrix (using row transformations) Rank of a matrix, row rank and column rank of a matrix, Normal form

Determinants: Definition of determinants, properties of determinants, minors, cofactors and adjoint of a matrix, Singular and non-singular matrices, Invertible matrices, Cramer's rule

Applications of matrices and determinants: Solution to linear systems, Row operations and equivalent systems, row reduced echelon form of matrix, consistency and inconsistency of linear systems

Eigen values and eigen vectors: Linear independence (and dependence) of rows/columns, Eigen values and eigen vectors, alternative to find inverse using Cayley-Hamilton.

Recommended Books:

1. NCERT 11^{th} and 12^{th} standard books.

Probability & Statistics

Course-V

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Algebra

Introduction to Statistical Analysis: Measures of Central Tendency and Dispersion, Mean, Median, Mode, Range, Mean deviation, Standard Deviation.

Probability: Classical, Relative Frequency and Axiomatic Definitions of Probability, Addition Rule and Conditional Probability, Multiplication Rule, Total Probability, Bayes' Theorem and Independence, Problems.

Random Variables: Discrete, Continuous Random Variables, Probability Mass, Probability Density And Cumulative Distribution Functions, Mathematical Expectation, Moments.

Special Distributions: Discrete uniform, Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Continuous Uniform, Exponential, Normal, Lognormal.

Joint Distributions: Joint, Marginal and Conditional Distributions, Independence of Random Variables

Linear Regression and Correlation: Linear Regression, Least Square Principle and Fitted Models, Karl Pearson's Correlation Coefficient, Rank Correlation, Lines of Regression.

Recommended Books:

1. NCERT 11^{th} and 12^{th} standard books.

Vedic Mathematics

Course-VI

L	T	P	Cr.
4	0	0	4.0

Prerequisites: Algebra

Introduction to Vedic Mathematics: History of Vedic mathematics, Advantages to Vedic mathematics, salient features of Vedic mathematics, Vedic mathematics formulas: 16 sutras, 13 sub sutras, Digital root of the number, Vinculum numbers, conversion of normal numbers to Vinculum number and vice-versa.

Addition, Subtraction & Divisibility: Place-wise Addition method, Addition by Shuddha Method, Subtraction by Shuddha Method, Vinculum Subtraction, Simultaneous Addition and Subtraction, Divisibility tests, Divisibility of Sums and products.

Multiplication and Division: Multiplication of complementary numbers like 23 X 27, Multiplication by numbers consisting of all 9s, Multiplication by numbers above the base, Multiplication by numbers below the base, Multiplication by 11, 101, 1001, Multiplication by 12, Multiplication of any number by 9, 99, 999, Multiplication by two-digit numbers, Multiplication by three and four-digit numbers, Decimal number Multiplications, Sum of products & product of sums, Division with single digit number, Division with double digit Divisor, Division with three digit Divisor, Division with four digit Divisor, Division of sums, Division of Product, Division of Sums of Products, Division of Product of sums, Division of Squares and Cubes.

Squares and cubes: Anurupyena method, Duplex Method, Square of two-digit, three-digit, four-digit number, Square of the number by Nikhilam method, Square of Number ending with 5, Squares of numbers near 50, 500 or 5000, Duplex method for sum and difference of Squares, Nikhilam method for Sum and differences of squares, Multiplication with squares of a number, Anurupyena method for cube of number, Sum or difference of cubes, Nikhilam method for cube of number, Product with cubes of two digit numbers.

Square roots and cube roots: Square roots by Vilokanam, Square roots by Dwandvayoga Method, Square roots of sum or product of numbers, Square roots of sums of squares, Cube Roots by Vilokanam, Cube Roots by Division Method, Pythagoras' Theorem.

Recommended Books:

1. Vedic Mathematics by Swami Bharati Krishna Tirtha
2. Enjoy Vedic Mathematics by Shriram M. Chauthaiwale, Dr. R. Kolluru
3. Speed Math by Gaurav Tekriwal

4. The power of Vedic Maths by Atul Gupta
5. Advanced Vedic Mathematics by Rajesh Kumar Thakur