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

MATHEMATICS HONOURS COURSE OUTCOMES

❖ Semester-1:

Core Course-1 (Calculus, Geometry & Differential Equation)

Course Code: *MATH-H-CC-T-01*

Unit-1:

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, thesecond 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·

Unit-2:

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

- 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-3:

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 normal
- Understand the geometrical terminology and have a detailed clear-cut idea of the Planes, Straight lines in 3D, Spheres, Cylindrical surfaces, Central conicoid, Paraboloids, Plane sections of conicoid along with the Tangent and normal of the conicoid.
- 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 softwires :
  - ✓ 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-4:

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

- Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation.
- Find the Triple product of Products and their Applications
- First order differential equations: Exact differential equations and integrating factors, special integrating factors and transformations, linear equations and Bernoulli equations.
- 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.

- 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)

Course Code: *MATH-H-CC-T-02*

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 forrational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of the complex variable.
- Theory of equations: Relation between roots and coefficients, transformation ofthe equation, Descartes rule of signs, Sturm's theorem, cubic equation (solutionby 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, divisibility, and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic.

Unit-3

- 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.
- Linear dependence and independence.

Unit-4

- Linear transformations, matrix of a linear transformation.
- Inverse of a matrix, characterizations of invertible matrices.
- Subspaces of R^n, dimension of subspaces of R^n.
- Rank of a matrix, Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

❖ Semester 2:

Core Course-3 (Real Analysis)

Course Code: *MATH-H-CC-T-03*

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 setsas 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'sfirst 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 thefollowing, 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 (Differential Equation & Vector Calculus)

Course Code: *MATH-H-CC-T-04*

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:*

Unit-1:

- The existence and uniqueness theorem of Picard (Statement only).
- 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.

Unit-2:

- System of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.

Unit-3:

- Planar linear autonomous systems: Equilibrium (critical) points, Interpretation of the phase plane and phase portraits.

Unit-4:

- Power series solution of a differential equation about an ordinary point, solution about a regular singular point (up to second order).

❖ Semester 3:

Core Course-5 (Theory of Real Functions & Introduction to Metric Space)

Course Code: *MATH-H-CC-T-05*

Learning Outcomes: *After completion of this course, the students will be able to understand the concept of real-valued functions, limit, continuity, anddifferentiability in detail. They can find expansions of real functions in series forms. The students will become conversant with many of the important theorems ofDifferential Calculus. The students will also have a new concept about metric space.*

Unit-1:

- 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.. Algebra of continuous functions as a consequence of algebra of limits.
- Bounded functions. 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.
- 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.

Unit-2:

- 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 andCauchy — as an application of Rolle's theorem.
- 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

Unit-3:

- 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.

Unit-4:

- Definition and examples metric spaces. open and closed balls, neighbourhood, open set, interior of a set.
- Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces.

Core Course-6: (Group Theory 1)

Course Code: *MATH-H-CC-T-06*

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 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.

Unit-2:

- 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-3:

- 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-4:

- External direct product of a finite number of groups.
- Normal subgroup and its properties. Quotient group.
- Cauchy's theorem for finite abelian groups.

Unit-5:

- Group homomorphisms, properties of homomorphisms.
- Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

Core Course-7 (Numerical Methods)

Course Code: *MATH-H-CC-T-07*

Learning Outcomes: *After completion of this course, the studentswill be able to:*

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:

- 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.

Unit-3:

- System of linear algebraic equations:
- Direct methods: Gaussian elimination and Gauss Jordan methods, Pivoting strategies.
- Iterative methods: Gauss Jacobi method, Gauss Seidelmethod and their convergence analysis. LU decomposition method.

Unit-4:

- Interpolation: Lagrange and Newton's methods. Error bounds.
- Finite difference operators. Newton (Gregory) forward and backward difference interpolation.
- Numerical differentiation: Methods based on interpolations; methods based on finite differences.

Unit-5:

- 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.
- The algebraic eigen value problem: Power method.

Unit-6

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

Core Course-7: Practical (Numerical Methods Lab)

Learning Outcomes: *On the completion of this course, the students become expert in solving different numerical problems (listed below) by using computer programming techniques of*

- Calculate the sum 1+½+1/3+---------- +1/N
- Enter 100 integers into an array and sort them in an ascendingorder.
- Solution of transcendental and algebraic equations by
  i) Bisection method
  ii) Newton Raphson method (Simple root, multiple roots, complexroots).
  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
ii) Newton's forward, backward and divide difference interpolation

- 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)

❖ Semester 4:

Core Course-8 (Riemann Integration & Series of Functions)

Course Code: *MATH-H-CC-T-08*

Learning Outcomes:

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

Unit-1:

- Riemann integration: inequalities of upper and lower sums.
- Darbaux integration, Darbaux theorem.
- Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral.
- Definition and integrability of piecewise continuous and monotone functions.
- Intermediate Value theorem for Integrals; Fundamental theorem of Integral Calculus.

