COURSE & PROGRAM OUTCOMES
OF
MATHEMATICS HONOURS (B.SC.)
UNDER CBCS

MATHEMATICS HONOURS COURSE OUTCOMES

❖ Semester-1:

Core Course-1 (Calculus, Geometry & Vector Analysis: Unit-1,2,3)
Paper Code (Theory): MTM-A-CC-1-1-TH
Paper Code (Tutorial): MTM-A-CC-1-1-TU

Unit-1: Calculus

Learning Outcomes: On completion of this area of the course, the student will be able to

- Understand the nature of Hyperbolic functions.
- Find higher order derivatives and apply the Leibnitz rule to solve problems related to such derivatives.
- Plot the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and compare them.
- Apply the concept and principles of differential calculus to find the curvature, concavity and points of inflection, envelopes, rectilinear asymptotes (Cartesian & parametric form only) of different curves.
- Trace standard curves in Cartesian coordinates and polar coordinates.
- Sketch parametric curves (Ex. trochoid, cycloid, epicycloids, hypocycloid).
- Apply the concept and principles of differential calculus to solve different geometric and physical problems that may arise in business, economics and life sciences.
- Solve various limit problems using L' Hospital's rule·
- Derive Reduction formulae for some complex integrations and hence Integrate functions of a much higher degree which are applicable in real life situations.
- Apply the integral calculus to find arc length of a curve, arc length of parametric curves, area under a curve, surface area and volume of surface of revolution.
- Graphically obtain the surface of revolution of curves.

Unit–2: Geometry

Learning Outcomes: On completion of this area of the course, the student will be able to

- Transform the co-ordinate system especially by Rotation of axes, thus reducing different second-degree equations to their corresponding simplest forms and also classify the conics using the discriminant.
- Become familiar with the polar equations of conics & their tangents and normals
- Understand the geometrical terminology and have a detailed clear-cut idea of the Planes, Straight lines in 3D, Spheres, Cylindrical surfaces, Central conicoids, Paraboloids, Plane sections of conicoids along with the Tangent and normals of the conicoids.
- Have an idea of classification of quadrics.
- Develop an idea of the generating lines.
- Be familiar with the illustrations of graphing standard quadric surfaces like cones, paraboloids, hyperboloids and ellipsoids.
- Visualize and graphically demonstrate geometric figures and classify different geometric solids using teaching aid - preferably free softwares :
    - ✓ Tracing of conics in cartesian coordinates/ polar coordinates.
    - ✓ Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using cartesian coordinates.
- Understand the basic applications of the analytical plane and solid geometry.

Unit–3: Vector Analysis

Learning Outcomes: On completion of this area of the course, the student will be able to

- Find the Triple product of Products and their Applications
- Deduce the Vector equations subject to different conditions.
- Understand the applications of vector algebra (particularly, vector products) to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces.
- Learn operations with vector-valued functions.
- Find the limits and verify continuity of vector functions.
- Differentiate and integrate vector functions of one variable.

Core Course-2 (ALGEBRA: Unit-1, 2 & 3)

Paper Code(Theory): MTM-A-CC-1-2-TH
Paper Code (Tutorial):MTM-A-CC-1-2TU

Learning Outcomes: On completion of this course, the student will have a clear-cut understanding of some important concepts of Classical Algebra, Abstract Algebra & Linear Algebra as follows:

Unit–1

- Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of the complex variable.
- Theory of equations: Relation between roots and coefficients, transformation of the equation, Descartes rule of signs, Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
- Inequality: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.
- Linear difference equations with constant coefficients (up to 2nd order).

Unit–2

- Relation: equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
- Mapping: injective, surjective, one to one correspondence, invertible mapping, composition of mappings, relation between the composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f: X \to Y$ and $B \subseteq Y$.
- Well-ordering property of positive integers, Principles of Mathematical induction, division algorithm, di-visibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as φ, τ, σ and their properties.

Unit–3

- Rank of a matrix, inverse of a matrix, characterizations of invertible matrices.
- Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $AX = B$, solution sets of linear systems, applications of linear systems.

❖ Semester 2:

Core Course-3 (Real Analysis: Unit-1,2,3)

Paper Code (Theory): MTM-A-CC-2-3-TH
Paper Code (Tutorial): MTM-A-CC-2-3-TU

Learning Outcomes:

After completion of this course, the students will be able to think about the basic proof techniques and fundamental definitions related to the real number system. They can demonstrate some of the fundamental theorems of analysis. The students will gradually develop Analysis skills in sets, sequences and infinite series of Real Numbers covered by the three respective units as follows:

Unit-1

- Intuitive idea of real numbers. Mathematical operations and usual order of real numbers revisited with their properties (closure, commutative, associative, identity, inverse, distributive). Idea of countable sets, un-countable sets and uncountability of R. Concept of bounded and unbounded sets in R. L.U.B. (supremum), G.L.B. (infimum) of a set and their properties. L.U.B. axiom or order completeness axiom. Archimedean property of R. Density of rational (and Irrational) numbers in R.
- Intervals. Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Bolzano-Weirstrass theorem for sets. Existence of limit point of every uncountable set as a consequence of Bolzano-Weirstrass theorem. Derived set. Closed set. Complement of open set and closed set. Union and intersection of closed sets as a consequence. No nonempty proper subset of R is both open and closed. Dense set in R as a set having non-empty intersection with every open interval.

Unit-2

- Real sequence. Bounded sequence. Convergence and non-convergence. Examples. Boundedness of convergent sequence. Uniqueness of limit. Algebra of limits.
- Relation between the limit point of a set and the limit of a convergent sequence of distinct elements. Monotone sequences and their convergence. Sandwich rule. Nested interval theorem. Limit of some important sequences. Cauchy's first and second limit theorems.
- Subsequence, Subsequential limits. A bounded sequence $\{x_n\}$ is convergent if and only if $\lim\sup x_n = \lim\inf x_n$. Every sequence has a monotone subsequence. Bolzano-Weirstrass theorem for sequence. Cauchy's convergence criterion. Cauchy sequence.

