

There will be two papers in the subject:

Paper I: Theory (3 hours)80 marks

Paper II: Project Work20 marks

PAPER I (THEORY) – 80 Marks

The syllabus is divided into three sections A, B and C. Section A is compulsory for all candidates. Candidates will have a choice of attempting questions from **EITHER** Section B **OR** Section C.

DISTRIBUTION OF MARKS FOR THE THEORY PAPER

S. No	UNIT	TOTAL WEIGHTAGE
SECTION A:65 MARKS		
1.	Relations and Functions	10 Marks
2.	Algebra	10 Marks
3.	Calculus	32 Marks
4.	Probability	13 Marks
SECTION B: 15 MARKS		
5.	Vectors	5 Marks
6.	Three – Dimensional Geometry	6 Marks
7.	Applications of Integrals	4 Marks
OR		
SECTION C: 15 MARKS		
8.	Application of Calculus	5 Marks
9.	Linear Regression	6 Marks
10.	Linear Programming	4 Marks
TOTAL		80 Marks

SECTION A

1. Relations and Functions

(i) Types of relations: reflexive, symmetric, transitive and equivalence relations. One to one and onto functions, composite functions, inverse of a function. Binary operations.

- *Relations as:*
 - Relation on a set A
 - Identity relation, empty relation, universal relation.
 - Types of Relations: reflexive, symmetric, transitive and equivalence relation.
- *Binary Operation: all axioms and properties*
- *Functions:*
 - As special relations, concept of writing “y is a function of x” as $y = f(x)$.
 - Types: one to one, many to one, into, onto.

- Real Valued function.
- Domain and range of a function.
- Conditions of invertibility.
- Composite functions and invertible functions (algebraic functions only).

(ii) Inverse Trigonometric Functions

Definition, domain, range, principal value branch. Graphs of inverse trigonometric functions. Elementary properties of inverse trigonometric functions.

- Principal values.

- $\sin^{-1} x$, $\cos^{-1} x$, $\tan^{-1} x$ etc. and their graphs.

$$-\sin^{-1} x = \cos^{-1} \sqrt{1-x^2} = \tan^{-1} \frac{x}{\sqrt{1-x^2}}$$

- $\sin^{-1} x = \operatorname{cosec}^{-1} \frac{1}{x}$; $\sin^{-1} x + \cos^{-1} x = \frac{\pi}{2}$ and similar relations for $\cot^{-1} x$, $\tan^{-1} x$ etc.

$$\sin^{-1} x \pm \sin^{-1} y = \sin^{-1} (x\sqrt{1-y^2} \pm y\sqrt{1-x^2})$$

$$\cos^{-1} x \pm \cos^{-1} y = \cos^{-1} (xy \mp \sqrt{1-y^2} \sqrt{1-x^2})$$

$$\text{similarly } \tan^{-1} x + \tan^{-1} y = \tan^{-1} \frac{x+y}{1-xy}, xy < 1$$

$$\tan^{-1} x - \tan^{-1} y = \tan^{-1} \frac{x-y}{1+xy}, xy > -1$$

- Formulae for $2\sin^{-1} x$, $2\cos^{-1} x$, $2\tan^{-1} x$, $3\tan^{-1} x$ etc. and application of these formulae.

2. Algebra

Matrices and Determinants

(i) Matrices

Concept, notation, order, equality, types of matrices, zero and identity matrix, transpose of a matrix, symmetric and skew symmetric matrices. Operation on matrices: Addition and multiplication and multiplication with a scalar. Simple properties of addition, multiplication and scalar multiplication. Noncommutativity of multiplication of matrices and existence of non-zero matrices whose product is the zero matrix (restrict to square matrices of order upto 3). Concept of elementary row and column operations. Invertible matrices and proof of the uniqueness of inverse, if it exists (here all matrices will have real entries).

(ii) Determinants

Determinant of a square matrix (up to 3×3 matrices), properties of determinants, minors, co-factors and applications of determinants in finding the area of a triangle. Adjoint and inverse of a square matrix. Consistency, inconsistency and number of solutions of system of linear equations by examples, solving system of linear equations in two or three variables (having unique solution) using inverse of a matrix.

- Types of matrices ($m \times n$; $m, n \leq 3$), order; Identity matrix, Diagonal matrix.

- Symmetric, Skew symmetric.

- Operation – addition, subtraction, multiplication of a matrix with scalar, multiplication of two matrices (the compatibility).

$$\text{E.g. } \begin{bmatrix} 1 & 1 \\ 0 & 2 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 2 \end{bmatrix} = AB(\text{say}) \text{ but } BA \text{ is not possible.}$$

- Singular and non-singular matrices.

