Mathematics

Syllabus (Old Course – OC 45)

PSO1: Students will be able to acquire core knowledge in Mathematics and develop analytical reasoning skills.

PSO2: Develop a skill in solving applied mathematics problems such as Ordinary Differential Equations, inventory models, transportation models, Project management, maximising profit and Queuing models. .

PSO3: Develop proficiency in statistical data analysis & interpretation of the data.

PSO4: Develop skills in solving various problems using numerical techniques

Semester-I

Paper 101: CALCULUS OF ONE VARIABLE

1. **FUNCTIONS AND GRAPHS.** **[10 hrs ; 16 marks]**

Prerequisites: Real Numbers, bounded sets. Definitions: Function, domain and range; One-one and onto functions. Examples. Graphical representation of functions. Polynomial and Rational functions. Power function: $y = x^{\alpha}$, where α is a real number ($x > 0$), General exponential function: $y = a^{x}$, where a is a positive number not equal to unity. Logarithmic function: $y = log_{a}x$, where a is a positive number not equal to unity. Trigonometric functions: sinx, cosx, tanx, cotx, secx and cosecx. Inverse trigonometric functions: arcsinx, arccosx, arctanx, arccotx, arcsecx and arccosecx. Absolute value function (|.|) Properties of the absolute Value function. Greatest integer function[ ].

Definitions of 'sup' and 'inf ' of a non-empty subset S of IR .Theorems on 'sup' and 'inf '. Axiom of Lub (sup) .

Reference: Chapter 2 in [1] and/or Chapter 1 & 3 in [2] . Also [4]

1. 2. **LIMIT AND CONTINUITY.** **[18 hrs ;24 marks]**

Limit, left limit and right limit. Theorems:

(a) $\lim\limits_{x \to c}(f \pm g)(x) = \lim\limits_{x \to c} f(x) \pm \lim\limits_{x \to c} g(x)$.

(b) $\lim\limits_{x \to c}(fg)(x) = \lim\limits_{x \to c} f(x) . \lim\limits_{x \to c} g(x)$.

(c) $\lim\limits_{x \to c}(\frac{f}{g})(x) = \frac{\lim\limits_{x \to c} f(x)}{\lim\limits_{x \to c} g(x)}$ provided $\lim\limits_{x \to c} g(x) \neq 0$.

Limit of a function. Definition of 'lim f(x) as x -> infinity.' Uniqueness of limit of a Function. Continuity at a point, continuity in an interval, types of discontinuities. Theorems on continuity: (a) If a function is continuous on a closed interval, then it attains its bounds at least once in it. (b) If a function f is continuous at an interior point c of an interval and $f(c) \neq 0$ then f keeps the same sign of f(c) in a neighbourhood of c. (c) If a function f is continuous on a closed & bounded interval [a, b], and $f(a)f(b) < 0$, then there exists at least one point $c \in (a,b)$ such that $f(c) = 0$. (d) Intermediate value theorem.(e) fixed point theorem.

Reference: Chapter 5 in [3] . Also Chapter 3 in [4]

1. 3. **THE DERIVATIVE** **[20 lectures ; 24 marks]**

Drivability (Differentiability) at a point, Drivability in an interval, increasing and decreasing functions, Sign of the derivative. Higher order derivatives. Theorems: (a) A function which is derivable at a point is necessarily continuous at that point. (b) If f is derivable at c and $f(c) \neq 0$, then $1/f$ is also derivable at c. (c) Darboux's theorem. (d) Intermediate value theorem for derivatives.(e) Rolle's theorem. (f) Lagranges mean value theorem.(g) Cauchy's mean value theorem.(h) Taylor's theorem.(i) Maclaurin's theorem. Increasing and decreasing functions.

Reference: Chapter 6 in [3]. Also Chapter 4 in [4]

4. APPLICATION OF TAYLOR'S THEOREM [12 lectures; 16 marks]

Approximations. Extreme Values, Investigation of the points of Maximum and Minimum Values. Indeterminate forms, $0/0$ form, ∞/∞ form, Problems. Theorems:

(a) If $f(c)$ is an extreme value of a function f, then $f'(c)$, in case it exists, is zero. (b) If c is an interior point of the domain of a function f and $f'(c)=0$, then the function has a maxima or a minima at c according as $f''(c)$ is negative or positive. (c) If f, g be two functions such that (i) $\lim_{x\to a} f(x) = \lim_{x\to a} g(x) = 0$ and (ii) $f'(a), g'(a)$ exist and $g'(a) \neq 0$ then $\lim_{x\to a} \frac{f(x)}{g(x)} = \frac{f(a)}{g(a)}$. (d) L'Hopital's Rule for $0/0$ form. (e) If f, g be two functions such that (i) $\lim_{x\to\infty} f(x) = \lim_{x\to\infty} g(x) = 0$ and (ii) $f'(a), g'(a)$ exist and $g'(x) \neq 0$ for all $x > 0$ except possibly at ∞, and (iii) $\lim_{x\to\infty} \frac{f'(x)}{g'(x)}$ exists ,then $\lim_{x\to\infty} \frac{f(x)}{g(x)} = \lim_{x\to\infty} \frac{f'(x)}{g'(x)}$ (f) L'Hopital's Rule for ∞/∞ form. Point of inflexion