Unit-3

Infinite series, convergence and non-convergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's n-th root test, Kummer's test and Gauss test (statements only). Alternating series, Leibniz test. Absolute and conditional convergence.

Graphical Demonstration (Teaching Aid-Preferably by computer softwares)
The students will gain hands on expertise in graphical demonstration of the following, using computer software or otherwise:

- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.
- Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
- Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
- Cauchy's root test by plotting n-th roots.
- Ratio test by plotting the ratio of n-th and $(n + 1)$-th term.

Core Course-4 (Group Theory-I: Unit-1,2,3)

Paper Code (Theory): MTM-A-CC-2-4-TH
Paper Code (Tutorial): MTM-A-CC-2-4-TU

Learning Outcomes: On the completion of this course, the students will understand the basic concepts of Group Theory in Abstract/Modern Algebra covered by the following three units:

Unit-1
Symmetries of a square, definition of group, examples of groups including permutation groups, dihedral groups and quaternion groups (through matrices), elementary properties of groups, examples of commutative and non-commutative groups. Subgroups and examples of subgroups, necessary and sufficient condition for a nonempty subset of a group to be a subgroup. Normalizer, centralizer, center of a group, product of two subgroups.

Unit-2
Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, order of an element, order of a group. Lagrange's theorem and consequences including Fermat's Little theorem.

Unit-3
Normal subgroup and its properties. Quotient group. Group homomorphisms, properties of homomorphisms, correspondence theorem and one-one correspondence between the set of all normal subgroups of a group and the set of all congruences on that group, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

❖ Semester 3:

Core Course-5 (Theory of Real Functions: Unit-1,2)

Paper Code (Theory): MTM-A-CC-3-5-TH
Paper Code (Tutorial): MTM-A-CC-3-5-TU

Learning Outcomes: After completion of this course, the students will be able to understand the concept of real-valued functions, limit, continuity, and differentiability in detail. They can find expansions of real functions in series forms. The students will become conversant with many of the important theorems of Differential Calculus after the completion of this Core Course which has been covered in the following two units:

Unit−1: Limit & Continuity of functions

- Limits of functions, sequential criterion for limits. Algebra of limits for functions, effect of limit on inequality involving functions, one sided limit. Infinite limits and limits at infinity. Some Important examples of limits.
- Continuity of a function on an interval and at an isolated point. Sequential criteria for continuity. Concept of oscillation of a function at a point. A function is continuous at x if and only if its oscillation at x is zero. Familiarity with the figures of some well-known functions: $y = x^a$ (a = 2, 3, −1, -2), $|x|$, sin x, cos x, tan x, log x, e^x. Algebra of continuous functions as a consequence of algebra of limits. Continuity of composite functions. Examples of continuous functions. Continuity of a function at a point does not necessarily imply the continuity in some neighbourhood of that point.
- Bounded functions. Neighbourhood properties of continuous functions regarding boundedness and maintenance of the same sign. Continuous function on $[a, b]$ is bounded and attains its bounds. Intermediate value theorem.
- Discontinuity of functions, type of discontinuity. Step functions. Piecewise continuity. Monotone functions. Monotone functions can have only jump discontinuity. Monotone functions can have at most countably many points of discontinuity. Monotone bijective function from an interval to an interval is continuous and its inverse is also continuous.
- Uniform continuity. Functions continuous on a closed and bounded interval is uniformly continuous. A necessary and sufficient condition under which a continuous function on a bounded open interval will be uniformly continuous. A sufficient condition under which a continuous function on an unbounded open interval will be uniformly continuous (statement only). Lipschitz condition and uniform continuity.

Unit-2: Di□erentiability of functions

- Differentiability of a function at a point and in an interval, algebra of differentiable functions. Meaning of sign of derivative. Chain rule.
- Darboux theorem, Rolle's theorem, Mean value theorems of Lagrange and Cauchy — as an application of Rolle's theorem. Taylor's theorem on closed

and bounded interval with Lagrange's and Cauchy's form of remainder deduced from Lagrange's and Cauchy's mean value theorem respectively. Expansion of e^x, log $(1 + x)$, $(1 + x)^m$, sin x, cos x with their range of validity (assuming relevant theorems). Application of Taylor's theorem to inequalities.

- Statement of L' Hospital's rule and its consequences. Point of local extremum (maximum, minimum) of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Determination of local extremum using first order derivative. Application of the principle of maximum/minimum in geometrical problems.

Core Course-6: Ring Theory & Linear Algebra-I

Paper Code (Theory): MTM-A-CC-3-6-TH

Paper Code (Tutorial): MTM-A-CC-3-6-TU

Learning Outcomes:

After completion of this course, the students will mainly be able to

- Develop a concept on Ring Theory of Abstract Algebra in details.
- Understand vector spaces over a field and subspaces and apply their properties.
- Understand linear independence and dependence.
- Find the basis and dimension of a vector space, and understand the change of basis.
- Compute linear transformations, kernel and range, and inverse linear transformations, and find matrices of general linear transformations.
- Find eigenvalues and eigenvectors of a matrix and of linear transformation.
- The Cayley-Hamilton Theorem and its use in finding the inverse of a matrix
- Understand various concepts of Abstract & Linear Algebra covered in details by the following units:

Unit-1: Ring theory

Definition and examples of rings, properties of rings, subrings, necessary and sufficient condition for a nonempty subset of a ring to be a subring, integral domains and fields, subfield, necessary and sufficient condition for a nonempty subset of a field to be a subfield, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms. First isomorphism theorem, second isomorphism theorem, third iso-morphism theorem, Correspondence theorem, congruence on rings, one-one correspondence between the set of ideals and the set of all congruences on a ring.

