MATHEMATICS/ APPLIED MATHEMATICS

Mathematics/Applied Mathematics

SECTION A

1. Algebra

(i) Matrices and types of Matrices

(ii) Equality of Matrices, transpose of a Matrix, Symmetric and Skew Symmetric Matrix

(iii) Algebra of Matrices

(iv) Determinants

(v) Inverse of a Matrix

(vi) Solving of simultaneous equations using Matrix Method

2. Calculus

(i) Higher order derivatives

(ii) Tangents and Normals

(iii) Increasing and Decreasing Functions

(iv). Maxima and Minima

3. Integration and its Applications

(i) Indefinite integrals of simple functions

(ii) Evaluation of indefinite integrals

(iii) Definite Integrals

(iv). Application of Integration as area under the curve

4. Differential Equations

(i) Order and degree of differential equations

(ii) Formulating and solving of differential equations with variable separable

5. Probability Distributions

(i) Random variables and its probability distribution

(ii) Expected value of a random variable

(iii) Variance and Standard Deviation of a random variable

(iv). Binomial Distribution

6. Linear Programming

(i) Mathematical formulation of Linear Programming Problem

(ii) Graphical method of solution for problems in two variables

(iii) Feasible and infeasible regions

(iv). Optimal feasible solution

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Section B1: Mathematics

UNIT I: RELATIONS AND FUNCTIONS

1. Relations and Functions

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

2. Inverse Trigonometric Functions

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

UNIT II: ALGEBRA

1. Matrices

Concept, notation, order, equality, types of matrices, zero matrix, transpose of a matrix, symmetric and skew symmetric matrices. Addition, multiplication and scalar multiplication of matrices, simple properties of addition, multiplication and scalar multiplication. Non-commutativity of multiplication of matrices and existence of non-zero matrices whose product is the zero matrix (restrict to square matrices of order 2). 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).

2. Determinants

Determinant of a square matrix (up to 3×3 matrices), properties of determinants, minors, cofactors 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.

UNIT III: CALCULUS

1. Continuity and Differentiability

Continuity and differentiability, derivative of composite functions, chain rule, derivatives of inverse trigonometric functions, derivative of implicit function. Concepts of exponential, logarithmic functions. Derivatives of log x and e^x. 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 interpretations.

2. Applications of Derivatives

Applications of derivatives: Rate of change, increasing/decreasing functions, tangents and normals, 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). Tangent and Normal.

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3. Integrals

Integration as inverseprocess of differentiation. Integration of avarietyof functions bysubstitution, bypartial fractions andbyparts, onlysimpleintegrals ofthetype –

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

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

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

to be evaluated.

Definite integrals as a limit of a sum. Fundamental Theorem of Calculus (without proof). Basic propertiesofdefiniteintegrals andevaluationofdefiniteintegrals.

4. Applications of the Integrals

Applications in finding the area under simple curves, especiallylines, arcs of circles/parabolas/ellipses (in standard form only), area between the two above said curves (the region should be cleraly identifiable).

5. Differential Equations

Definition, orderand degree, general andparticular solutions of adifferential equation. Formation of differential equation whose general solution is given. Solution of differential equations bymethod of separation of variables, homogeneous differential equations of first order and first degree. Solutions of linear differential equation ofthetype –

$$\frac{dy}{dx} + Py = Q, \text{ where P and Q are functions of } x \text{ or constant}$$

$$\frac{dx}{dy} + Px = Q, \text{ where P and Q are functions of } y \text{ or constant}$$

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UNIT IV: VECTORSAND THREE-DIMENSIONALGEOMETRY

1. Vectors

Vectors and scalars, magnitude and direction of a vector. Direction cosines/ratios of vectors. 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. Scalar (dot) product of vectors, projection of a vector on a line. Vector (cross) product of vectors, scalar triple product.

2. Three-dimensional Geometry

Direction cosines/ratios of alinejoiningtwo points. Cartesian andvector equation of a line, coplanar and skew lines, shortest distance between two lines. Cartesian and vector equation of a plane.Angle between(i) twolines, (ii) two planes, (iii) a lineand a plane. Distance of apoint from a plane.

UnitV: Linear Programming

Introduction, related terminologysuch as constraints, objectivefunction, optimization, different types of linearprogramming(L.P.) problems, mathematicalformulation of L.P. problems, graphicalmethod of solution for problems in two variables, feasible and infeasible regions, feasible and infeasible solutions,optimalfeasiblesolutions(uptothreenon-trivialconstrains).

UnitVI: Probability

Multiplicationstheorem on probability. Conditionalprobability, independentevents, total probability, Baye's theorem. Random variable and its probability distribution, mean and variance of haphazard variable.Repeatedindependent(Bernoulli)trialsandBinomialdistribution.