Reference: Chapter 7 in [3]. Also Chapter 4 and 7 in [4]

Learning Objective

- To study elementary functions and their properties.
- To study the concept of L.U.B and G.L.B of subsets of IR, order completeness and Archimedean property, intervals and properties of absolute valued function.
- To study the concept of neighbouzrhood of a point, limit of a function, continuity, types of discontinuities and properties of continuous functions.
- To study the theory of derivatives, Rolle's Theorem, Lagrange's Theorem and their interpretation, Taylor/Maclaurin series expansion, maxima and minima and indeterminate forms.

Course Outcomes:

After completion of this course, a student should be able to:

- Apply the properties of absolute value function,
- Check if a function is continuous and identify the types of discontinuities.
- Use L'Hospitals rule to find limits of indeterminate forms.
- Find Taylors/Maclauirn series expansion, find and classify stationary points and find local maxima and minima of a function.

Paper 102 : ANALYTICAL GEOMETRY

1 Analytic Geometry of two Variables. **[10 lectures; 20 marks]**

General Equation of Second Degree. Equation $ax+2hxy+by+2gx+2fy+c=0$ Transformation of Co-ordinates. Change of Origin and Rotation of Axes. To show that the general second degree equation represents. (a)Ellipse if $h^2<ab$.(b) Parabola if $h^2=ab$. (c) Hyperbola if $h^2>ab$. (d) Circle if $a=b$ and $h=0$. (e) Rectangular Hyperbola if $a+b=0$. (f) Two straight lines if $\Delta=0$. (g) Two parallel straight lines if $\Delta=o$ and $h^2=ab$,

where $\Delta=\begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix}$.

2. Conic sections. **[20 lectures ; 30 marks]**

Standard equations of conics using focus-directrix property. Parametric equations of standard conics. Tangent at a point (x_1, y_1). Tangents in terms of slope. Tangent in terms of parametric co-ordinations. Condition of tangency. Properties of i) Parabola ii) Ellipse and iii) Hyperbola as listed in **Annexure 1**. Center of a Conic, Central Conic. Tangents and Normals. Pole & Polar with respect to conic.

3. Three Dimensional Geometry: Prerequisites: **(20 lectures; 20 marks]**

Direction Cosines, direction ratios. Equations of lines, planes, intersection of two planes, symmetric forms of equation, lines perpendicular to planes, angles between two lines and between a line and a plane. Projection of a line on a plane. Sphere: Intersection of a sphere by planes, intersection of two spheres

4.Central conicoids: **[10 lectures; 10 marks]**

Shapes, ellipsoids, hyperboloid of one sheet, two sheets. Intersection of a conicoid and a line. Cone and right cylinder. Standard equations

Learning Objectives:

- To study locus of a line, circle, conics in planes and plane sections.
- To study coordinate system and transformation of coordinates.
- To study sphere, cone, cylinder and conicoids.
- To study lines and planes in three space.

Course Outcomes:

After completion of this course, a student should be able to:

- Solve problems in analytical geometry.
- classify conics.
- Verify properties of lines, circles, parabola , ellipse etc.
- Transform coordinates.

Semester II

Paper 201: Discrete Mathematical Structures.

1. Propositional Calculus (Chapter 1. Last section only) **[5 lectures; 8 marks]**

2. Graphs (Chapter 5.) **[12 lectures; 16 marks]**

3. Trees (Chapter 6.) **[12 lectures; 16 marks]**

4. Discrete Numeric Functions (Chapter 9.) **[10 lectures; 12 marks]**

5. Recurrence Relation and Recursive Algorithms. (Chapter 10.) **[10 lectures; 12 marks]**

7. Boolean Algebra (Chapter 12.) **[11 lectures; 16 marks]**

Learning Objectives:

- To understand the concept of graph theory, basic concept of eulerian path and circuits and Hamiltonian paths and circuits.
- To find spanning trees and find the minimal spanning trees.
- To study recurrence relations.
- To study basic Boolean algebra.

Course Outcomes:

After completion of this course, a student should be able to:

- Identify Eluerian/Hamiltonian paths and circuits in graphs.
- Find shortest paths using Djkistras algorithm.
- Find minimum spanning trees.
- Apply the concept Boolean algebra in computers/physics.

Paper 202: Probability & Statistics*

Review of Probability and Random experiments. Theorems of total and compound probability. Total probability for n events (Statement only) Bayes' theorem, application problems.