Unit-2: Linear algebra-I

- Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Subspaces of R^n, dimension of subspaces of R^n. Geometric significance of subspace.
- Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, change of coordinate matrix. Algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms. Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Core Course-7: Ordinary Differential Equation & Multivariate Calculus-I

Paper Code (Theory): MTM-A-CC-3-7-TH
Paper Code (Tutorial): MTM-A-CC-3-7-TU

Unit-1: Ordinary di□erential equation

Learning Outcomes:

On completion of this course, the student will be able to identify the type of a given differential equation and select and apply the appropriate analytical technique for finding the solution. The students will be well conversant with the following types of differential equations:

- First order differential equations: Exact differential equations and integrating factors, special integrating factors and transformations, linear equations and Bernoulli equations, the existence and uniqueness theorem of Picard (Statement only).
- Linear equations and equations reducible to linear form. First order higher degree equations solvable for *x, y* and *p*. Clairaut's equations and singular solution.
- Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.
- Linear differential equations of second order, Wronskian: its properties and applications, Euler equation, method of undetermined coefficients, method of variation of parameters.
- System of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.
- Planar linear autonomous systems: Equilibrium (critical) points, Interpretation of the phase plane and phase portraits.
- Power series solution of a differential equation about an ordinary point, solution about a regular singular point (up to second order).

Unit-2: Multivariate Calculus-I

Learning Outcomes:

On completion of this course, the student will be able to

- Understand the concept of neighbourhood of a point in R^n ($n > 1$), interior point, limit point, open set and closed set in R^n ($n > 1$).
- Identify functions from $R^n (n > 1)$ to $R^m (m \geq 1)$
- Develop concepts on limit and continuity of functions of two or more variables, their partial derivatives, total derivative and differentiability,

along with the sufficient condition for differentiability, Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.

- Find Extrema of functions of two variables & understand the use of the method of Lagrange multipliers & solve constrained optimization problems.

❖ Semester 4:

Core Course-8 (Riemann Integration & Series of Function: Unit-1,2,3)

Paper Code (Theory): MTM-A-CC-4-8-TH
Paper Code (Tutorial): MTM-A-CC-4-8-TU

Unit-1: Riemann integration

Learning Outcomes:

On completion of this unit of the course, the student will be able to

- Understand Partition and refinement of partition of a closed and bounded interval.
- Conceptualise Upper Darboux sum $U(P, f)$ and lower Darboux sum $L(P, f)$ and associated results. Upper integral and lower integral.
- Understand Darboux's theorem along with Darboux's definition of integration over a closed and bounded interval.
- Learn Riemann's definition of integrability and its Equivalence with Darboux definition of integrability along with the Necessary and sufficient condition for Riemann integrability.
- Conceptualize negligible set (or zero set) defined as a set covered by countable number of open intervals sum of whose lengths is arbitrary small, Examples of negligible sets: any subset of a negligible set, finite set, countable union of negligible sets.
- Learn that a bounded function on a closed and bounded interval is Riemann integrable if and only if the set of points of discontinuity is negligible.
- Develop the capacity to integrate, while understanding the examples of Riemann integrable functions.
- Develop the concept of Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions & properties of Riemann integrable functions arising from the above results.
- Have an idea of the functions defined by definite integral and its properties, Antiderivative (primitive or indefinite integral) and also the properties of Logarithmic function defined as the definite integral.
- Understand the Fundamental theorem of Integral Calculus & First Mean Value theorem of integral calculus.

Unit-2: Improper integral

Learning Outcomes:

On completion of this unit of the course, the student will be able to

- Understand well the Range of integration-finite or infinite and learn the Necessary and sufficient condition for convergence of improper integral in both cases.

- Learn the Tests of convergence: Comparison and M-test, Absolute and non-absolute convergence and inter-relations.
- Understand the Statement of Abel's and Dirichlet's test for convergence on the integral of a product.
- Develop an idea of convergence and working knowledge of Beta and Gamma and their interrelation.
- Compute different integrals when they exist (using Beta and Gamma function).

Unit-3: Series of functions

Learning Outcomes:

On completion of this unit of the course, the student will be able to develop a clear-cut idea on sequence and series of functions defined on a set after covering the following:

- Sequence of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weirstrass' M-test. Boundedness, continuity, integrability and differentiability of the limit function of a sequence of functions in case of uniform convergence.
- Series of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weierstrass' M-test. Passage to the limit term by term. Boundedness, continuity, integrability, differentiability of a series of functions in case of uniform convergence.
- Power series: Fundamental theorem of power series. Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Properties of sum function. Differentiation and integration of power series. Abel's limit theorems. Uniqueness of power series having sum function.
- Fourier series: Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier coefficients for periodic functions defined on $[-\pi, \pi]$. Statement of Dirichlet's condition of convergence. Statement of theorem of sum of Fourier series.

Core Course-9 (**Partial differential equation & Multivariate Calculus-II**)

Paper Code(Theory): MTM-A-CC-4-9-TH
Paper Code (Tutorial):MTM-A-CC-4-9-TU

Unit-1: Partial di□erential equation

Learning Outcomes:

On completion of this unit of the course, the student will be able to understand, derive and solve different types of partial differential equations which may arise in real life problems:

- Partial differential equations of the first order, Lagrange's solution, non- linear first order partial differential equations, Charpit's general method of solution, some special types of equations which can be solved easily by methods other than the general method.

- Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.
- The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of finite and infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem.

