H. D. Jain College, Ara

(A Constituent Unit of V. K. S. U, Ara)

4 Years Bachelor of Arts B.A. (Hons.) in Mathematics under CBCS

POS (Major Courses)

S.No	UG Semester	Course	POS
1.	I	MJC-1 Algebra	i) Polar representation of complex numbers, De Moivre's theorem and its applications, Logarithms of complex quantities, Hyperbolic functions, Gregory series, Summation of series, Resolution into factors.. ii) Cartesian product of sets, Equivalence relations, partition, partial and total order relation Functions, Composition of functions, Invertible functions, Cardinality of a set, Countable and Uncountable sets, Cantor's theorem. iii) Matrices, Operation on Matrices, Kinds of matrices. Transpose, symmetric & skew symmetric Matrices, Hermitian, skew Hermitian Matrices, Adjoint and Inverse of a matrix, orthogonal matrix, Solution of a system of linear equations by matris methods. Echelon forms, Rank of a matrix. iv) Matrices, Operation on Matrices, Kinds of matrices. Transpose, symmetric & skew symmetric Matrices, Hermitian, skew Hermitian Matrices, Adjoint and Inverse of a matrix, orthogonal matrix, Solution of a system of linear equations by matris methods. Echelon forms, Rank of a matrix. V) Fundamental theorem of algebra, Relation between roots and coefficients of a polynomial equation, Symmetric Function of roots, Transformation of equation, Descartes rule of signs, Solution of Cubic equation (Cardon's method) and bi quadratic equation (Euler's method).
2.	II	MJC-2 Calculus & Geometry	i) Successive differentiation and Leibnitz's theorem, Maclaurin 's and Taylor's series of Expansion, Tangent and Normal, Partial differentiation and Euler's theorem, Total Differential, L'Hospital's rule, Curvature, Asymptotes, Curve tracing in Cartesian coordinates and polar coordinates of standard curves. ii) Integration of rational and irrational functions. Evaluation of definite integrals, Reduction formulae. Area, Length of plane curves and area bounded by plane curves. Volume and surface aren of solid of revolution, Beta and Gamma Functions, Multiple Integrals iii) Transformation of rectangular axes, General equations of conics and its reduction to the normal form, Equation of the tangent and normal at a point of the Conics iv) Sphere, Cone, Cylinder, Central conicoid, Paraboloids, Plane section of conicoid, Generating lines. Tangent plane and normal to a conicoid v) Scalar triple product and vector triple product, Product of four vectors, Introduction to vector functions, Operations with vector-valued functions, Differentiation and integration of vector functions, Gradient of a scalar and Divergence and Curl of a vector function in Cartesian coordinate
3.	III	MJC-3 Real Analysis	i) Dedekind theory of real numbers, Algebraic and order properties of R. Archimedean Property, Density Theorem, Completeness property of R,

			Bounded sets, Theorems on Suprema and Infima. ii) Neighbourhood of a point in R. Open and closed sets, Limit points and isolated points of a set, Bolzano-Weierstrass theorem for a set. Derived set, Clouser and Interior of a set. iii) Sequence and its convergence, Bounded sequence, Monotone sequences, Subsequences, Limit sequence, Limit Theorem, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's general principle of convergence iv) Infinite series and their convergence, Cauchy Criterion, Tests for convergence: Comparison test, D'Alembert Ratio Test, Cauchy's root test, Rabbe's test. Logarithmic test, D'Morgan and Bertrand's test, Cauchy integral test, Cauchy condensation test, Gauss's test, Alternating series, Leibnitz test, Absolute and Conditional convergence
4	III	MJC-4 Ordinary Differential Equations	i) Formulation of Differential equations and its order and degree, General, Particular and Singular solutions of differential equations, variables separable, Equations reducible to variables separable, Homogeneous differential equations, Equations reducible to homogeneous form, Exact differential equations and equations reducible to the exact form, Linear differential equations and equations reducible to linear form, Bernoulli equation. ii) Differential equations of first order but not of first degree, Singular soluti Clairaut's form, Orthogonal Trajectories of family of curves, Wronskian ani properties, Linear differential equation of order greater than one with cons. coefficients, Cauchy-Euler Equation, Legendre's Linear Equation. iii) Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters, Total differential equation in three variables, Simultaneous differential equations. iv) Definition of Laplace transform, Existence Theorem, Formulas and Properties of Laplace transform, Laplace transform of special functions viz: Dirac's delta, Unit step, Periodic, Bessel, Error functions, Inverse Laplace transform, Formulas and Properties of inverse Laplace transform, Convolution theorem, Solution of ordinary differential equation using Laplace transform.
5.	IV	MJC-5 Theory of Real Functions	i) Limit of functions, Sequential criterion for limits, Divergence criteria, Limit theorems, One-sided limits, Infinite limits and limits at infinity.. ii) Continuous functions, Sequential criterion for continuity Algebra of continuous functions, Properties of continuous functions on closed intervals, Uniform continuity, Uniform continuity theorem. and discontinuity iii) Differentiability of a function, Algebra of differentiable functions, Increasing and Decreasing functions, Sign of derivatives, Chain rule, Darbous's theorem, Intermediate value theorem for derivatives, Rolle's theorem, Lagrange's and Cauchy's Mean value theorem and their