Section B2: Applied Mathematics

Unit I: Numbers, Quantification and Numerical Applications

A. Modulo Arithmetic
- Define modulus of an integer
- Apply arithmetic operations using modular arithmetic rules

B. Congruence Modulo
- Define congruence modulo
- Apply the definition in variousproblems

C. Allegation andMixture
- Understand the rule of allegation to produce a mixture at a givenprice
- Determine the mean price of amixture
- Apply rule of allegation

D. Numerical Problems
- Solve real life problems mathematically

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E. Boats and Streams
- Distinguish between upstreamand downstream
- Express the problem in the formof an equation

F. Pipes andCisterns
- Determine the time taken bytwo or more pipes to fill or

G. Races andGames
- Compare the performance oftwo players w.r.t. time,
- distance taken/distance covered/ Work done from the givendata

H. Partnership
- Differentiate between activepartner and sleeping partner
- Determine the gain or loss tobe divided among the partners in the ratio of their investment with due
- consideration of the time volume/surface area for solid formed using two ormore shapes

I. Numerical Inequalities
- Describe the basic concepts ofnumerical inequalities
- Understand and write numericalinequalities

UNIT II: ALGEBRA
A. Matrices andtypes of matrices
- Define matrix
- Identify different kinds ofmatrices

B. Equality of matrices, Transpose of amatrix, Symmetric andSkew symmetric matrix
- Determine equality of twomatrices
- Write transpose of given matrix
- Define symmetric and skewsymmetric matrix

UNIT III: CALCULUS

A. Higher OrderDerivatives
- Determine second and higherorder derivatives
- Understand differentiation ofparametric functions and implicit functions Identify dependent andindependent variables

B. Marginal Cost and Marginal Revenue usingderivatives
- Define marginal cost andmarginal revenue
- Find marginal cost and marginalrevenue

C. Maxima andMinima
- Determine critical points of thefunction
- Find the point(s) of local maxima and local minima and corresponding local maximumand local minimum values
- Find the absolute maximum and absolute minimum value of afunction

UNIT IV: PROBABILITY DISTRIBUTIONS

A. Probability Distribution
- Understand the concept ofRandom Variables and its Probability Distributions
- Find probability distribution ofdiscrete random variable

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B. Mathematical Expectation
- Apply arithmetic mean of frequency distribution to find the expected value of a random variable

C. Variance
- Calculate the Variance and S.D.of a random variable

UNIT V: INDEX NUMBERS AND TIME BASED DATA

A. Index Numbers
- Define Index numbers as aspecial type of average

B. Construction ofIndex numbers
- Construct different type of indexnumbers

C. Test of Adequacy of Index Numbers
- Apply time reversal test

D. Time Series
- Identify time series aschronological data

E. Components ofTime Series
- Distinguish between differentcomponents of time series

F. Time Series analysis for univariate data
Solve practical problems basedon statistical data and Interpret

UNIT VI : INFERENTIAL STATISTICS

A. Population andSample
- Define Population and Sample
- Differentiate between population and sample
- Define a representative samplefrom a population

B. Parameter andStatistics and Statistical Interferences
- Define Parameter with reference to Population
- Define Statistics with referenceto Sample
- Explain the relation betweenParameter and Statistic
- Explain the limitation of Statisticto generalize the estimation for population
- Interpret the concept of Statistical Significance andStatistical Inferences
- State Central Limit Theorem
- Explain the relation betweenPopulation-Sampling Distribution-Sample

UNIT VII: FINANCIAL MATHEMATICS

A. Perpetuity, Sinking Funds
- Explain the concept of perpetuity and sinking fund
- Calculate perpetuity
- Differentiate between sinkingfund and saving account

B. Valuation ofBonds
- Define the concept of valuationof bond and related terms

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- Calculate value of bond usingpresent value approach

C. Calculation ofEMI
- Explain the concept of EMI
- Calculate EMI using variousmethods

D. Linear method of Depreciation
- Define the concept of linearmethod of Depreciation
- Interpret cost, residual value and useful life of an asset fromthe given information
- Calculate depreciation

UNIT VIII: LINEAR PROGRAMMING

A. Introductionand relatedterminology
- Familiarize with terms related toLinear Programming Problem

B. Mathematicalformulation ofLinear ProgrammingProblem
- Formulate Linear ProgrammingProblem

C. Different types of Linear Programming Problems
- Identify and formulate differenttypes of LPP

D. Graphical Method of Solution for problems in two Variables
- Draw the Graph for a system oflinear inequalities involving twovariables and to find its solutiongraphically

E. Feasible and InfeasibleRegions
- Identify feasible, infeasible andbounded regions

F. Feasible andinfeasible solutions, optimal feasible solution
- Understand feasible andinfeasible solutions
- Find optimal feasible solution