Unit–2: Multivariate Calculus–II

Learning Outcomes:

After completion of this unit of the course which covers the following topics on multiple integrals, line integrals etc., the student will be able to apply these concepts to solve many real-life problems that may arise in different fields:

- Multiple integral: Concept of upper sum, lower sum, upper integral, lower-integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions. Iterated or repeated integral, change of order of integration. Triple integral. Cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Transformation of double and triple inte-grals (problems only). Determination of volume and surface area by multiple integrals (problems only). Differentiation under the integral sign, Leibniz's rule (problems only).
- Definition of vector field, divergence and curl. Line integrals, applications of line integral: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.
- Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

Core Course-10 (Mechanics)

Paper Code (Theory): MTM-A-CC-4-10-TH
Paper Code (Tutorial): MTM-A-CC-4-10-TU

Learning Outcomes: After completion of this course, the students will be able to learn and explain different concepts on Mechanics including Statics covered by the following units:

Unit-1

- Coplanar forces in general: Resultant force and resultant couple, Special cases, Varignon's theorem, Necessary and sufficient conditions of equilibrium. Equilibrium equations of the first, second and third kind.
- An arbitrary force system in space: Moment of a force about an axis, Varignon's theorem. Resultant force and resultant couple, necessary and sufficient conditions of equilibrium. Equilibrium equations, Reduction to a wrench, Poinsot's central axis, intensity and pitch of a wrench, Invariants of a system of forces. Statically determinate and indeterminate problems.
- Equilibrium in the presence of sliding Friction force: Contact force between bodies, Coulomb's laws of static Friction and dynamic friction. The angle and cone of friction, the equilibrium region.

Unit-2

- Virtual work: Workless constraints - examples, virtual displacements and virtual work. The principle of virtual work, Deductions of the necessary and sufficient conditions of equilibrium of an arbitrary force system in plane and space, acting on a rigid body.
- Stability of equilibrium: Conservative force field, energy test of stability, condition of stability of a perfectly rough heavy body lying on a fixed body. Rocking stones.

Unit-3

- Kinematics of a particle: velocity, acceleration, angular velocity, linear and angular momentum. Relative velocity and acceleration. Expressions for velocity and acceleration in case of rectilinear motion and planar motion - in Cartesian and polar coordinates, tangential and normal components. Uniform circular motion.
- Newton laws of motion and law of gravitation: Space, time, mass, force, inertial reference frame, principle of equivalence and g. Vector equation of motion.

Work, power, kinetic energy, conservative forces - potential energy. Existence of potential energy function. Energy conservation in a conservative field. Stable equilibrium and small oscillations: Approximate equation of motion for small oscillation. Impulsive forces

Unit-4

- Problems in particle dynamics: Rectilinear motion in a given force field - vertical motion under uniform gravity, inverse square field, constrained rectilinear motion, vertical motion under gravity in a resisting medium, simple harmonic motion, Damped and forced oscillations, resonance of an oscillating system, motion of elastic strings and springs.
- Planar motion of a particle: Motion of a projectile in a resisting medium under gravity, orbits in a central force field, Stability of nearly circular orbits. Motion under the attractive inverse square law, Kepler's laws of planetary motion. Slightly disturbed orbits, motion of artificial satellites. Constrained motion of a particle on smooth and rough curves. Equations of motion referred to a set of rotating axes.
- Motion of a particle in three dimensions: Motion on a smooth sphere, cone, and on any surface of revolution.

Unit-5 (Many particles system)

- The linear momentum principle: Linear momentum, linear momentum principle, motion of the centre of mass, conservation of linear momentum.
- The angular momentum principle: Moment of a force about a point, about an axis. Angular momentum about a point, about an axis. Angular momentum principle about centre of mass. Conservation of angular momentum (about a point and an axis). Impulsive forces.
- The energy principle: Configurations and degrees of freedom of a multi-particle system, energy principle, energy conservation.
- Rocket motion in free space and under gravity, collision of elastic bodies. The two-body problem.

Semester 5:

Core Course-11 (Probability & Statistics)

Paper Code (Theory): MTM-A-CC-5-11-TH

Paper Code (Tutorial): MTM-A-CC-5-11-TU

Learning Outcomes: After completion of this course, the students will be able to understand & apply the concepts of probability & statistics covered in the following Units:

Unit-1

- Random experiment, σ-field, Sample space, probability as a set function, probability axioms, probability space. Finite sample spaces. Conditional probability, Bayes theorem, independence. Real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function. Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, Continuous distributions: uniform, normal, exponential.

Unit-2

- Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, moments, covariance, correlation coefficient, independent random variables, joint moment generating function (jmgf) and calculation of covariance from jmgf, characteristic function. Conditional expectations, linear regression for two variables, regression curves. Bivariate normal distribution.

Unit-3

- Markov and Chebyshev's inequality, Convergence in Probability, statement and interpretation of weak law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance.

Unit-4

• Sampling and Sampling Distributions: Populations and Samples, Random Sample, distribution of the sample, Simple random sampling with and without replacement. Sample characteristics. Sampling Distributions: Statistic, Sample moments. Sample variance, Sampling from the normal distributions, Chi-square, t and F -distributions and some other sampling distributions

Estimation of parameters: Point estimation. Interval Estimation-Confidence Intervals for mean and variance of Normal Population. Mean-squared error. Properties of good estimators - unbiasedness, consistency, sufficiency, Minimum-Variance Unbiased Estimator (MVUE).

- Method of Maximum likelihood: likelihood function, ML estimators for discrete and continuous models.

Unit-5

- Statistical hypothesis: Simple and composite hypotheses, null hypotheses, alternative hypotheses, one-sided and two-sided hypotheses. The critical region and test statistic, type I error and type II error, level of significance. Power function of a test, most powerful test. The *p*-value (observed level of significance), Calculating *p*-values.
- Simple hypothesis versus simple alternative: Neyman-Pearson lemma (Statement only).
- Bivariate frequency Distribution: Bivariate data, Scatter diagram, Correlation, Linear Regression, principle of least squares and fitting of polynomials and exponential curves.

Graphical Demonstration (Teaching Aid Preferably by free softwares (e.g. R/ Python / SageMath etc.) but can be taught through black board/white board / square sheet etc. in case of unavailability.)