- Existence of two non-zero matrices whose product is a zero matrix.

- Inverse ($2 \times 2, 3 \times 3$) $A^{-1} = \frac{\text{Adj } A}{|A|}$

• Martin's Rule (i.e. using matrices)

$$a_1x + b_1y + c_1z = d_1$$

$$a_2x + b_2y + c_2z = d_2$$

$$a_3x + b_3y + c_3z = d_3$$

$$A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \quad B = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix} \quad X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

$$AX = B \implies X = A^{-1}B$$

Problem based on above.

NOTE 1: The conditions for consistency of equations in two and three variables, using matrices, are to be covered.

NOTE 2: Inverse of a matrix by elementary operations to be covered.

• Determinants

- Order.

- Minors.

- Cofactors.

- Expansion.

- Applications of determinants in finding the area of triangle and collinearity.

- Properties of determinants. Problems based on properties of determinants.

3. Calculus

(i) Continuity, Differentiability and Differentiation. Continuity and differentiability, derivative of composite functions, chain rule, derivatives of inverse trigonometric functions, derivative of implicit functions. Concept of exponential and logarithmic functions.

Derivatives of logarithmic and exponential functions. Logarithmic differentiation, derivative of functions expressed in parametric forms. Second order derivatives. Rolle's and Lagrange's Mean Value Theorems (without proof) and their geometric interpretation.

- *Continuity*

- *Continuity of a function at a point $x = a$.*
- *Continuity of a function in an interval.*
- *Algebra of continuous function.*
- *Removable discontinuity.*

- *Differentiation*

- *Concept of continuity and differentiability of x , $[x]$, etc.*
- *Derivatives of trigonometric functions.*
- *Derivatives of exponential functions.*
- *Derivatives of logarithmic functions.*
- *Derivatives of inverse trigonometric functions*
- *differentiation by means of substitution.*
- *Derivatives of implicit functions and chain rule.*
- *e for composite functions.*
- *Derivatives of Parametric functions.*
- *Differentiation of a function with respect to another function e.g. differentiation of $\sin x^3$ with respect to x^3 .*
- *Logarithmic Differentiation*
Finding dy/dx when $y = x^{x^x}$.
- *Successive differentiation up to 2nd order*

NOTE 1: *Derivatives of composite functions using chain rule.*

NOTE 2: *Derivatives of determinants to be covered.*

- *L' Hospital's theorem.*
 - $\frac{0}{0}$ form, $\frac{\infty}{\infty}$ form, 0^0 form, ∞^∞ form etc.
- *Rolle's Mean Value Theorem - its geometrical interpretation.*
- *Lagrange's Mean Value Theorem - its geometrical interpretation*

(ii) *Applications of Derivatives*

Applications of derivatives: rate of change of bodies, increasing/decreasing functions, tangents and normals, use of derivatives in approximation, maxima and minima (first derivative test motivated geometrically and second derivative test given as a provable tool). Simple problems (that illustrate basic principles and understanding of the subject as well as real-life situations).

- *Equation of Tangent and Normal*

- Approximation.
- Rate measure.
- Increasing and decreasing functions.
- Maxima and minima.
 - Stationary/turning points.
 - Absolute maxima/minima
 - local maxima/minima
 - First derivatives test and second derivatives test
 - Point of inflexion.
 - Application problems based on maxima and minima.

(iii) Integrals

Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts, Evaluation of simple integrals of the following types and problems based on them.

Definite integrals as a limit of a sum, Fundamental Theorem of Calculus (without proof). Basic properties of definite integrals and evaluation of definite integrals.

- Indefinite integral
 - Integration as the inverse of differentiation.
 - Anti-derivatives of polynomials and functions $(ax + b)^n$, $\sin x$, $\cos x$, $\sec^2 x$, $\operatorname{cosec}^2 x$ etc.
 - Integrals of the type $\sin^2 x$, $\sin^3 x$, $\sin^4 x$, $\cos^2 x$, $\cos^3 x$, $\cos^4 x$.
 - Integration of $1/x$, e^x .
 - Integration by substitution.
 - Integrals of the type $f'(x)[f(x)]^n$, $\frac{f'(x)}{f(x)}$.
 - Integration of $\tan x$, $\cot x$, $\sec x$, $\operatorname{cosec} x$.
 - Integration by parts.
 - Integration using partial fractions.