Unit-2:

- Improper integrals. Convergence of Beta and Gamma functions.

Unit-3:

- Pointwise and uniform convergence of sequence of functions.
- Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.
- Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions.
- Cauchy criterion for uniform convergence and Weierstrass M-Test.

Unit-4:

- Fourier series: Definition of Fourier coefficients and series.
- Reimann Lebesgue lemma, Bessel's inequality,Parseval's identity.
- Dirichlet's condition. Examples of Fourier expansions and summation results for series.

Unit-5:

- Power series: Fundamental theorem of power series.
- Cauchy-Hadamard theorem. Determination of radius of convergence.
- Differentiation and integration of power series.
- Abel's limit theorems. Uniqueness of power series having sum function.

Core Course-9 (Multivariate Calculus)

Course Code: *MATH-H-CC-T-09*

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

Unit-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 oneand 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.

Unit-2:

- Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates.
- Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.
- Change of variables in double integrals and triple integrals.

Unit-3

- Definition of vector field, divergence and curl.
- Line integrals, applications of line integral: mass and work.
- Fundamental theoremfor line integrals, conservative vector fields, independence of path.

Unit-4

- Green's theorem, surface integrals, integrals over parametricallydefined surfaces. Stoke's theorem, The Divergence theorem.

Core Course-10 (Ring Theory and Linear Algebra I)

Course Code: *MATH-H-CC-T-10*

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 various concepts of Abstract Algebra covered indetails by the following unit:*

Unit-1:

- 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 generatedby a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.
- Cyclic groups from number systems, complex roots of unity.
- The general linear group GLn(n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square.
- The permutation group Sym (n), Group of quaternions.
- Examples of commutative and non-commutative rings: rings from number systems, Zn the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions.
- Examples of fields: Zp, Q, R, and C. Field of rational functions.

❖ Semester 5:

Core Course-11 (Partial Differential Equations and Application)

Course Code: *MATH-H-CC-T-11*

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:*

Unit-1:

- Partial differential equations of the first order. Basic concepts and definitions. Mathematical problems.
- First- order equations: classification, construction and geometrical interpretation.
- Method of characteristics for obtaining general solution of quasi linear equations.
- Canonical forms of first-order linear equations. Method of separation of variables for solving first order partial differential equations.

Unit-2:

- 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 tocanonical forms.

Unit-3:

- 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.

Core Course-12 (Group Theory-II)

Course Code: *MATH-H-CC-T-12*

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 .*

Unit-1:

- Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.

Unit-2:

- External direct product and its properties, the group of units modulo *n* as an external direct product, internal direct product. Fundamental theorem of finite abelian groups.

Unit-3:

- Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn.
- p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for $n \geq 5$, non-simplicity tests.

Discipline Specific Elective Course-1A (Linear Programming)

Course Code: *MATH-H-DSC-T-1A*

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

Unit-1:

- Introduction to linear programming problem. Theory of simplex method, graphical solution.
- Convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format.
- Introduction to artificial variables, two-phase method. Big-M method and their comparison.

Unit-2:

- Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.
- Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem.
- Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.
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Unit-3:

- Game theory: formulation of two persons zero sum games, solving two person zero sum games.
- Games with mixed strategies, graphical solution procedure, linear programming solution of games.

Discipline Specific Elective Course-2A (Probability & Statistics)

Course Code: *MATH-H-DSC-T-2A*

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 EstimationConfidence Intervals for mean and variance of Normal Population. Meansquared 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.

❖ Semester 6:

Core Course-13 (Metric Space & Complex Analysis)

Course Code: *MATH-H-CC-T-13*

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

Unit-1:

- 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.

Unit-2:

- Continuous mappings, sequential criterion of continuity. Uniform continuity.
- Compactness, Sequential compactness, Heine-Borel theorem in R. Finite intersection property, continuous functions on compact sets.