- Graphical representation of data - how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), frequency polygon, pie chart, gives graphical summaries of data.
- Measures of central tendency and measures of dispersion, moments, skewness and kurtosis.
- Karl Pearson correlation coefficient.
- Correlation coefficient for a bivariate frequency distribution.
- Lines of regression, angle between lines and estimated values of variables.
- Fitting of polynomials, exponential curves by method of least squares.
- Confidence interval for the parameters of a normal distribution (one sample and two sample problems).

Core Course-12 (Group Theory-II & Linear Algebra-II)

Paper Code(Theory): MTM-A-CC-5-12-TH
Paper Code (Tutorial):MTM-A-CC-5-12-TU

Learning Outcomes: After completion of this course, the students will be able to demonstrate the mathematical maturity of understanding the advance aspects of Group Theory and Linear Algebra

Unit-1: Group theory

- Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.
- External direct product and its properties, the group of units modulo *n* as an external direct product, internal direct product, converse of

Lagrange's theorem for finite abelian group, Cauchy's theorem for finite abelian group, Fundamental theorem of finite abelian groups.

Unit-2: Linear algebra

- Inner product spaces and norms, Gram-Schmidt orthonormalization process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator and its basic properties.
- Bilinear and quadratic forms, Diagonalization of symmetric matrices, Second derivative test for critical point of a function of several variables, Hessian matrix, Sylvester's law of inertia. Index, signature.
- Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigenspaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms (Jordan & rational).

❖ Semester 6:

Core Course-13 (Metric Space & Complex Analysis)

Paper Code (Theory): MTM-A-CC-6-13-TH
Paper Code (Tutorial): MTM-A-CC-6-13-TU

Unit-1: Metric space

Learning Outcomes: On successful completion of the course students will be able to develop conceptual understanding of the following:

- Definition and examples of metric spaces. Open ball. Open set. Closed set as complement of open set. Interior point and interior of a set. Limit point and closure of a set. Boundary point and boundary of a set. Properties of interior, closure and boundary. Bounded set and diameter of a set. Distance between two sets. Subspace of a metric space.
- Convergent sequence. Cauchy sequence. Every convergent sequence is Cauchy and bounded, but the converse is not true. Completeness. Cantor's intersection theorem. R is a complete metric space. Q is not complete.
- Continuous mappings, sequential criterion of continuity. Uniform continuity.
- Compactness, Sequential compactness, Heine-Borel theorem in R. Finite intersection property, continuous functions on compact sets.
- Concept of connectedness and some examples of connected metric space, connected subsets of R, C.
- Contraction mappings, Banach Fixed point Theorem and its application

to ordinary differential equations.

Unit-2: Complex analysis

Learning Outcomes: After completion of this course, the students will be able to demonstrate understanding of the basic concepts and fundamental definitions underlying complex analysis. They can prove and explain concepts of series and integration of complex functions and clearly understand problem-solving using complex analysis techniques after covering the following topics:

- Stereographic projection. Regions in the complex plane. Limits, limits involving the point at infinity. Continuity of functions of complex variables.
- Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, exponential function, logarithmic function, trigonometric functions, hyperbolic functions. M¨obius transformation.
- Power series: Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Analytic functions represented by power series. Uniqueness of power series.
- Contours, complex integration along a contour and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem (statement only) and its consequences, Cauchy integral formula.

Core Course-14 (Numerical Methods)

Paper Code (Theory): MTM-A-CC-6-14-TH

Learning Outcomes: After completion of this course, the students will be able to: • Apply numerical methods to obtain approximate solutions to mathematical problems. • Solve the nonlinear equations, system of linear equations and interpolation problems using numerical methods. • Examine the appropriate numerical differentiation and integration methods to solve problems. • Apply the numerical methods to solve algebraic as well as differential equations. The course will be covered in the following units:

Unit–1

- Representation of real numbers, Machine Numbers - floating point and fixed point. Sources of Errors, Rounding of numbers, significant digits and Error Propagation in machine arithmetic operations. Numerical Algorithms - stability and convergence.

Unit–2

- Approximation: Classes of approximating functions, Types of approximations- polynomial approximation, The Weierstrass polynomial approximation theorem (statement only).
- Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Newton (Gregory) forward and backward difference interpolation.
- Central Interpolation: Stirling's and Bessel's formulas. Different interpolation zones, Error estimation. Hermite interpolation.

Unit–3

- Numerical differentiation: Methods based on interpolations; methods based on finite differences.
- Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3-rd rule, Simpson's 3/8-th rule, Weddle's rule, Boole's Rule, midpoint rule. Composite trapezoidal rule, composite Simpson's 1/3-rd rule, composite Weddle's rule. Gaussian quadrature formula.

Unit–4

- Transcendental and polynomial equations: Bisection method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Condition of convergence (if any), Order of convergence, Rate of convergence of these methods. Modified Newton-Raphson method for multiple roots, Complex roots of an algebraic equation by Newton-Raphson method. Numerical solution of a system of nonlinear equations - Newton's method.

Unit-5

System of linear algebraic equations:

- Direct methods: Gaussian elimination and Gauss Jordan methods, Pivoting strategies.
- Iterative methods: Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition method (Crout's LU decomposition method).
- Matrix inversion: Gaussian elimination and LU decomposition method (Crout's LU decomposition method) (operational counts).
- The algebraic eigen value problem: Power method.

Unit-6

- Ordinary differential equations: Single-step difference equation methods- error, convergence. The method of successive approximations (Picard), Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Core Course-14 Practical (Numerical Methods Lab)

Paper Code (Practical): MTM-A-CC-6-14-P

Learning Outcomes: For any of the CAS (Computer aided software), students are introduced to Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays. The students become expert in solving different numerical problems (listed below) by using computer programming techniques *of C/ C++/ FORTRAN 90*

- Calculate the sum 1+½+1/3+---------+1/N
- Enter 100 integers into an array and sort them in an ascending order.
- Solution of transcendental and algebraic equations by

i) Bisection method

ii) Newton Raphson method (Simple root, multiple roots, complex roots).

iii) Secant method.
iv) Regula Falsi method.