[10 lectures; 10 marks]

Random Variables (Discrete and Continuous)- Probability, Distribution-Probability Density Functions-Mathematical Expectation- Functions of Random Variables. Joint Probability distribution. Marginal distribution function. Mathematical expectations and Generating Functions. Characteristic function.

[15 lectures; 15 marks]

Binomial and Poisson Distribution- Moments and Moment Generating Functions of these distribution and their simple properties- Recurrence Relations for moments of the Binomial and Poisson distributions.Fitting of Binomial and Poisson Distribution. Normal Distribution and its properties. Statement of the Lindberg-levy Central Limit Theorem. **[15 lectures; 20 marks]**

Sampling and Large Sample Tests. Z test and Student's t test . the significance of sample mean, difference between two sample means, Variances. Snedecor's 'F' Distributions

Chi- square Distribution. Applications of the Chi-square Distribution-Tests of Goodness Fit-Contingences Tables. **[20 lectures; 35 marks]**

Learning Objectives:

- To study the importance, limitations and distrust of statistics.
- To study correlation analysis.
- To study the theory of probability and theoretical probability distributions.
- To study the methods of testing of hypothesis and large sample tests.

Course Outcomes:

After completion of this course, a student should be able to:

- Correlate and perform analysis.
- Find measures of central tendency and dispersion.
- Use testing of hypothesis using t test, chi square test.
- use large sample test.

Semester III

Semester III

Paper 301 : Numerical Methods

Elementary Error Analysis : **[4 lectures; 6 marks]**

Introduction. Numbers: Exact and Approximate. Significant digits. Errors: Absolute, Relative and Percentage errors. Examples

Calculus of Finite differences: **[6 lectures; 10 marks]**

Operators Δ, ∇ & E . Difference Tables. Properties of Δ, ∇, & E. Fundamental Theorem of Difference Calculus. Expression of any value of a function in terms of leading term and leading differences of a difference table. Method of separation of symbols.

Interpolation and Extrapolation: **[6 lectures; 12 marks]**

_Newton's forward and backward interpolation formulae. Lagrange's Interpolation formula .Newton's Divided Difference formula.

Examples based on the above formulae.

Numerical Differentiation and Integration: **[9 lectures; 14 marks]**

Differentiation formulae for equidistant arguments. Examples. General quadrature formula for equidistant ordinates (Newton –Cotes Formula Or Gauss Legendre quadrature formulae). Trapezoidal rule and its Geometrical interpretation. Simpson's one third rule, Simpson's three-eighth rule. Weddle's rule (Only Statements)

Solution of Algebraic and transcendental Equations: **[6 lectures; 10 marks]**

Introduction. Method of Bisection, Regula-Falsi Method, Newton-Raphson Method and their Computation scheme. Special Cases of Newton-Raphson Method like finding q^{th} root of a positive real number'd' and finding reciprocal of a positive real number 'd' without using division.

Approximations: **[5 lectures;8 marks]**

The least square polynomial approximation method (Linear, quadratic, Exponential)

Learning Objectives:

- . To study the iterative procedures to solve transcendental equations to interpolate, integrate and differentiate.
- To study method of least squares for approximations of functions

Course Outcomes:

After completion of this course, a student should be able to:

- Solve numerically any transcendental equation using Bisection method, Regula Falsi method, Newton Raphsons to desired accuracy level.
- To interpolate a function by Using Newton Forward/Backward Interpolations and Lagranges interpolation formula.
- perform numerical differentiation using Newton cotes formula.
- To perform numerical Integration using Trapezoidal, Simpsons and Weddels rule.
- To approximate function by using methods of Least Squares.

Paper 302 : CALCULUS OF TWO VARIABLES

1. FUNCTIONS OF TWO VARIABLES **[32 lectures; 44 marks]**

Function of two variables, neighbourhood of a point, limit point, limit of a function, non-existence of limit, Algebra of limits, repeated limits, continuity, partial derivatives, differentiability, partial derivatives of higher order, change in the order of partial derivation, the derivation of a composite function (chain rule), change of variables, Extreme values, maxima and minima, sufficient condition for $f(x,y)$ to have an extreme value at (a,b). Lagrange's Multipliers. Theorems: (a) Mean value theorem (b) Sufficient condition for continuity. (c) Sufficient condition for differentiability.(d) sufficient condition for the equality of f_{xy} and f_{yx} : Young's theorem and Schwarz's theorem. (e) Taylor's theorem; Maclaurin's expansion.

2.INTEGRATION ON R^2 **[28 lectures; 36 marks]**

Line integrals, plane curves, properties of line integrals. Double integrals, partition of a rectangle, integration over a rectangle.

Statements (only) of the following:

(a)Condition of integrability, integrals as a limit of sums, integrable functions (continuous function is integrable, bounded function with finite number of discontinuity is integrable etc.) (b)Repeated integrals, Calculation of double integral over a rectangle (reduction to repeated integrals). (c) Fubini's theorem. (d) Leibnitz's rule.(e) General Leibnitz's rule. (f) Two repeated integrals are equal. Double integrals over a region, Integrability over a bounded domain, reduction to iterated integrals. Change of variables and problems. Volume of a cylindrical solid by double integrals, volume enclosed by two surfaces, volume enclosed by closed surface.

