# SRI A.S.N.M GOVERNEMENT COLLEGE (A), PALAKOL

# B.Sc (MATHEMATICS) (For M.P.C, M.P.Cs,M.C.Cs,M.S.Ds) Syllabus



### SRI A.S.N.M. GOVERNMENT COLLEGE(A), PALAKOL. W.G.DT (Affiliated to Adikavi Nannaya University, Rajahmahendravaram) (Accredited with NAAC "B" Grade with 2.61 CGPA ) I B.Sc Mathematics (for 2021-2024 batch, w.e.f 2020-21) Paper I, Syllabus for I semester **Differential Equations**

<b>UNIT - I:</b> (12 Hours) <b>Differential equations of first order and first degree</b> (10 Marks-2,5 Marks-Bridge Course- Basics of Differential equations and Integration (No question to be given from this portion)
Itolii ulis portioli) Additional Input: (Variables Senarable, Homogeneous Differential equations)
Linear differential equations: Differential equations reducible to linear form: Exact
differential equations: Integrating factors: Change of variables.
UNIT – II (12 Hours) Differential Equations of first order but not of the first degree :
(10Marks-2, 5Marks-1)
<b>Orthogonal Trajectories,</b> Equations solvable for p, Equations solvable for y, Equation solvable for x, Equations that do not contain x (or) y, Equations of the first degree in x a y. Claimatica Equation
y- Chairaut S Equation. UNIT-III. (12 Hours) Higher order linear differential equations I (10 Marks 2, 5 Marks 1)
Solution of homogeneous linear differential equations of order n with consta coefficients; Solution of the non-homogeneous linear differential equations with consta coefficients by means of polynomial operators. General Solution of f(D)y=0
General Solution of $f(D)y=Q$ , where Q is a function of x.
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$\overline{f(D)}$ is Expressed as partial fractions.
P.I. of $f(D)y = Q$ when $Q = be^{ax}$
P.I. of $f(D)y = Q$ when $Q = b \sin ax$ or $b \cos ax$ .
UNIT-IV: (12 Hours) Higher order linear differential equations II (10Marks-2, 5Marks-2)
Solution of the non-homogeneous linear differential equations with constant coefficients.
P.I. of $f(D)y = Q$ when $Q = bx^k$
P.I. of $f(D)y = Q$ when $Q = e^{ax}V$ , where V is a function of x.
P.I. of $f(D)y = Q$ when $Q = xV$ , where V is a function of x.
P L of $f(D)y = O$ when $O = x^m V$ where V is a function of x
<b>UNIT-V:</b> (12 Hours) Higher order linear differential equations III (10Marks-2, 5Marks-2)
Method of Variation of Parameters; Linear Differential Equations with Non-Constant
Coefficients, The Cauchy-Euler equation, Legendre's linear equations, miscellaneous
Differential equations.
Prescribed Text Book: (1) A Text Book of B.Sc Mathematics Volume-I (S.Chand & Company)
(V. Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastr
Reference Books: (1) Ordinary and Partial Differential Equations Raisingnania, published of
S. Chand & Company, New Deini.
(2) Differential Equations with applications and programs – S. Balachand
Rao & HK Anuradha- universities press.
(3) Differential Equations and Their Applications by Zafarpublished
Prentice-Hall of India Learning Pvt. Ltd. New Delhi-

Second edition. <u>Suggested Activities:</u>Seminar/ Quiz/ Assignments

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### **UNIT – I (12 hrs) : The Plane :** (10 Marks-2,5 Marks-1)

Equation of plane in terms of its intercepts on the axis, Equations of the plane through the given points, Length of the perpendicular from a given point to a given plane, **Bisectors** of angles between two planes, Combined equation of two planes, Orthogonal projection on a plane.

#### **UNIT – II (12 hrs) : The Line :** (10Marks-2, 5Marks-2)

Equation of a line; Angle between a line and a plane; The condition that a given line may lie in a given plane; The condition that two given lines are coplanar; Number of arbitrary constants in the equations of straight line; Sets of conditions which determine a line; The shortest distance between two lines; The length and equations of the line of shortest distance between two straight lines; Length of the perpendicular from a given point to a given line.