Expressions of the form $\frac{f(x)}{g(x)}$ when degree of $f(x) <$ degree of $g(x)$

E.g. $\frac{x+2}{(x-3)(x+1)} = \frac{A}{x-3} + \frac{B}{x+1}$
 $\frac{x+2}{(x-2)(x-1)^2} = \frac{A}{x-1} + \frac{B}{(x-1)^2} + \frac{C}{x-2}$
 $\frac{x+1}{(x^2+3)(x-1)} = \frac{Ax+B}{x^2+3} + \frac{C}{x-1}$

When degree of $f(x) \geq$ degree of $g(x)$,

E.g. $\frac{x^2+1}{x^2+3x+2} = 1 - \frac{3x+1}{x^2+3x+2}$

- Integrals of the type:

$$\int \frac{dx}{x^2 \pm a^2}, \int \frac{dx}{\sqrt{x^2 \pm a^2}}, \int \frac{px+q}{ax^2+bx+c} dx, \int \frac{px+q}{\sqrt{ax^2+bx+c}} dx$$

$$\text{and } \int \sqrt{a^2 \pm x^2} dx, \int \sqrt{x^2 - a^2} dx, \int \sqrt{ax^2 + bx + c} dx,$$

$$\int (px + q) \sqrt{ax^2 + bx + c} dx,$$

Integrations reducible to the above forms.

$$\int \frac{dx}{a \cos x + b \sin x}, \int \frac{dx}{a + b \cos x}, \int \frac{dx}{a + b \sin x}, \int \frac{dx}{a \cos x + b \sin x + c},$$

$$\int \frac{(a\cos x + b\sin x)dx}{c\cos x + d\sin x}, \int \frac{dx}{a\cos^2 x + b\sin^2 x + c}, \int \frac{1 \pm x^2}{1 + x^4} dx, \int \frac{dx}{1 + x^4},$$

$$\int \sqrt{\tan x} dx, \int \sqrt{\cot x} dx \text{ etc.}$$

• *Definite Integral*

- *Definite integral as a limit of the sum.*

- *Fundamental theorem of calculus (without proof)*

- *Properties of definite integrals.*

- *Problems based on the following properties of definite integrals are to be covered.*

$$\int_a^b f(x)dx = \int_a^b f(t)dt$$

$$\int_a^b f(x)dx = \int_b^a f(x)dx$$

$$\int_a^b f(x)dx = \int_a^c f(x)dx + \int_c^b f(x)dx$$

Where $a < c < b$

$$\int_a^b f(x)dx = \int_a^b f(a + b - x)dx$$

$$\int_0^a f(x)dx = \int_0^a f(a - x)dx$$

$$\int_0^{2a} f(x)dx = \begin{cases} 2 \int_0^a f(x)dx, & \text{if } f(2a - x) = f(x) \\ 0, & \text{if } f(2a - x) \neq f(x) \end{cases}$$

$$\int_{-a}^a f(x)dx = \begin{cases} 2 \int_0^a f(x)dx, & \text{if } f \text{ is an even function} \\ 0, & \text{if } f \text{ is an odd function} \end{cases}$$

iv) *Differential Equations*

Definition, order and degree, general and particular solutions of a differential equation. Formation of differential equation whose general solution is given. Solution of differential equations by method of separation of variables solutions of homogeneous differential equations of first order and first degree. Solutions of linear differential equation of the type: $\frac{dy}{dx} + py = q$, where p and q are functions of x or constants. $\frac{dx}{dy} + py = q$, where p and q are functions of y or constants.

- *Differential equations, order and degree.*

- *Formation of differential equation by eliminating arbitrary constant(s).*

- Solution of differential equations.
- Variable separable.
- Homogeneous equations.
- Linear form $\frac{dy}{dx} + py = Q$ where P and Q are functions of x only. Similarly, for $\frac{dx}{dy}$.
- Solve problems of application on growth and decay.
- Solve problems on velocity, acceleration, distance and time.
- Solve population-based problems on application of differential equations.
- Solve problems of application on coordinate geometry.

NOTE 1: Equations reducible to variable separable type are included.

NOTE 2: The second order differential equations are excluded.

4. Probability

Conditional probability, multiplication theorem on probability, independent events, total probability, Bayes' theorem, Random variable and its probability distribution, mean and variance of random variable. Repeated independent (Bernoulli) trials and Binomial distribution.

- Independent and dependent events conditional events.
- Laws of Probability, addition theorem, multiplication theorem, conditional probability.
- Theorem of Total Probability.
- Baye's theorem.
- Theoretical probability distribution, probability distribution function; mean and variance of random variable, Repeated independent (Bernoulli trials), binomial distribution – its mean and variance.