Learning Objective:

- To present the fundamental concepts of two variable calculas and to develop students understanding and skills for its applications to science and engineering.
- To study curves in planes.
- To study line integral, double integrals, surface integrals and volume integrals.
- To study higher derivatives of functions of two variables and extremisation.

Course Outcomes:

After completion of this course, a student should be able to:

- Calculate and interpret derivatives of two dimensions.
- Integrate functions of two variables over curves and surfaces.
- Evaluate line, surface and Volume integrals.

Semester IV

Paper 401: MATRIX ALGEBRA *

1. Vectors and operations with vectors in IR^3 and generalization to IR^n. Linear combinations. Linear dependence and independence. Basis, Linear span and dimension. **[9 lectures; 15 marks]**

2. Elementary operations on a matrix: Elementary matrices. Effects of multiplying by these on a matrix. Equivalence of matrices: Row/column equivalence, Echelon forms. Normal form. **[9 lectures; 15 marks]**

3. Rank of a matrix: Definition using minors. Finding rank of a matrix using definition. (upto 3x3 only) Theorem: Elementary operations do not change the rank of a matrix. Finding the rank using echelon forms. Linear Independence of Row and Column Matrices. Definition of rank of a matrix using independence of Row or column vectors. Equivalence of two definitions of Rank.
[9 lectures; 15marks]

4. Application of matrices. Solutions of a system of linear equations. Characteristic Values of a Matrix. Cayley-Hamilton Theorem. Diagonalisation of a matrix up to order 3 (when eigenvalues are distinct).
[9 lectures; 15 marks]

Learning Objectives:

- To study matrix algebra and use it to solve system of linear equations.
- To study vector spaces and their basis..
- .To study rank of a matrix.
- To study eigen values and eigen vectors of a matrix and diagonalization.

Course Outcomes:

After completion of this course, a student should be able to:

- Solve system of equation of equations using matrices.
- Determine eigen values and eigen vectors and diagonalize a matrix.
- Find inverse of a matrix using Cayley Hamilton theorem.

Paper 402: Differential equations I

Review of basic concepts. Differential equation of the first order homogeneous, non-homogeneous, exact differential equations, conditions for exactness, integrating factors, integrating factors by inspection and rules for finding integrating factors, linear equations. Equations reducible to the linear form. Equations of first order, but not of first degree. Bernoulli's equation. Clairaut's form and equations reducible to it. Ricatti's equation. Applications. Modelling with differential equations.

[15 lectures; 20 marks]

Statement of sufficiency conditions for the existence and uniqueness of a solution of non-homogeneous differential equation $y'' + p(x)\, y' + q(x)y = r(x)$ together with the initial conditions $y(x_0)= y_0$; $y'(x_0)= y_1$.

Theorem: The dimension of the solution space of the homogeneous differential equation $y''+ p(x)y' + q(x)y=0$ is two. General solution of the homogeneous equation. Characteristics Equation of a homogeneous differential equation with constant coefficients of order two and computation of linearly independent solutions. Wronskian. Use of known solution to obtain another linearly independent solution. Method of undetermined coefficients. Variation of parameters Formula. Extension of methods to n order. Applications of second order linear differential equation. (Models)

[25 lectures; 30 marks]

D-operator Method to solve linear differential equation with constant coefficients. $f(D)\, y = 0$. Solution for different types of roots. Inverse D-operator. Solution of $f(D)y = X$ where $X = \exp(kx)$, $\cos(kx)$, $\sin(kx)$, polynomials in x and their products.

$\{1/ (D^2 + a^2) \}\, f(x)$, where $f(x) = \text{Sin}\, ax$, $\text{Cos}\, ax$. **[15 lectures; 20 marks]**

Numerical solutions of ordinary differential equations. Euler's method. Taylor's series method. Picard's method of successive approximations. **[5 lectures; 10 marks]**

Learning Objectives:

- To classify and study the methods of solutions of various types of first and second order differential equations.
- To study the applications of O.D.E and modelling with differential equations.
- To study conversion of n^{th} order differential equationto a system of first order differential equations.
- To study numerical methods to solve ODEs.