UNIT – III (12 hrs) : Sphere : (10Marks-1, 5Marks-2)

**Definition and equation of the sphere**; Equation of the sphere through four given points; Plane sections of a sphere; Intersection of two spheres; Equation of a circle; Sphere through a given circle; Intersection of a sphere and a line; Power of a point; Tangent plane; Plane of contact; Polar plane; Pole of a Plane; Conjugate points; Conjugate planes.

UNIT – IV(12 hrs):Sphere&Cones : (10Marks-3, 5Marks-2)(10 Marks Questions from Sphere 2 and Cone 1)

Angle of intersection of two spheres; Conditions for two spheres to be orthogonal; Radical plane; Coaxial system of spheres; Simplified form of the equation of two spheres, limiting points.

Definitions of a cone; vertex; guiding curve; generators; Equation of the cone with a given vertex and guiding curve; Enveloping cone of a sphere; Equations of cones with vertex at origin are homogenous; Condition that the general equation of the second degree should represent a cone; Condition that a cone may have three mutually perpendicular generators. **UNIT – V (12 hrs) Cones:** (10Marks-2, 5Marks-1)

Intersection of a line and a quadric cone; Tangent lines and tangent plane at a point; Condition that a plane may touch a cone; Reciprocal cones; Intersection of two cones with a common vertex; Right circular cone; Equation of the right circular cone with a given vertex; axis and semi-vertical angle.

Prescribed Text Book: (1) A Text Book of B.Sc Mathematics Volume-I (S.Chand & Company)

(V.Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastry) **Reference Books :** 

1. Analytical Solid Geometry by Shanti Narayan and P.K. Mittal, Published by S. Chand &

Company Ltd. 7th Edition.

- 2. A text Book of Analytical Geometry of Three Dimensions, by P.K. Jain and Khaleel Ahmed, Published by Wiley Eastern Ltd., 1999.
- 3. Co-ordinate Geometry of two and three dimensions by P. Balasubrahmanyam, K.Y. Subrahmanyam, G.R. Venkataraman published by Tata-MC Gran-Hill Publishers Company Ltd., New Delh

# SRI A.S.N.M. GOVERNMENT COLLEGE(A), PALAKOL. W.G.DT (Affiliated to Adikavi Nannaya University, Rajahmahendravaram) (Accredited with NAAC "B" Grade with 2.61 CGPA ) II B.Sc Mathematics (for 2019-2022 batch, w.e.f 2016-17) Paper III, Syllabus for III semester

# Abstract Algebra

# UNIT – 1 : (10 Hrs) Groups(10 Marks-2, 5 Marks-1)

Binary Operation – Algebraic structure – semi group-monoid – Group definition and elementary properties Finite and Infinite groups – examples – order of a group. Composition tables with examples.

### UNIT - 2 : (14 Hrs) Subgroups, Co-Sets and Lagrange's Theorem

(10 Marks-2, 5 Marks-2)

Complex Definition – Multiplication of two complexes Inverse of a complex-Subgroup definition – examples-criterion for a complex to be a subgroups.

Criterion for the product of two subgroups to be a subgroup-union and Intersection of subgroups.

Cosets Definition – properties of Cosets–Index of a subgroups of a finite groups–Lagrange's Theorem.

### UNIT -3: (12 Hrs) Normal Subgroups(10 Marks-2, 5 Marks-2)

Definition of normal subgroup – proper and improper normal subgroup–Hamilton group – criterion for a subgroup to be a normal subgroup – intersection of two normal subgroups – Sub group of index 2 is a normal sub group – simple group – quotient group – criteria for the existence of a quotient group.(ADDITIONAL INPUT: SYLOWS THEOREMS)

# **Homomorphism:**

Definition of homomorphism – Image of homomorphism elementary properties of homomorphism – Isomorphism – automorphism definitions and elementary properties–kernel of a homomorphism – fundamental theorem on Homomorphism and applications.

UNIT – 4 : (10 Hrs) Permutation Group: (10 Marks-2, 5 Marks-2)

Definition of permutation – permutation multiplication – Inverse of a permutation – cyclic permutations – transposition – even and odd permutations – **Cayley's theorem. Cyclic Groups :-**

Definition of cyclic group – elementary properties – classification of cyclic groups.