			applications. iv) Taylor's theorem with Lagrange's and Cauchy's remainder forms, Maclaurin's theorem, Application of Taylor's theorem in error estimation, Extreme values, Theorems related to extrema.
6	IV	MJC-6 Group Theory	i) Definition and examples of groups, Elementary properties of groups, Subgroups and examples of subgroups, Generator of a group, Cyclic group, Properties of cyclic groups. ii) Permutations Group, Even and odd permutations, Alternating Group, Cosets and its properties, Lagrange's theorem, Fermat's Little theorem, Euler's theorem, Normal subgroups, Quotient groups, Center of a group, Normalizer of an element, Normalizer of a subgroup. iii) Automorphism, Inner automorphism, Group of Automorphisms, of finite and infinite cyclic groups, Commutator subgroup. iv) Conjugacy classes, Class equation, p-groups, Cauchy's theorem for finite abelian groups, Sylow's theorems.
7.	IV	MJC-7 Partial Differential Equations	i) Partial differential equations Basic concepts and definitions, Formation of PDEs, Classification of First order PDEs, Lagrange's and Charpit's method for solving PDEs. ii) Homogeneous and non-homogeneous Partial differential equation of second and higher order with constant coefficients, Partial differential equations reducible to equations with constant coefficients. iii) Partial differential equations of second order with variable coefficients, Monge's Methods, Classification of second order linear equations as hyperbolic, parabolic or elliptic, Reduction of second order linear equations to canonical forms. iv) Fourier series in (c, e+ 2x), Dirichlet's condition (without proof), Euler's formulae, Fourier series for even and odd functions, Fourier series of arbitrary interval (0, 21.) and (-L, L), Fourier Half range sine and cosine series, Method of Separation of variables, Solution of the Wave, Heat and Laplace equations and their applications.
8.	V	MJC-8 Ring Theory and Linear Algebra-I	i) Definition and examples of rings, Properties of rings, Definition and examples of Subrings, Zero divisors, Integral domains and its examples, Properties of integral domains, Division rings, fields, Characteristic of a ring, Ideals and its properties, Quotient rings. ii) Ring homomorphisms, Kernel of Ring homomorphisms, Properties of ring homomorphisms, Isomorphism theorems for Rings. iii) Vector spaces, Subspaces, Algebra of subspaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces, Quotient spaces. iv) Linear transformations, Null Spaces and Ranges, Matrix representation ofa linear transformation, Rank-Nullity theorem, Algebra of linear transformation, Eigenvalues and Eigenvectors, Characteristic equation of a matrix and Cayley-Hamilton theorem.

			v) Isomorphisms for vector spaces, Isomorphism theorems for vector spaces, Invertibility and Isomorphisms.
9.	V	MJC-9 Multivariate Calculus	i) Functions of several variables, Limits and continuity, Partial derivatives, Euler's theorem, Higher order partial derivatives. Total differential and differentiability. Schwarz and Young's theorem, Chain rule. ii) Directional derivatives, Gradient, Maximal and normal property of the gradient, Tangent planes and normal lines, Level curves and surfaces, Gradient and Tangents to Level curves, Extrema of functions of two variables, Critical points. Saddle points, Method of Lagrange multipliers. iii) Double integrals in Cartesian and polar co-ordinates, area and surface area, Triple integrals, Volume by triple integrals, triple integrals in cylindrical and spherical coordinates, Change of variables in double and triple integrals. iv) Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Definition of vector field, Conservative vector fields, Divergence and curl. v) Green's theorem- Tangential and Normal form, Evaluation of line integrals using Green's theorem, Surface integral, Stokes' theorem, The Gauss divergence theorem.
10.	VI	MJC-10 Complex Analysis	i) ntroduction to complex number and its geometrical interpretation, algebra of complex numbers, functions of complex variables, limit of a complex function, continuity and uniform continuity, differentiability, Analytic and regular functions, Cauchy-Riemann equation and it's applications. ii) Exponential function, logarithmic function, Branches and derivatives of logarithms, trigonometric and hyperbolic functions, derivatives of functions, Definite integrals of functions, Contours, Contour integrals with examples, Upper bounds for moduli of contour integrals. iii) Complex integration, Cauchy's theorem, Cauchy's Goursat theorem, primitives. Cauchy's integral formula, Cauchy's integral formula for the derivative of an analytic function, Morera's theorem, Poisson's integral formula for a circle. Cauchy's inequality, Liouville's Theorem and Fundamental theorem of Algebra. iv) Convergence of sequences and series, Taylor series with examples, Laurent series and its examples, Absolute and uniform convergence of power series, Uniqueness of series representations of power series. v) Linear Transformation, Jacobian of a transformation, Elementary transformations: translation, rotation, magnification, inversion, Mobius transformation (bilinear transformation), Cross ratio, preservation of cross ratio under bilinear transformation, fixed point of a bilinear transformation.
11.	VI	MJC-11 Metric Space	i) Definition and examples of metric spaces, notion of Open and closed ball, Neighborhood of a point, Open set, Interior point, Interior of a set, Limit point of a set, Derived set, Closed set, Closure of a set, Diameter of a set, Dense set, Subspaces. ii) Sequences in metric spaces, Cauchy sequences, Complete metric space,