Course Outcomes:

After completion of this course, a student should be able to:

- Solve first and second order differential equations with constant coefficients.
- Identify the type of difffferntial equation and use method of D operators to various cases of. differential equations
- Solve ODEs using numerical methods

Semester V

Paper 501: Analysis I

Sequences and series

I Sequences in IR: Bounded Sequences, Algebra of sequences, Convergence of sequences, Sub sequences, monotone sequences, Cauchy sequences, Bolzano – Weierstrass theorem, Cauchy's General Principle of Convergence. Sequences in ℂand IR^2 . **[15 lectures; 20 marks]**

2 Series (Real and Complex): Examples. Positive term series, Geometric Series, Power series, Alternating Series. Convergence of series. A necessary condition for convergence. Cauchy's General principal of Convergence, Absolute Convergence, Conditional Convergence, Comparison test for positive term series, Ratio test, Cauchy's root test, Leibinitz test for Alternating series.
[15 lectures; 20 marks]

Sequences and series of functions:-

3 Examples of Sequences of real-valued functions, point wise and uniform convergence of sequences and of series of real valued and complex Valued functions defined on a subset of IR, Cauchy's Condition for uniform convergence of a sequence of functions, Continuity of the uniform limit function, uniform convergence. Properties of Boundedness, Integrability and Differentiability of the limit function. **[15lectures; 20 marks]**

4 Term by term integration and differentiation of series of functions from lR ----> IR. Comparison test. Uniform convergence of Infinite series of functions. Cauchy's condition for uniform Convergence of series. Weierstras's M-test for Uniform convergence. Dirichlet's test for uniform convergence. Uniform convergence and term by term integration and differentiation. Examples of non-uniformly convergent series that can be integrated term by term. **[15 lectures; 20 marks]**

Learning Objectives:

- To study the convergence of real number sequences, monotone sequences, and subsequences.
- To study the concept of infinite series, their convergence as a limit of sequence of partial sums and various tests for convergence of a series.
- To study the concept of sequences and series of functions, their pointwise and uniform convergence.

Course Outcomes:

After completion of this course, a student should be able to:

- classify the sequence as convergent or divergent.
- Apply a suitable test and discuss the convergence of a series.
- Discuss the pointwise and uniform convergence of a sequence of functions using basic definition and properties.
- Discuss uniform convergence of a series of functions using limit of partial sum and M test.

<u>Paper 502: Algebra</u>

1 Sets, Relations and mappings, equivalence relations, partitions. Binary operations and their properties. Divisibility in the set of integers.
Congruence modulo n, residue classes, addition and multiplication modulo n, Roots of unity.
[15 lectures; 20 marks]

2 Groups (definition and examples). Simple properties, subgroups, cyclic groups. Coset decomposition. Lagrange's theorem and its consequences. Fermat's and Euler's theorems. Homeomorphisms and isomorphisms of groups. **[20 lectures; 25 marks]**

3 Normal subgroups, quotient groups. Fundamental theorem of group homomorphism. Permutation group, even and odd permutations, alternating group, Caley's theorem.Rings, Integral domain, Division rings and Fields. **[15 lectures; 20 marks]**

4 Subring of a ring, characteristic of a ring, ideals. Homomorphism and isomorphism of rings, quotient rings. Fundamental theorem of ring homomorphism.
[10 lectures; 15 marks]

Learning Objectives:

- To study group theory and various examples of groups.
- To study properties of groups.
- To study mappings on groups.
- To study the Fundamental Theorem of Finite Abelian Group
- To study rings and their properties.

Course Outcomes:

On Completetion of the course, Student should be able to :

- Perform standard group computations and permutations on a finite set.
- Give examples of Groups, Rings and Fields.
- Apply lagranges theorem to study subgroups of a finite group.
- Understand the notion of homomorphisms and issomorphisms of groups and rings.

Paper 503: Analysis II

1 Riemann Integral: Partition of an interval-properties of partitions- Upper and lower sums of a bounded real valued function over a closed interval-Riemann Integrability- Necessary and sufficient conditions. **[10 lectures; 15 marks]**

2 Riemann Integrals of Step, monotonic and continuous functions. Integrability of the absolute value, sums, scalar multiples of Riemann integrable Functions. Integrability of products, quotients and composition of functions. **[15 lectures; 20 marks]**

Theorems: (i) $_a\int^c f(x)\,dx + {}_c\int^b f(x)\,dx = {}_a\int^b f(x)\,dx$, $a \le c \le b$

(i) $\int [f(x) \pm g(x)]dz = \int f(x)\,dx \pm \int g(x)\,dx$.

(ii) $\int c\, f(x)\, dx = c \int f(x)\, dx$

(iii) $_a\int^b f(x)dx = -\, {}_b\int^a f(x)\,dx$

3 Continuity and differentiability of the integral as a function of the upper limit . Fundamental theorem of Calculus and the Mean Value Theorem for the Integral.

[10 lectures; 15 marks]

4 Improper integrals of both types. Beta and gamma functions (basic definitions and simple properties.) **[25 lectures; 30 marks]**

Learning Objectives:

- To study the concept of Riemann integration as an area under the curve, concept of upper integral and lower integral, criteria for Riemann integrability and proofs of properties of integrations.
- To study the mean value theorem, the concept of antiderivative and relation between integrals and derivatives.
- To study improper integrals.
- To study special improper integrals i.e. Beta and gamma functions.