UNIT - 5: (14 Hrs) Rings: (10 Marks-2, 5 Marks-1)

Definition of Ring and basic properties, Boolean Rings, divisors of zero and cancellation laws Rings, Integral Domains, Division Ring and Fields, The characteristic of a ring - The characteristic of an Integral Domain, The characteristic of a Field. Sub Rings, Ideals

Prescribed Text Book: A Text Book of B.Sc Mathematics Volume-II (S.Chand & Company)

(V.Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastry )

ADDITIONAL INPUTS : SYLOWS THEOREMS

#### **Reference Books :**

1. A. First course in Abstract Algebra, by J.B. Fraleigh Published by Narosa Publishinghouse.

2. Modern Algebra by M.L. Khanna

# SRI A.S.N.M. GOVERNMENT COLLEGE(A), PALAKOL. W.G.DT (Affiliated to Adikavi Nannaya University, Rajahmahendravaram) (Accredited with NAAC "B" Grade with 2.61 CGPA II B.Sc Mathematics (for 2020-2023 batch, w.e.f 2021-22) Paper IV, Syllabus for IV semester

# Real Analysis

# UNIT – I (12 hrs) : REAL NUMBERS

The algebraic and order properties of R, Absolute value and Real line, Completeness property of R, Applications of supreme property; intervals. (No. Question is to be set from this portion) Real Sequences (10 Marks-2, 5 Marks-2)

Sequences and their limits, Range and Boundedness of Sequences, Limit of a sequence and Convergent sequence.

The Cauchy's criterion, properly **divergent sequences**, Monotone sequences, Necessary and Sufficient condition for Convergence of Monotone Sequence, Limit Point of Sequence, Sub sequences and the Bolzano-weierstrass theorem – **Cauchy Sequences** – Cauchy's general principle of convergence theorem.

UNIT -II (12 hrs) : INFINITIE SERIES(10 Marks-2, 5 Marks-2)

**Series :** Introduction to series, convergence of series. Cauchy's general principle of convergence for series tests for convergence of series, Series of Non-Negative Terms.

#### 1. P-test

2. Canchy's n<sup>th</sup> root test or Root Test.

3. D-Alembert's Test or Ratio Test.

4. Alternating Series – Leibnitz Test.

Absolute convergence and conditional convergence, semi convergence.

UNIT – III (12 hrs) : CONTINUITY (10 Marks-1, 5 Marks-1)

Limits : Real valued Functions, Boundedness of a function, Limits of functions. Some extensions of the limit concept, Infinite Limits. Limits at infinity. (No. Question is to be set from this portion) Continuous functions : Continuous functions, Combinations of continuous functions, Continuous

Functions on intervals, uniform continuity.

# UNIT - IV (12 hrs) : DIFFERENTIATION & MEAN VALUE THEOREMS

(10 Marks-2, 5 Marks-2)

The derivability of a function, on an interval, at a point, Derivability and continuity of a function, Graphical meaning of the Derivative, Mean value Theorems; Role's Theorem, Lagrange's Theorem, Cauchy's Mean value Theorem.

#### **ADDITIONAL INPUT:**

Generalized Mean value Theorems - Taylor's Theorem(Statement Only), Maclaurin's Theorem(Statement only), Expansion of functions with different forms of remainders, Taylor's Maclaurins Series, power series representation of functions.

UNIT – V (12 hrs) : RIEMANN INTEGRATION(10 Marks-3, 5 Marks-1)

**Riemann Integral**, Riemann integral functions, Darboux theorem. Necessary and sufficient condition for R – integrability, Properties of integrable functions, **Fundamental theorem of integral calculus**, integral as the limit of a sum, Mean value Theorems.

**Prescribed Text Book:** A Text Book of B.Sc Mathematics Volume-II (S.Chand & Company)

(V.Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastry ) **REFERENCE TEXT BOOKS :** 

1. "Introduction to Real Analysis" by RABERT g BARTELY and .D.R. SHERBART Published by

# SRI A.S.N.M. GOVERNMENT COLLEGE(A), PALAKOL. W.G.DT (Affiliated to Adikavi Nannaya University, Rajahmahendravaram) (Accredited with NAAC "B" Grade with 2.61 CGPA points)

II B.Sc Mathematics (for 2020-2023 batch, w.e.f 2021-22) Paper V, Syllabus for IV semester LINEAR ALGEBRA

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#### UNIT – I (12 hrs) : Vector Spaces-I(10Marks-2, 5Marks-2)

Vector Spaces, General properties of vector spaces, n-dimensional Vectors, addition and scalar multiplication of Vectors, internal and external composition, Null space, Vector subspaces, Algebra of subspaces, Linear Sum of two subspaces, linear combination of Vectors, Linear span Linear independence and Linear dependence of Vectors.

