Syllabus for the Post of PGT Mathematics

1. Sets, Relations & Functions

- **Sets:** Sets and their representations, Empty set, Finite and Infinite sets, Equal sets, Subsets. Subsets of a set of real numbers especially intervals (with notations). Universal set. Venn diagrams. Union and Intersection of sets. Difference of sets. Complement of a set, Properties of Complement.
- **Relations & Functions:** Ordered pairs. Cartesian product of sets. Number of elements in the Cartesian product of two finite sets. Cartesian product of the set of reals with itself (up to $R \times R \times R$). Definition of relation, pictorial diagrams, domain, co-domain and range of a relation. Function as a special type of relation. Pictorial representation of a function, domain, co-domain and range of a function.
- **Real-Valued Functions:** Domain and range of real valued functions, constant, identity, polynomial, rational, modulus, signum, exponential, logarithmic and greatest integer functions, with their graphs. Sum, difference, product and quotients of functions.
- **Types of Relations & Functions:** Types of relations: reflexive, symmetric, transitive and equivalence relations. One to one and onto functions.

2. Algebra & Number Systems

- **Complex Numbers & Quadratic Equations:** Need for complex numbers, especially $\sqrt{-1}$, to be motivated by inability to solve some of the quadratic equations. Algebraic properties of complex numbers. Argand plane.
- **Linear Inequalities:** Linear inequalities. Algebraic solutions of linear inequalities in one variable and their representation on the number line.
- **Permutations & Combinations:** Fundamental principle of counting. Factorial n (n!). Permutations and combinations, derivation of formulae for nPr and nCr and their connections, simple applications.
- **Binomial Theorem:** Historical perspective, statement and proof of the binomial theorem for positive integral indices. Pascal's triangle, simple applications.

- **Sequence & Series:** Sequence and Series. Arithmetic Progression (A.P.), Arithmetic Mean (A.M.), Geometric Progression (G.P.), general term of a G.P., sum of n terms of a G.P., infinite G.P. and its sum, geometric mean (G.M.), relation between A.M. and G.M.
- **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. On commutativity of multiplication of matrices and existence of non-zero matrices whose product is the zero matrix (restrict to square matrices of order 2). Invertible matrices and proof of the uniqueness of inverse, if it exists (all matrices with real entries).
- **Determinants:** Determinant of a square matrix (up to 3×3 matrices), 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.

3. Trigonometry

- **Trigonometric Functions:** Positive and negative angles. Measuring angles in radians and in degrees and conversion from one measure to another. Definition of trigonometric functions with the help of unit circle. Truth of the identity $\sin^2 x + \cos^2 x = 1$, for all x. Signs of trigonometric functions. Domain and range of trigonometric functions and their graphs. Expressing $\sin(x \pm y)$ and $\cos(x \pm y)$ in terms of sin x, sin y, cos x & cos y and their simple applications. Identities related to sin 2x, cos 2x, tan 2x, sin 3x, cos 3x and tan 3x.
- **Inverse Trigonometric Functions:** Definition, range, domain, principal value branch. Graphs of inverse trigonometric functions.

4. Calculus

- **Limits & Derivatives:** Derivative introduced as rate of change both as that of distance function and geometrically. Intuitive idea of limit. Limits of polynomials and rational functions, trigonometric, exponential and logarithmic functions. Definition of derivative

related to scope of tangent of the curve, derivative of sum, difference, product and quotient of functions. Derivatives of polynomial and trigonometric functions.

- **Continuity & Differentiability:** Continuity and differentiability, derivative of composite functions, chain rule, derivative 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.
- **Applications of Derivatives:** Applications of derivatives: rate of change of bodies, increasing/decreasing functions, 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).
- **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.
  - $\int dx / (x^2 \pm a^2)$, $\int dx / \sqrt{(x^2 \pm a^2)}$, $\int dx / \sqrt{(a^2 - x^2)}$, $\int dx / (ax^2 + bx + c)$, $\int dx / \sqrt{(ax^2 + bx + c)}$
  - $\int (px + q)/(ax^2 + bx + c)\, dx$, $\int (px + q)/\sqrt{(ax^2 + bx + c)}\, dx$
  - $\int \sqrt{(a^2 \pm x^2)}\, dx$, $\int \sqrt{(x^2 - a^2)}\, dx$, $\int \sqrt{(ax^2 + bx + c)}\, dx$

  Fundamental Theorem of Calculus. Basic properties of definite integrals and evaluation of definite integrals.
- **Applications of Integrals:** Applications in finding the area under simple curves, especially lines, circles/parabolas/ellipses (in standard form only).
- **Differential Equations:** Definition, order and degree, general and particular solutions of a differential equation. 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 equations of the type:
  - $dy/dx + Py = Q$, where P and Q are functions of x or constants.
  - $dx/dy + Px = Q$, where P and Q are functions of y or constants.

5. Coordinate Geometry & Vector Algebra

- **Straight Lines:** Slope of a line and angle between two lines. Various forms of equations of a line: parallel to axis, point-slope form, slope-intercept form. Distance of a point from a line.

- **Conic Sections:** Sections of a cone: circles, ellipse, parabola, hyperbola, a point, a straight line and a pair of intersecting lines as a degenerated case of a conic section. Standard equations and simple properties of parabola, ellipse and hyperbola. Standard equation of a circle.
- **Three-Dimensional Geometry:** Coordinate axes and coordinate planes in three dimensions. Coordinates of a point. Distance between two points. Direction cosines and direction ratios of a line joining two points. Cartesian equation and vector equation of a line, skew lines, shortest distance between two lines. Angle between two lines.
- **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.

6. Linear Programming, Statistics & Probability

- **Linear Programming:** Introduction, related terminology such as constraints, objective function, optimization, graphical method of solution for problems in two variables, feasible and infeasible regions (bounded or unbounded), feasible and infeasible solutions, optimal feasible solutions (up to three non-trivial constraints).
- **Statistics:** Measures of Dispersion: Range, Mean deviation, variance and standard deviation of ungrouped/grouped data.
- **Probability:** Random experiments; outcomes, sample spaces (set representation). Events; occurrence of events, 'not', 'and' and 'or' events, exhaustive events, mutually exclusive events, Axiomatic (set theoretic) probability, connections with other theories of earlier classes. Probability of an event, probability of 'not', 'and' and 'or' events. Conditional probability, multiplication theorem on probability, independent events, total probability, Bayes' theorem, Random variable and its probability distribution, mean of random variable.