Unit-3:

- Limits, limits involving the point at infinity. Continuity of functions of complex variables.
- Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Unit-4:

- Analytic functions, exponential function, logarithmic function, trigonometric functions, hyperbolic functions.
- 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 (Ring Theory and Linear Algebra II)

Course Code: *MATH-H-CC-T-14*

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

Unit-1:

- Ring homomorphisms, properties of ring homomorphisms. First isomorphism theorem, second isomorphism theorem, third iso-morphism theorem.
- Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains.
- Factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in Z[x].

Unit-2:

- Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigenspaces of a linear operator.

Unit-3:

- Diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms.
- Inner product spaces and norms, Gram-Schmidt orthonormalization process, orthogonal complements.

Discipline Specific Elective Course-3B (Number Theory)

Course Code: *MATH-H-DSC-T-3B*

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

Unit-1:

- Linear diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues.
- Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.

Unit-2:

- Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function.
- Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-3:

- Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots.
- Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.
- Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem. (statement)

Discipline Specific Elective Course-4A (Mechanics)

Course Code: *MATH-H-DSC-T-4A*

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:

- Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work.
- Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium.

Unit-2:

- Central force. Constrained motion, varying mass, tangent and normal components of acceleration.
- Modelling ballistics and planetary motion, Kepler's second law.

Unit-3:

- Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium.
- Stability of nearly circular orbits. Motion under the inverse square law. Slightly disturbed orbits. Motion of artificial satellites.
- Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution.

Unit-4:

- Degrees of freedom. Moments and products of inertia. Momental Ellipsoid. Principal axes. D'Alembert's Principle. Motion about a fixed axis.
- Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces. Conservation of momentum and energy.

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 develop an understanding of Computer Graphics which are very familiar in today's life. The students can also acquire the skill in Graph Theory which is very important part in discrete Mathematics and Computer Sciences. The students can learn about basic properties of graph, circuits and represent graph by matrix. The students can also acquire the skill in the operating system Linux.

Course Outcomes of Mathematics

Generic ElectiveB.A. & B.Sc. under CBCS

[For students having Honours in subjects other than Mathematics]

❖ First Semester:

Generic Elective-1 (Differential Calculus)

Course Code: *MATH-H-GE-T-01*

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

- 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.
- Types of discontinuities.
- Derivative-its geometrical and physical interpretation. Sign of derivative-Monotonic increasing and decreasing functions. Relation between continuity and derivative Differential - application in finding approximation.
- Successive derivative - Leibnitz's theorem and its application. Partial differentiation, Euler's theorem on homogeneous functions.
- Tangents and normal Curvature, Asymptotes, Singular points.
- Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates
- Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder.
- Taylor's series, Maclaurin's series of sin x, cos x, ex, log(l+x), $(l+x)^n$,.
- Maxima and Minima, Indeterminate forms.

❖ Second Semester

Generic Elective-2 (Differential Equations)

Course Code: *MATH-H-GE-T-02*

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.*

- First order equations :Exact equations and those reducible to such equation.
- Euler's and Bernoulli's equations (Linear).Clairaut's Equations : General and Singular solutions.
- Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous diffierential equations, Simple eigen-value problem.
- Order and degree of partial diffierential equations, Concept of linear and non-linear partial diffierential equations, Formation of first order partial diffierential equations, Linear partial diffierential equation of first order, Lagrange's method, Charpit's method.
- Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.

❖ Third Semester:

Generic Elective-3 (Differential Calculus)

Course Code: *MATH-H-GE-T-03*

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

- 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.
- Types of discontinuities.
- Derivative-its geometrical and physical interpretation. Sign of derivative-Monotonic increasing and decreasing functions. Relation between continuity and derivative Differential - application in finding approximation.
- Successive derivative - Leibnitz's theorem and its application. Partial differentiation, Euler's theorem on homogeneous functions.
- Tangents and normal Curvature, Asymptotes, Singular points.
- Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates
- Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder.
- Taylor's series, Maclaurin's series of sin x, cos x, ex, log(l+x), $(l+x)^n$,.
- Maxima and Minima, Indeterminate forms.

❖ Fourth Semester

Generic Elective-4 (Differential Equations)

Course Code: *MATH-H-GE-T-04*

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.*

- First order equations :Exact equations and those reducible to such equation.
- Euler's and Bernoulli's equations (Linear).Clairaut's Equations : General and Singular solutions.
- Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous diffierential equations, Simple eigen-value problem.
- Order and degree of partial diffierential equations, Concept of linear and non-linear partial diffierential equations, Formation of first order partial diffierential equations, Linear partial diffierential equation of first order, Lagrange's method, Charpit's method.
- Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.