UNIT -II (12 hrs) : Vector Spaces-II(10Marks-2, 5Marks-1)

**Basis of Vector space**, Finite dimensional Vector spaces, basis extension, **co-ordinates**, Dimension of a Vector space, Dimension of a subspace, Quotient space and **Dimension of Quotientspace**.

### UNIT –III (12 hrs) : Linear Transformations (10Marks-2, 5Marks-2)

**Linear transformations, linear operators**, Properties of L.T, sum and product of LTs, Algebra of Linear Operators, Range and null space of linear transformation, Rank and Nullity of linear transformations – Rank – Nullity Theorem.

#### UNIT -IV (12 hrs) : Matrix(10Marks-2, 5Marks-1)

Linear Equations, Characteristic Roots, Characteristic Values & Vectors of square Matrix, Cayley – Hamilton Theorem.

# UNIT -V (12 hrs) : Inner product space(10Marks-2, 5Marks-2)

Inner product spaces, Euclidean and unitary spaces, Norm or length of a Vector, Schwartz inequality, Triangle in Inequality, Parallelogram law, Orthogonality, Orthonormal set, complete orthonormal set, Gram – Schmidt orthogonalisation process. Bessel's inequality and Parseval's Identity.

#### **Prescribed Text Books:**

(1) A Text Book of B.Sc Mathematics Volume-III (S.Chand & Company)

(V.Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastry)

# **Reference Books :**

- 1. Linear Algebra by J.N. Sharma and A.R. Vasista, published by Krishna Prakashan Mandir, Meerut- 250002.
- 2. Matrices by Shanti Narayana, published by S.Chand Publications.
- 3. Linear Algebra by Kenneth Hoffman and Ray Kunze, published by Pearson Education (low priced edition), New Delhi.
- 4. Linear Algebra by Stephen H. Friedberg et al published by Prentice Hall of India Pvt. Ltd. 4<sup>th</sup> Edition 2007.

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#### III B.Sc Mathematics (for 2019-2022 batch, w.e.f 2017-18) PaperV, Syllabus for V semester **RING THEORY & VECTOR CALCULUS**

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# <u>UNIT – 1 (12 hrs) Rings-I (10Marks-2, 5Marks-2)</u>

Definition of Ring and basic properties, Boolean Rings, divisors of zero and cancellation laws Rings, Integral Domains, Division Ring and Fields, The characteristic of a ring - The characteristic of an Integral Domain, The characteristic of a Field. Sub Rings, Ideals

### <u>UNIT – 2 (12 hrs) Rings-II(10Marks-2, 5Marks-2)</u>

Definition of Homomorphism – Homomorphic Image – Elementary Properties of Homomorphism –Kernel of a Homomorphism – Fundamental theorem of Homomorphism – Maximal Ideals – Prime Ideals.

#### <u>UNIT –3 (12 hrs) Vector Differentiation (10Marks-2, 5Marks-2)</u>

Vector Differentiation, Ordinary derivatives of vectors, Differentiability, Gradient, Divergence, Curl operators, Formulae Involving these operators.

#### UNIT – 4 (12 hrs) Vector Integration (10Marks-2, 5Marks-1)

Line Integral, Surface Integral, Volume integral with examples.

#### <u>UNIT – 5 (12 hrs) Vector Integration Applications (10Marks-2, 5Marks-1)</u>

Theorems of Gauss and Stokes, Green's theorem in plane and applications of these

theorems.

### Prescribed book:

(1) A Text Book of B.Sc Mathematics Volume-III (S.Chand & Company)

(V.Venkateswara Rao, N.Krishnamurthy, B.V.S.S.Sarma, S.Anjaneya Sastry )

# **<u>Reference Books</u>**:-

1. Abstract Algebra by J. Fralieh, Published by Narosa Publishing house.

2. Vector Calculus by Santhi Narayana, Published by S. Chand & Company Pvt. Ltd.,

New

Delhi.