			Cantor's intersection theorem, Baire's category theorem, Contraction mapping, Banach fixed point theorem iii) Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism iv) Connectedness, Connected subsets of R, Connectedness and continuous mappings v) Compactness, boundedness, Continuous functions on compact spaces.
12.	VI	MJC-12 Riemann Integration and Series of Functions	i) Definition and existence of Riemann Integral of bounded functions, Darboux theorem, necessary and sufficient condition for R-Integrability, Riemann integrability of continuous functions, monotonic function and function having finite number of discontinuities, Riemann integral as the limit of a sum, fundamental theorem of integral calculus, Mean value theorems. ii) Improper integrals of Type-1, Type-11 and mixed type, test for convergence of improper integral such as comparison test and p-test, Convergence of Beta and Gamma functions and their properties iii) Pointwise and uniform convergence of sequence of functions, Cauchy criterion for uniform convergence, theorems on boundedness, continuity, derivability and integrability of the limit function of a sequence of functions with uniform convergence. iv) Series of functions, Theorems on the continuity, integrability and derivability of the sum function of a uniformly convergence series of functions, Cauchy criterion for uniform convergence and Weierstrass M-Test v) Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series, Abel's Theorem, Weierstrass Approximation Theorem.
13.	VII	MJC-13 Ring Theory and Linear Algebra-II	i) Field of quotients of an integral domain, Embedding of rings, Polynomial rings, The Division algorithm and consequences, The Remainder Theorem, The Factor Theorem, Irreducible Polynomials, Reducible polynomials, Primitive Polynomial, Gauss's Lemma, Irreducibility tests, Unique factorization domains. ii) Linear Functionals, Dual spaces, dual basis, Double dual, Annihilators, Transpose of a linear transformation and its matrix in the dual basis. iii) Eigenspaces of a linear operator, Diagonalization of Linear Operators, Invariant subspaces, The minimal polynomial for a linear operator iv) Inner products and Norms, Orthonormal basis, Gram-Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality. v) The adjoint of a linear operator, Least squares approximation, Minimal solutions to systems of linear equations, Normal and Self-Adjoint Operators, Unitary and orthogonal operators
14.	VII	MJC-14 (Research Methodology in Science)	
15.	VII	MJC-15 Numerical	i) Errors: Relative, Absolute, Round off. Truncation, Finding roots of

		Methods	Transcendental and Polynomial equations: Bisection method, Secant method, Regula-Falsi method, Newton-Raphson method, Fixed point iteration method, Rate of convergence ii) Solution of system of linear algebraic equations: Partial pivoting, LU decomposition and its applications, Gaussian Elimination and Gauss Jordan methods, Gauss Jacobi method, Gauss Seidel method, SOR methods and their convergence analysis. iii) Finite differences, Interpolation, Newton's Forward and Backward interpolation, Stirling's Formula, Bessel formula, Newton's divided difference, Lagrange's Interpolation, Inverse Interpolation iv) Numerical differentiation, Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3 rule, Simpsons 3/8 rule, Gauss quadrature formula v) Solution of difference equation of the first order, General solution, Linear difference equation with constant co-efficient, Solution of ordinary differential equations one step method: Euler's and modified Euler's method, Picard's method, Runge-Kutta methods.
16.	VIII	MJC-16 Mathematical Finance	i) Interest rates, Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity, Exchange traded markets and OTC markets. ii) Derivatives-Forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage, No Arbitrage principle, Short selling, Forward price for an investment asset. iii) Types of Options, Option positions, Underlying assets, Factors affecting option prices, Bounds on option prices, Put-call parity. Early exercise, Effect of dividends. iv) Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model), Lognormal property of stock prices, Distribution of rate of return, expected return.