- Solution of system of linear equations

i) LU decomposition method
ii) Gaussian elimination method
iii) Gauss-Jacobi method
iv) Gauss-Seidel method

- Interpolation

i) Lagrange Interpolation
i) Newton's forward, backward and divided difference interpolations

- Numerical Integration

i) Trapezoidal Rule
ii) Simpson's one third rule
iii) Weddle's Rule
iv) Gauss Quadrature

- Method of finding Eigenvalue by Power method (up to 4×4)
- Fitting a Polynomial Function (up to third degree)
- Solution of ordinary differential equations

i) Euler method
ii) Modified Euler method
iii) Runge Kutta method (order 4)
iv) The method of successive approximations (Picard)

Skill Enhancement Courses (Semester-3 & 4)

Learning Outcomes:

After the completion of these courses the students will acquire skills in thinking more logically in Mathematics, as well as they will understand the importance of C programming or object-oriented programming C++, both of which are very good programming tools for solving many real-life problems. The students can also acquire the skill of scientific computing using the software SageMath / R. The students will be introduced to the fundamental commands and structure of SageMath/R. The

Course Outcomes of Mathematics Generic Elective

B.A. & B.Sc under CBCS

[For students having Honours in subjects other than Mathematics]

❖ First Semester:

Core Course-1 / Generic Elective-1 (Unit-1,2,3,4)

Paper Code (Theoretical) : MTM-G-CC-1-1-TH /MTM-G-GE-1-1-TH
Paper Code (Tutorial): MTM-G-CC-1-1-TU /MTM-G-GE-1-1-TU

Unit-1 : Algebra-I

Learning Outcomes: On completion of this course, the student will hav understanding of some important concepts of Classical Algebra & Linea follows:

- Complex Numbers : De Moivre's Theorem and its applications. Sine, Cosine and Logarithm of a complex number. Definition of Inverse circular and Hyperbolic functions.
- Polynomials : Fundamental Theorem of Algebra (Statement only). with real coe□cients, the *n*-th degree polynomial equation has exa Nature of roots of an equation (surd or complex roots occur in pairs of Descarte's rule of signs and its applications.
- Statements of : (i) If a polynomial $f(x)$ has opposite signs for two r and b of x, the equation $f(x) = 0$ has an odd number of real roots be b. If $f(a)$ and $f(b)$ are of the same sign, either no real root or an eve roots lies between a and b.
  (ii) Rolle's Theorem and its direct applications.
- Relation between roots and coe□cients, symmetric func-tion transformations of equations. Cardan's method of solution of a cubic
- Rank of a matrix : Determination of rank either by considering minors out process. Consistency and solution of a system of linear equations v than 3 variables by matrix method.

Unit-2 : Differential Calculus-I

Learning Outcomes: On completion of this area of the course, the student will be able to develop a clear concept of the following:

- Rational numbers, Geometrical representations, Irrational number, Real number represented as point on a line — Linear Continuum. Acquaintance with basic properties of real number (No deduction or proof is included).
- Real-valued functions defined on an interval, limit of a function (Cauchy's definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance (on proof) with the important properties of continuous functions no closed intervals. Statement of existence of inverse function of a strictly monotone function and its continuity.
- Derivative-its geometrical and physical interpretation. Sign of derivative-Monotonic increasing and decreasing functions. Relation between continuity and derivability. Differential - application in finding approximation.
- Successive derivative - Leibnitz's theorem and its application.
- Functions of two and three variables : their geometrical representations. Limit and Continuity (definitions only) for function of two variables. Partial derivatives. Knowledge and use of chain Rule. Exact differentials (emphasis on solving problems only). Functions of two variables - Successive partial Derivatives : Statement of Schwarz's Theorem on Commutative property of mixed derivatives. Euler's Theorem on homogeneous function of two and three variables.
- Applications of Differential Calculus : Curvature of plane curves. Rectilinear Asymptotes (Cartesian only). Envelope of a family of straight lines and of curves (problems only). Definitions and examples of singular points (Viz. Node, Cusp, Isolated point).

Unit-3 : Differential Equation-I

problems:

- Order, degree and solution of an ordinary differential equation (ODE) in presence of arbitrary constants, Formation of ODE.
- First order equations : (i) Exact equations and those reducible to such equation. (ii) Euler's and Bernoulli's

  equations (Linear). (iii) Clairaut's Equations : General and Singular solutions.
- Second order linear equations : Second order linear differential equation with constant coefficients. Euler's Homogeneous equations.
- Second order differential equation : (i) Method of variation of parameters, (ii)

Method of undetermined coe□cients.

Unit-4 : Coordinate Geometry

Learning Outcomes: After completion of this part of the course, the students will be able to understand the basic applications of coordinate geometry.

- Transformations of Rectangular axes : Translation, Rotation and their combinations. Invariants.

- General equation of second degree in x and y : Reduction to canonical forms. Classification of conic.

- Pair of straight lines : Condition that the general equation of 2nd degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.
- Equations of pair of tangents from an external point, chord of contact, poles and polars in case of General conic : Particular cases for Parabola, Ellipse, Circle, Hyperbola.
- Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.
- Sphere and its tangent plane. Right circular cone.

❖ Second Semester

<u>Core Course-2 / Generic Elective-2 (Unit-1,2,3,4)</u>

Paper Code (Theoretical) : MTM-G-CC-2-2-TH /MTM-G-GE-2-2-TH

Paper Code (Tutorial):MTM-G-CC-2-2-TU /MTM-G-GE-2-2-TU

Unit-1 : Di□erential Calculus-II

Learning Outcomes: On completion of the course, the student will be able to apply the concept and principles of differential calculus to solve geometric and physical problems.

- Sequence of real numbers : Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems. Concept of convergence and divergence of monotone sequences-applications of the theorems, in particular, definition of e. Statement of

Cauchy's general principle of convergence and its application.