3. Vector Calculus by R. Gupta, Published by Laxmi Publications.

4. Vector Calculus by P.C. Matthews, Published by Springer Verlag publications.

5. Rings and Linear Algebra by Pundir & Pundir, Published by Pragathi Prakashan

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### UNIT- I: (10 hours)(5 Marks -2)

**Errors in Numerical computations :** Errors and their Accuracy, Mathematical Preliminaries, Errors and their Analysis, Absolute, Relative and Percentage Errors, A general error formula, Error in a series approximation.

# UNIT - II: (12 hours)(5 Marks-1, 10Marks-3)

**Solution of Algebraic and Transcendental Equations: The bisection method,** The iteration method, The method of false position, **Newton Raphson method**, Generalized Newton Raphson method. Muller's Method

# UNIT – III: (12 hours) Interpolation – I(5 Marks-1 10Marks-1)

**Interpolation :** Errors in polynomial interpolation, Finite Differences, Forward differences, Backward differences, Central Differences, Symbolic relations, Detection of errors by use of Differences Tables, Differences of a polynomial

### UNIT – IV: (12 hours) Interpolation – II(5 Marks-2, 10 Marks - 3)

Newton's formulae for interpolation. Central Difference Interpolation Formulae, Gauss's central difference formulae, Stirling's central difference formula, Bessel's Formula, Everett's Formula.

### UNIT – V : (14 hours) Interpolation – III(5 Marks-2, 10 Marks - 3)

Interpolation with unevenly spaced points, Lagrange's formula, Error in Lagrange's formula, Divided differences and their properties, Relation between divided differences and forward differences, Relation between divided differences and backward differences Relation between divided differences and central differences, Newton's general interpolation Formula, Inverse interpolation.

#### PRESCRIBED TEXT BOOK:

Numerical Analysis by Dr. A Anjaneyulu, published by Deepti Publications.

# **Reference Books :**

- 1. Numerical Analysis by S.S.Sastry, published by Prentice Hall of India Pvt. Ltd., New Delhi. (Latest Edition)
- 2. Numerical Analysis by G. Sankar Rao published by New Age International Publishers, New Hyderabad.

Finite Differences and Numerical Analysis by H.C Saxena published by S. Chand

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CLUSTER ELECTIVE - VIII-A – ADVANCED NUMERICAL ANAL ISIS

# **Unit – I (10 Hours)(5 Marks-1, 10 Marks-2)**

**Curve Fitting:** Least – Squares curve fitting procedures, fitting a straight line, nonlinear curve fitting, Curve fitting by a sum of exponentials.

# UNIT- II : (12 hours) (5 Marks-2, 10 Marks-1)

**Numerical Differentiation:** Derivatives using Newton's forward difference formula, Newton's backward difference formula, Derivatives using central difference formula, stirling's interpolation formula, Newton's divided difference formula, Maximum and minimum values of a tabulated function.

# UNIT- III : (12 hours) (5 Marks-2, 10 Marks-2)

**Numerical Integration:** General quadrature formula on errors, **Trapozoidal rule**, **Simpson's 1/3 – rule**, Simpson's 3/8 – rule, and Weddle's rules, Euler – Maclaurin Formula of summation and quadrature, The Euler transformation.

# UNIT - IV: (14 hours) (5 Marks-2, 10 Marks-2)

**Solutions of simultaneous Linear Systems of Equations:** Solution of linear systems – Direct methods, Matrix inversion method, Gaussian elimination methods, Gauss-Jordan Method ,Method of factorization, Solution of Tridiagonal Systems,. Iterative methods. Jacobi's method, Gauss-siedal method.

# UNIT - V (12 Hours) (5 Marks-1, 10 Marks-3)

**Numerical solution of ordinary differential equations:** Introduction, Solution by Taylor's Series, Picard's method of successive approximations, Euler's method, Modified Euler's method, Runge – Kutta methods.

# PRESCRIBED TEXT BOOK:

Numerical Analysis by Dr. A Anjaneyulu, published by Deepti Publications.