Course Outcomes

A student should to able to:

- Check whether a given bounded function on a closed and bounded interval is Riemann integrable or not.
- Understand and classify the improper integrals.
- evaluate integrals using Beta Gamma functions.

Paper 504: Vector calculus

1 Vector valued functions of a single variable**.** Their limits, continuity, derivatives and integrals**.** Space curves in **IR^3.** Smooth and Regular curves. Arc-length parameter. Reparametrisation of curves**.** Tangent, Normal and Binormal vectors**.** Equations of tangent line and normal line**.** Torsion and Curvature**.** Serret- Frenet formula**.** Equations of fundamental planes**.**

[15 lectures; 20 marks]

2 Level surfaces**.** Scalar and vector fields**.** Vector differential operator**.** Gradient of scalar field and its properties**.** Directional derivatives**.** Curl and Divergence of vector field**.** Properties of curl and divergence**.** Irrotational and solenoidal vector fields**.** Identities on gradient, curl and divergence**.** Physical significance of gradient, curl and divergence**.** Laplacian operator**.**

[15 lectures; 20 marks]

3 Spherical and Cylindrical coordinates**.** Line integrals and its properties**.** Physical significance of line integrals**.** Independence of path**.** Problems on line integrals**.** Greens theorem(with proof) and its applications**.** **[15 lectures; 20 marks]**

4 Surface and volume integrals**.** Stokes theorem(with proof) and its applications**.** Gauss divergence theorem(with proof)and its applications**.** **[15 lectures; 20 marks]**

Learning Objective:

- To present the fundamental concepts of multivariable calculas and to develop students understanding and skills for its applications to science and engineering.
- To study curves in planes and spaces.
- To study scalar field and vector fields.
- To study line integral, double integrals, surface integrals and volume integrals.
- To study gradient, divergence and curl and its applications.
- To study higher derivatives of functions of two and three variables and ectremisation.

Course Outcomes:

A student should to able to

- Understand vectors to perform geometrical calculations in three dimensions.
- Calculate and interpret derivatives upto three dimensions.
- Integrate functions of several variables over curves and surfaces.
- Use greens theorem , Gauss Divergence Theorem and Stokes theorem to compute varios integrals such as Line, surface and Volume integrals.

Paper 505 : Number Theory*

1) Divisibility: Divisibility Primes. Congruences, solution of congruences, Chinese Remainder Theorem Farmat Theorem, Wilson's theorem Congruences of degree 1

(15 lectures 20 marks)

2) Some Functions of Number Theory: , the function φ(n), Greatest integer function formula, the multiplication of Arithmetic functions, **(15 lectures 20 marks)**

3 Quadratic Residues, Quadratic reciprocity, Jacobi symbol.
Some Diophantine Equations: the Equations ax +by=c, the equation $x^2 + y^2 = z^2$, the equation $x^4 + y^4 = z^4$, sum of Four and five squares. **(15 lectures 20 marks)**

4 Simple continued fractions, Infinite continued fractions, Periodic continued fractions. Fibonacci numbers. **(15 lectures 20 marks)**

Learning Objectives:

- To introduce the theory of numbers and basic concepts related to numbers.
- To study Division algorithm.
- To study different Arithnetic functions.
- To study congruences.
- To study Diophantine equations.

Course Outcomes:

By the end of the course, the students should be able to

- apply Division algorithm.
- Solve linear congruences and system of linear congruences.
- solve Diophantine equations.
- apply Fermats theorem.

Paper 506: Operations Research I *

1 Definition of standard form, formulation of LPP, convex set and extreme points of convex sets. (Only definitions) and examples . Graphical method (Only two variables).

[6 lectures; 10 marks]

2 Simplex Method: Theorems related to simplex method .and problems .Cases pertaining to existence of multiple solutions, unbounded and no feasible solution. Artificial techniques: Big M method and Two phase Simplex method

[24 lectures; 26 marks]

3 Duality, theorems on duality, linear programming problems with unrestricted variables. Dual simplex method. Revised simplex method.

[20 lectures; 24 marks]

4 Post – Optimal Analysis: Effects of change in the component of the cost vector and requirement vector, parameterization of the cost vector and requirement vector.

[10 lectures; 20 marks]

Learning Objectives:

- To study the various methods of solving linear programming problems, transportation problems, inventory controls and queueing systems.
- To study post optimal analysis in LPP

Course Outcomes:

After completion of this course, a student should be able to:

- Solve a L.P.P using simplex method, transportation problems using Modi method, assignment problem problems using Hungarian method, economic order policy for economic control and problems in queuing models.
- Apply post optimalilty analysis in LPP.