- Infinite series of constant terms; Convergence and Divergence (definitions). Cauchy's principle as applied to infinite series (application only). Series of positive terms: Statements of comparison test. D.Alembert's Ratio test. Cauchy's nth root test and Raabe's test Applications. Alternating series. Statement of Leibnitz test and its applications.
- Real-Valued functions defined on an interval: Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's Theorems with Lagrange's and Cauchy's from of remainders. Taylor's and Maclaurin's Infinite series of functions like e^x, sin x, cos x, $(1 + x)^n$, $\log(1 + x)$ with restrictions wherever necessary.
- Indeterminate Forms : L'Hospital's Rule : Statement and Problems only.
- Application of the principle of Maxima and Minima for a function of a single variable in geometrical, physical and to other problems.
- Maxima and minima of functions of not more than three variables Lagrange's Method of undetermined multiplier - Problems only.

Unit-2 : Di erential Equation-II

Learning Outcomes: On completion of this course, the student will be able to identify the type of a given ordinary as well as partial differential equation and select and apply the appropriate analytical technique for finding the solution.

- Linear homogeneous equations with constant coe cients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous di erential equations, Simple eigen-value problem.
- Order and degree of partial di erential equations, Concept of linear and non-linear partial di erential equations, Formation of first order partial di erential equations, Linear partial di erential equation of first order, Lagrange's method, Charpit's method.

Unit-3: Vector Algebra

Learning Outcomes: On completion of this course, students will be able to manipulate vectors to perform geometrical calculations in three dimensions as well as calculations that may arise in solving mechanical problems.

- Addition of Vectors, Multiplication of a Vector by a Scalar. Collinear and Coplanar Vectors. Scalar and Vector products of two and three vectors. Simple applications to problems of Geometry. Vector equation of plane and straight line. Volume of Tetrahedron. Applications to problems of Mechanics (Work done and Moment).

Unit-4 : Discrete Mathematics

Learning Outcomes: On successful completion of the course students will be able to develop conceptual understanding of

- Integers : Principle of Mathematical Induction. Division algorithm. Representation of integers in an arbitrary base. Prime Integers. Some properties of prime integers. Fundamental theorem of Arithmetic. Euclid's Theorem. Linear Diophantine equations. Statement of Principle of Mathematical Induction, Strong form of Mathematical induction. Applications in different problems. Proofs of division algorithm. Representation of an integer uniquely in an arbitrary base, change of an integer from one base to another base. Computer operations with integers, Divisor of an integer, g.c.d. of two positive integers, prime integer, Proof of Fundamental theorem, Proof of Euclid's Theorem. To show how to find all prime numbers less than or equal to a given positive integer. Problems related to prime number. Linear Diophantine equation & some applications.
- Congruences : Congruence relation on integers, Basic properties of this relation. Linear congruences,Chinese Remainder Theorem. System of Linear congruences. Definition of Congruence , to show it is an equivalence relation, to prove some of its properties.
  Linear Congruence, to show how to solve these congruences, Chinese remainder theorem Statement and proof and some applications. System of linear congruences, when solution exists with some applications.
- Application of Congruences : Divisibility tests. Check-digit and an ISBN, in Universal product Code, in major credit cards. Error detecting capability. Using Congruence, develop divisibility tests for integers based on their expansions with respect to different bases, Show that congruence can be used to schedule Round-Robin tournaments. Check digits for different identification numbers such as International standard book number, universal product code etc. Theorem regarding error detecting capability.
- Congruence Classes : Congruence classes, addition and multiplication of congruence classes. Fermat's little theorem. Euler's theorem. Wilson's theorem. Some simple applications. Definition of Congruence Classes,properties of Congruence classes, addition and multiplication,

existence of inverse. Fermat's little theorem.Euler's theorem. Wilson's theorem - Statement, proof and some applications.

- Boolean algebra : Boolean Algebra, Boolean functions, Logic gates, Minimization of circuits.

❖ Third Semester:

Core Course-3 / Generic Elective-3 (Unit-1,2,3)

Paper Code (Theoretical) : MTM-G-CC-3-3-TH/MTM-G-GE-3-3-TH
Paper Code (Tutorial):MTM-G-CC-3-3-TU /MTM-G-GE-3-3-TU

Unit-1 : Integral Calculus

Learning Outcomes: On completion of the following topics of the course in this unit, the student will be able to apply the concept and various principles of integral calculus to integrate the functions which are applicable in real life situations:

- Evaluation of definite integrals.
- Integration as the limit of a sum (with equally spaced as well as unequal intervals).
- Reduction formulae for integrals.
- Definition of Improper Integrals : Statements of (i) μ-test (ii) Comparison test - Simple problems only. Use of Beta and Gamma functions (convergence and important relations being assumed).
- Working knowledge of double integral.
- Applications : Rectification, Quadrature, volume and surface areas of solids formed by revolution of plane curve and areas problems only.

Unit-2 : Numerical Methods

Learning Outcomes: After completion of this unit of the course, the students will be able to apply numerical methods to obtain approximate solutions to various mathematical problems. The student will get an overall idea of

- Approximate numbers, Significant figures, Rounding o numbers. Error : Absolute, Relative and percent-age.
- Definitions of some Operators and some relations among them.
- Interpolation : The problem of interpolation Equispaced arguments Dierence Tables, Deduction of New-ton's Forward Interpolation

Formula, remainder term (expression only). Newton's Backward interpolation Formula (Statement only) with remainder term. Unequally-spaced arguments Lagrange's Interpolation Formula (Statement only). Numerical problems on Interpolation with both equally and unequally spaced arguments.