# **Reference Books :**

- 1. Numerical Analysis by S.S.Sastry, published by Prentice Hall India (Latest Edition).
- 2. Numerical Analysis by G. Sankar Rao, published by New Age International Publishers, New Hyderabad.
- 3. Finite Differences and Numerical Analysis by H.C Saxena published by S. Chand and Company, Pvt.Ltd., New Delhi.

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# UNIT-I:(10 Marks-2)(5 Marks-2 )

**Hermite Polynomial:** Hermite Differential Equations, Solution of Hermite Equation, Hermite's Polynomials, Generating function, other forms for Hermite Polynomial, To find first few Hermite Polynomials, Orthogonal properties of Hermite Polynomials, Recurrence formulae for Hermite Polynomials.

# UNIT-II:(10 Marks-2 )(5 Marks -2)

Laguerre Polynomials- I : Laguerre's Differential equation, Solution of Laguerre's equation, Laguerre Polynomials, Generating function, Other forms for the Laguerre Polynomials, To find first few Laguerre Polynomials, Orthogonal property of the Laguerre Polynomials, Recurrence formula for Laguerre Polynomials, Associated Laguerre Equation. UNIT-III: (10Marks - 2)(5 Marks -1)

**Legendre's equation :** Definition, Solution of Legendre's equation, definition of  $P_n(x)$  and  $Q_n(x)$ , General solution of Legendre's Equation (deviations not required) To show that  $P_n(x)$ 

is the coefficient of  $h^n$  in the expansion of  $(1 - 2xh + h^2)^{-\frac{1}{2}}$ , Orthogonal properties of Legendre's Equation, Recurrence formula, Rodrigues formula.

# UNIT-IV : (10Marks -2)(5 Marks -1)

**Bessel's equation :** Definition, Solution of Bessel's General Differential Equations, General Solution of Bessel's Equation, Integration of Bessel's equation in series for n = 0, Definition of  $J_n(x)$ , Recurrence formulae for  $J_n(x)$ , Generating function for  $J_n(x)$ .

# UNIT-V: (10 Marks -2)(5 Marks -2)

**Beta and Gamma functions:** Euler's Integrals – Beta and Gamma functions, Elementary properties of Gamma Functions, Transformation of Gamma Functions, Another form of Beta Function, Relation between Beta and Gamma Functions, Other Transformation.

# PRESCRIBED TEXT BOOK:

Special Functions by J.N.Sharma and Dr.R.K.Gupta.

SRI A.S.N.M. GOVERNMENT COLLEGE(A), PALAKOL. W.G.DT (Affiliated to Adikavi Nannaya University, Rajahmahendravaram) (Accredited with NAAC "B" Grade with 2.61 CGPA point LIFE SKILL COURSE - ANALYTICAL SKILLS Syllabus, For all Degree Programmes. Semester – III ( for 2020 -23 admitted batch, w.e.f. 2021-22 )

(Total 30 Hrs)

**Course Objective:** Intended to inculcate quantitative analytical skills and reasoning as an inherent ability in students.

# **Course Outcomes:**

After successful completion of this course, the student will be able to;

- 1) Understand the basic concepts of arithmetic ability, quantitative ability, logical reasoning, business computations and data interpretation and obtain the associated skills.
- 2) Acquire competency in the use of verbal reasoning.
- 3) Apply the skills and competencies acquired in the related areas
- 4) Solve problems pertaining to quantitative ability, logical reasoning and verbal ability inside and outside the campus.

# **UNIT** – **I** :

### **Arithmetic ability: (10 Questions)**

Algebraic operations BODMAS, Fractions, Divisibility rules, LCM & GCD (HCF).

### Verbal Reasoning: (10 Questions)

Number Series, Coding & Decoding, Blood relationship, Clocks, Calendars.

# UNIT – II :

# **Quantitative aptitude (10 Questions)**

Averages, Ratio and proportion, Problems on ages, Time-distance - speed.

# **Business computations (10 Questions)**

Percentages, Profit &loss, Partnership, simple compound interest.

# **UNIT – 3**:

Data Interpretation: (2 Questions)

Tabulation, Bar Graphs, Pie Charts, Line Graphs, Venn diagram.