Semester VI:

Paper 601: Linear Algebra

1 : Vector space [Definition and examples], subspaces, sum and direct sum of subspaces. Linear span, linear dependence, independence and their properties. Basis, existence theorem for basis, dimension of a vector space , finite dimensional vector spaces. Dimension of sum of subspaces. Existence of complementary subspace of a finite dimensional vector space. Quotient space and its dimension. **[15 lectures; 20 marks]**

2 Linear transformation, Fundamental theorem of Linear transformations . Vector space homomorphism, Matrix representation of linear transformation. Rank nullity theorem.

[15 lectures; 20 marks]

3 Eigen values and eigen vectors of a linear transformation on a finite dimensional vector space. Eigen values of square matrix. Eigenspace. Cayley- Hamiltion theorem. Diagonalisation of an n x n matrix over IR **[15 lectures; 20 marks]**

4 Inner products spaces. Cauchy- Schwarz inequality, orthogonal vectors, orthogonal complement, orthogonal sets and bases, Gram-schmidt orthogonalisation , Bessel's inequality,

[15 lectures; 20 marks]

Learning Objectives:

- To study vector spaces and Linear transformations.
- To relate a linear transformation with a matrix.
- To study eigen values and eigen vectors of a matrix and diagonalization.
- To study inner product spaces.
- Orthonormalisation of a basis.

Course Outcomes:

After completion of this course, a student should be able to:

- Find baisi for a given vector space.
- Determine eigen values and eigen vectors and diagonalize a matrix.
- Find a linear transformation associated with a matrix and vice versa.
- Check whether a given vector space is an inner product space or not.
- Apply Gram Schimdt Orthonormalisation process to orthonormalise a basis.

Paper 602 : Metric Spaces

1 Definition and examples of metric spaces.
Open ball and open sets, closed set as complement of an open set. Properties of closed sets and open sets. Limit points of a set, closure of a set, dense sets.

[15 lectures; 20 marks]

2 Subspace of a metric space.Convergence of a sequence in a metric space, Cauchy sequences.Continuous functions from a metric space X to a metric space Y (ε-δ definition), their characterization in terms of open sets, closed sets, closure and convergent sequences.

[20 lectures; 25 marks]

3 Complete metric space, completeness of a closed subspace of a complete metric space, Cantor's Intersection Theorem.
Contraction mapping, Fixed point theorem and its application to Picard's existence theorem for solution of a first order differential equation. **[15 lectures; 20 marks]**

4 Connectedness in a metric space, Theorems on connectedness, Connected subsets of IR. Intermediate Value Theorem. **[10 lectures;15 marks]**

Learning Objectives:

- To introduce students toconcept of metric spaces, its aubspaces , open and closed balls and continuity of functiona.
- To study complete metric spaces.
- To study continous functions on metric spaces.
- To understand Picards Fixed point theorem for the existence and Uniqueness of solutions to first order IVPs.
- To study connected metric spaces.

Course Outcomes:

On completion of the course, students should be able to

- Identify metric spaces.
- Check the convergence of a given sequence in a metric space.

- Identify complete metric spaces.
- Check the continuity of functions on metric spaces using open sets and convergence of sequences.
- Check connectedness of metric spaces.

Paper 603: Complex Analysis.

1 Complex Numbers: Algebraic Properties of Complex Numbers, Modulus, Argand Diagram, Exponential Form and Polar Co-ordinates ,Triangle inequality and Metric properties, Connectedness of regions. (Chapter 1.) (Analytic Functions: Complex and functions on Complex domain, Limits continuity of Complex valued function on a Complex domain, Differentiability and analytic Functions, Algebra of Differentiability, Cauchy-Riemann Equations, Sufficient condition for Differentiability, Harmonic Functions. (Chapter 2.)

[18 lectures; 24 marks]

2 Elementary Function: Exponential Function, Logarithmic Function and its Branches, Trigonometric Functions, Hyperbolic Functions. (Chapter 3.)

[14 lectures; 18 marks]

3 Contour Integration: Contours and Contour Integrals, Cauchy Goursat's theorem (with out proof), Simply Connected Domains, Cauchy's Integral Formula, Higher Derivatives of Analytic Functions, Liouville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Principle. (Chapter 4.) Series: Convergence of Series, Taylor Series, Laurent Series. (Chapter 5. First three sections on the above topics) **[20 lectures; 26 marks]**

4 Residue Theory: Singularities of a Function, Poles and essential singularity, Residues at a singular point and its Computation, Residue Theorem **[8 lectures; 12 marks]**

Learning Objectives:

- To introduce complex numbers and their properties.
- To study analytic functions.
- To study branches of elementary functions.
- To study contour integrals.
- To study Cauchys Integral Formula and its applications.
- To study Taylors and Laurent series of complex functions..
- To study residues and Poles of complex functions.

Course Outcomes:

A student will be able to:

- perform basic operations and Geometric interpretation of complex numbers.

- Identify analytic functions
- evaluate contour integrals.
- apply Cauchy Integral formula.
- to express functions in terms of Lauratnt series.
- residues and poles of complex functions and apply it to evaluate contour integrals.