SECTION B

5. Vectors

Vectors and scalars, magnitude and direction of a vector. Direction cosines and direction ratios of a vector. Types of vectors (equal, unit, zero, parallel and collinear vectors), position vector of a point, negative of a vector, components of a vector, addition of vectors, multiplication of a vector by a scalar, position vector of a point dividing a line segment in a given ratio. Definition, Geometrical Interpretation, properties and application of scalar (dot) product of vectors, vector (cross) product of vectors, scalar triple product of vectors.

- As directed line segments.
- Magnitude and direction of a vector.
- Types: equal vectors, unit vectors, zero vector.
- Position vector. - Components of a vector.
- Vectors in two and three dimensions.

- $\hat{i}, \hat{j}, \hat{k}$ as unit vectors along the x, y and the z axes; expressing a vector in terms of the unit vectors.
- Operations: Sum and Difference of vectors; scalar multiplication of a vector.
- Section formula.
- Triangle inequalities.
- Scalar (dot) product of vectors and its geometrical significance.
- Cross product - its properties - area of a triangle, area of parallelogram, collinear vectors.
- Scalar triple product - volume of a parallelepiped, co-planarity.

NOTE: Proofs of geometrical theorems by using Vector algebra are excluded.

6. Three - dimensional Geometry

Direction cosines and direction ratios of a line joining two points. Cartesian equation and vector equation of a line, coplanar and skew lines, shortest distance between two lines. Cartesian and vector equation of a plane. Angle between (i) two lines, (ii) two planes, (iii) a line and a plane. Distance of a point from a plane.

- Equation of x -axis, y -axis, z axis and lines parallel to them.
- Equation of xy - plane, yz - plane, zx - plane.
- Direction cosines, direction ratios.
- Angle between two lines in terms of direction cosines /direction ratios.
- Condition for lines to be perpendicular/ parallel.

• Lines

- Cartesian and vector equations of a line through one and two points.
- Coplanar and skew lines.
- Conditions for intersection of two lines.
- Distance of a point from a line.
- Shortest distance between two lines.

NOTE: Symmetric and non-symmetric forms of lines are required to be covered.

• Planes

- Cartesian and vector equation of a plane.
- Direction ratios of the normal to the plane.
- One point form.
- Normal form.
- Intercept form.
- Distance of a point from a plane.
- Intersection of the line and plane.
- Angle between two planes, a line and a plane.
- Equation of a plane through the intersection of two planes i.e. $P_1 + kP_2 = 0$.

7. Application of Integrals

Application in finding the area bounded by simple curves and coordinate axes. Area enclosed between two curves.

- Application of definite integrals - area bounded by curves, lines and coordinate axes is required to be covered.
- Simple curves: lines, circles/ parabolas/ ellipses, polynomial functions, modulus function, trigonometric function, exponential functions, logarithmic functions.

SECTION C

8. Application of Calculus

Application of Calculus in Commerce and Economics in the following:

- Cost function,
- average cost,
- marginal cost and its interpretation
- demand function,
- revenue function,
- marginal revenue function and its interpretation,
- Profit function and breakeven point.
- Rough sketching of the following curves: AR, MR, R, C, AC, MC and their mathematical interpretation using the concept of maxima & minima and increasing-decreasing functions.

Self-explanatory

NOTE: Application involving differentiation, integration, increasing and decreasing function and maxima and minima to be covered.

9. Linear Regression

- Lines of regression of x on y and y on x.
- Scatter diagrams
- The method of least squares.
- Lines of best fit.
- Regression coefficient of x on y and y on x.
- $b_{xy} \times b_{yx} = r^2, 0 \leq b_{xy} \times b_{yx} \leq 1$
- Identification of regression equations
- Angle between regression line and properties of regression lines.
- Estimation of the value of one variable using the value of other variable from appropriate line of regression.

Self-explanatory

10. Linear Programming

Introduction, related terminology such as constraints, objective function, optimization, different types of linear programming (L.P.) problems, mathematical formulation of L.P. problems, graphical method of solution for problems in two variables, feasible and infeasible regions (bounded and unbounded), feasible and infeasible solutions, optimal feasible solutions (up to three non-trivial constraints).

Introduction, definition of related terminology such as constraints, objective function, optimization, advantages of linear programming; limitations of linear programming;

application areas of linear programming; different types of linear programming (L.P.) problems, mathematical formulation of L.P problems, graphical method of solution for problems in two variables, feasible and infeasible regions, feasible and infeasible solutions, optimum feasible solution.

PAPER II – PROJECT WORK – 20 Marks

Candidates will be expected to have completed two projects, one from Section A and one from either Section B or Section C.