- Numerical Integration : Trapezoidal and Simpson's one-third formula (statement only). Problems on Numerical Integration.
- Solution of Numerical Equation : To find a real root of an algebraic or transcendental equation. Loca-tion of root (tabular method), Bisection method, Newton-Raphson method with geometrical significance, Numerical Problems. (Note : Emphasis should be given on problems)

Unit-3 : Linear Programming

Learning Outcomes: After completion of this unit of the course, the students will be able to Formulate the LPP, Conceptualize the feasible region, Solve the LPP using different methods & understand the importance of LPP in daily life. In details, the student will be able to understand and visualize the

- Motivation of Linear Programming problem. Statement of L.P.P. Formulation of L.P.P. Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, convex Polyhedron, Basic solutions and Basic Feasible Solutions (B.F.S.). Degenerate and Non-degenerate B.F.S.
- The set of all feasible solutions of an L.P.P. is a convex set. The objective function of an L.P.P. assumes its optimal value at an extreme print of the convex set of feasible solutions, A.B.F.S. to an L.P.P. corresponds to an extreme point of the convex set of feasible solutions.
- Fundamental Theorem of L.P.P. (Statement only) Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method (for two variables), by simplex method and method of penalty. Concept of Duality. Duality Theory. The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Dual problems with at most one unrestricted variable, one constraint of equality. Transportation and Assignment problem and their optimal solutions.

❖ Fourth Semester:

Core Course-4 / Generic Elective-4 (Unit-1,2,3)

Paper Code (Theoretical) : MTM-G-CC-4-4-TH /MTM-G-GE-4-4-TH
Paper Code (Tutorial):MTM-G-CC-4-4-TU /MTM-G-GE-4-4-TU

Unit-1 : Algebra-II (20 Marks)

Learning Outcomes: After completion of this unit of the course, the students will be able to demonstrate the mathematical maturity of understanding a group, a ring and a field in Abstract Algebra. In Linear Algebra, the students will understand vector spaces over a field and subspaces and apply their properties. Students will get an overall understanding of the following concepts:

- Introduction of Group Theory : Definition and examples taken from various branches (example from number system, roots of Unity, 2 ×2 real matrices, non singular real matrices of a fixed order). Elementary properties using definition of Group. Definition and examples of sub- group - Statement of necessary and su□cient condition and its applications.
- Definitions and examples of (i) Ring, (ii) Field, (iii) Sub-ring, (iv) Sub- field.
- Concept of Vector space over a Field : Examples, Concepts of Linear combinations, Linear dependence and independence of a finite number of vectors, Sub-space, Concepts of generators and basis of a finite-dimensional vector space. Problems on formation of basis of a vector space (No proof required).
- Real Quadratic Form involving not more than three variables (problems only).
- Characteristic equation of square matrix of order not more than three. Determination of Eigen Values and Eigen Vectors (problems only). Statement and illustration of Cayley-Hamilton Theorem.

Unit-2 : Computer Science & Programming

Learning Outcomes: After completing this unit, the students will have a practical outlook and understanding of the computers, use computers in their daily life for better efficiency, represent their knowledge with the help of the computers and various programming languages.

Students will learn the basic concepts of computer science from the following:

- •Computer Science and Programming : Historical Development, Computer Generation, Computer Anatomy Di□erent Components of a computer system. Operating System, hardware and Software.
- •Positional Number System. Binary to Decimal and Decimal to Binary. Other systems. Binary Arithmetic. Octal, Hexadecimal, etc. Storing of data in a Computer - BIT, BYTE, WORD etc. Coding of a data-ASCII, etc.
- •Programming Language : Machine language, Assembly language and High level language, Compiler and interpreter. Object Programme and source Programme. Ideas about some HLL– e.g. BASIC, FORTRAN, C, C++, COBOL, PASCAL, etc.
- •Algorithms and Flow Charts– their utilities and important features, Ideas about the complexities of an algo-rithm. Application in simple problems. FORTRAN 77/90: Introduction, Data Type– Keywords, Constants and Variables - Integer, Real, Complex, Logical, character, subscripted variables, Fortran Expressions.

Unit-3 : Probability & Statistics

Learning Outcomes: On completion of this unit of the course, the student will be able to understand basic probability axioms and rules as well as different statistical methods for solving and analyzing different types of real-life problems. The students will be able to develop a clear-cut idea in the following:

- •Elements of probability Theory : Random experiment, Outcome, Event, Mutually Exclusive Events, Equally likely and Exhaustive. Classical definition of probability, Theorems of Total Probability, Con-ditional probability and Statistical Independence. Baye's Theorem. Problems, Shortcoming of the classical definition. Axiomatic approach problems, Random Variable and its Expectation, Theorems on mathematical expectation. Joint distribution of two random variables.

- Theoretical Probability Distribution Discrete and Continuous (p.m.f., p.d.f.) Binomial, Poisson and Normal distributions and their properties.
- Elements of Statistical Methods. Variables, Attributes. Primary data and secondary data, Population and sample. Census and Sample Survey. Tabulation Chart and Diagram, Graph, Bar diagram, Pie diagram etc. Frequency Distribution Ungrouped and grouped cumulative frequency distribution. Histogram, Frequency curve, Measures of Central tendencies. Averages : AM,; GM, HM, Mean, Median and Mode (their advantages and disadvantages). Measures of Dispersions - Range, Quartile Deviation, Mean Deviation, Variance / S.D., Moments, Skewness and Kurtosis.
- Sampling Theory : Meaning and objects of sampling. Some ideas about the methods of selecting samples, Statistic and parameter, Sampling Proportion. Four fundamental distributions, derived from the normal:

(i) standard Normal Distribution, (ii) Chi-square distribution (iii) Student's distribution (iv) Snedecor's F-distribution. Estimation and Test of Significance. Statistical Inference. Theory of estimation Point estimation and Interval estimation. Confidence Interval / Confidence Limit. Statistical Hypothesis - Null Hypothesis and Alternative Hypothesis. Level of significance. Critical Region. Type I and II error. Problems.

- Bivariate Frequency Distribution. Scatter Diagram, Correlation co-e□cient Definition and properties. Regression lines.