Paper 604: Analysis III

1: Weierstras's polynomial Approximation theorem. Power series in IR, their domain of Convergence, and Uniform convergence- term by term differentiation and integration of power series in IR.
Power series definitions of Exponential, Logarithmic and trigonometric functions, their properties.
[20 lectures; 30 marks]

2 Inner product : (f, g) = ∫ f(x) g(x) dx. Norm of f. Orthogonal system of functions. (Orthogonal and orthonormal sequences of functions). **[8 lectures; 10 marks]**

3 Fourier series of real functions on ($-\pi$, π) and (0, π). Fourier coefficients, properties of Fourier coefficients, the Fourier series of a function relative to an orthonormal system. Bessel's inequality. Trigonometric Fourier series, Fourier series of odd & even function. Fourier series from power series. **[16 lectures; 20 marks]**

4 Integration & differenciation of Fourier series at a point. Fourier theorem. Norm in C[a, b]. Cauchy-Schwartz inequality. Fourier Series of real functions on (c,c+2l) Riemann-Lebesgue Lemma. Parsevel's identity. **[16 lectures; 20 marks]**

Learning Objectives

- To study power series and its convergence, differentiation and integration.
- To study inner products of functions.
- To study fourier series of functions.

Course Outcomes :

On completion of the course, students should be able to

- Analyse a power series and its radius of convergence.
- To write half range and full range fourier series.
- Express special functions such as logarithmic, exponential and trigonometric functions in terms of power series..

Paper 605 : Differential Equations II

1 Differential equations with Variable Coefficient which are analytic. Power series method. Legendre equation. Equation with regular singular points, exceptional cases. Bessel equation. Regular singular point at infinity. Gauss hypergeometric equation. Properties of Legendre Polynomial & Bessels functions. Laguerre equation, Tchebychev equations. Hermit equation. Euler equation.

[15 lectures; 20 marks]

2 System of 1st order differential equations. Conversion of nth order equation to 1st order system . Existence and uniqueness of solution (statement only). Methods of solution for Linear system . Homogeneous and non homogeneous equations with constant Coefficients . D operator method. **[20 lectures; 25 marks]**

3 Laplace Transformation:-Introduction to Laplace Transformations – Laplace transformation of elementary functions- Laplace transformation of periodic functions- inverse Laplace transformation- Convolution Theorem. Solution of first order and second order linear differential equations with constant coefficients using Laplace transformation. **[20 lectures; 25 marks]**

4 Numerical solution of differential equations. Multistep method . Predictor – corrector method Runge Kutta of order 2 and 4 . System of differential equations .

[5 lectures; 10 marks]

Learning Objectives:

- To undesratnd singular points.
- To learn power series method to solve differential equations.
- To learn Laplace transforms its application to solve differential equations.
- To learn numerical methods to solve ODE.

Course Outcomes: On completion of the course, students should be able to

- Solve ODE using power series method.
- Solve IVPs using laplace transforms.
- Solve IVPs using numerical methods like rungakutta methods and Milnes Method.

Paper 606 : Operations Research II *

1 Queuing Theory:
Queuing system and its characteristics, Poisson Process, Exponential process, classification of queues – Transient and steady states, (M/M/C) : (∞/FIFO) , (M/M/1) : (∞/FIFO) . Queuing system.
[12 lectures; 16 marks]

2 PERT/CPM: Concepts of network, construction of network, Time estimates, CPM calculation, various floats, PERT calculations. **[11 lectures; 14 marks]**

Transportation Problems: Mathematical formulation, condition for existence of feasible solution, rank of transportation matrix, Initial basic feasible solution by (i) NWC method (ii) Matrix-minima and (iii) VAM, Modi's method to find an optimal solution, balanced and unbalanced transportation problems. **[8 lectures; 10 marks]**

3 Inventory Control:
Basis concepts of Inventory control, definition of inventory costs and other factors, Deterministic inventory problem (3 cases), Probabilistic inventory problems (discrete & continuous units)
[12 lectures; 16 marks]

4 Dynamic Programming;
Bellman's principle of optimality, recursive equation approach, characteristics of Dynamic programming, computational procedure in dynamic programming, multi-stage decision problems, solution of linear programming problem using dynamic programming
[10 lectures; 14 marks]

Assignment Problems: Mathematical formulation, Hungarian methods to solve assignment problems, balanced & unbalanced assignments problems **[7 lectures; 10 marks]**

Learning Objectives:

- To study various models in Inventory controls
- To study project management.
- To study elements of network PERT and CPM.
- To study transportation and assignment problems.
- To study dynamic programming.

Course Outcomes:

By the end of the course, the students should be able to

- Solve basic problems in Queuing theory
- handle project scheduling by CPM and PERT techniques..
- solve transportation problems using MODI method.
- solve dynamic programming problems.
- Find EOQ in inventory models.
- Solve assignment problems using Hungarian method.