

## JEE ADVANCED SYLLABUS - MATHEMATICS

### Sets, Relations and Functions

Sets and their representations, different kinds of sets (empty, finite and infinite), algebra of sets, intersection, complement, difference and symmetric difference of sets and their algebraic properties, De-Morgan's laws on union, intersection, difference (for finite number of sets) and practical problems based on them. Cartesian product of finite sets, ordered pair, relations, domain and codomain of relations, equivalence relation Function as a special case of relation, functions as mappings, domain, codomain, range of functions, invertible functions, even and odd functions, into, onto and one-to-one functions, special functions (polynomial, trigonometric, exponential, logarithmic, power, absolute value, greatest integer etc.), sum, difference, product and composition of functions.

### Algebra

Algebra of complex numbers, addition, multiplication, conjugation, polar representation, properties of modulus and principal argument, triangle inequality, cube roots of unity, geometric interpretations. Statement of fundamental theorem of algebra, Quadratic equations with real coefficients, relations between roots and coefficients, formation of quadratic equations with given roots, symmetric functions of roots. Arithmetic and geometric progressions, arithmetic and geometric means, sums of finite arithmetic and geometric progressions, infinite geometric series, sum of the first  $n$  natural numbers, sums of squares and cubes of the first  $n$  natural numbers. Logarithms and their properties, permutations and combinations, binomial theorem for a positive integral index, properties of binomial coefficients.

### Matrices

Matrices as a rectangular array of real numbers, equality of matrices, addition, multiplication by a scalar and product of matrices, transpose of a matrix, elementary row and column transformations, determinant of a square matrix of order up to three, adjoint of a matrix, inverse of a square matrix of order up to three, properties of these matrix operations, diagonal, symmetric and skew-symmetric matrices and their properties, solutions of simultaneous linear equations in two or three variables.

### Probability and Statistics

Random experiment, sample space, different types of events (impossible, simple, compound), addition and multiplication rules of probability, conditional probability, independence of events, total probability, Bayes Theorem, computation of probability of events using permutations and combinations.

Measure of central tendency and dispersion, mean, median, mode, mean deviation, standard deviation and variance of grouped and ungrouped data, analysis of the frequency distribution with same mean but different variance, random variable, mean and variance of the random variable.

### Trigonometry

Trigonometric functions, their periodicity and graphs, addition and subtraction formulae, formulae involving multiple and sub-multiple angles, general solution of trigonometric equations.

Inverse trigonometric functions (principal value only) and their elementary properties.

### Analytical Geometry

Two dimensions: Cartesian coordinates, distance between two points, section formulae, shift of origin.

Equation of a straight line in various forms, angle between two lines, distance of a point from a line; Lines

through the point of intersection of two given lines, equation of the bisector of the angle between two lines, concurrency of lines; Centroid, orthocentre, incentre and circumcentre of a triangle.

Equation of a circle in various forms, equations of tangent, normal and chord. Parametric equations of a circle, intersection of a circle with a straight line or a circle, equation of a circle through the points of intersection of two circles and those of a circle and a straight line. Equations of a parabola, ellipse and hyperbola in standard form, their foci, directrices and eccentricity, parametric equations, equations of tangent and normal. Locus problems.

Three dimensions: Distance between two points, direction cosines and direction ratios, equation of a straight line in space, skew lines, shortest distance between two lines, equation of a plane, distance of a point from a plane, angle between two lines, angle between two planes, angle between a line and the plane, coplanar lines.

### **Differential Calculus**

Limit of a function at a real number, continuity of a function, limit and continuity of the sum, difference, product and quotient of two functions, L'Hospital rule of evaluation of limits of functions. Continuity of composite functions, intermediate value property of continuous functions. Derivative of a function, derivative of the sum, difference, product and quotient of two functions, chain rule, derivatives of polynomial, rational, trigonometric, inverse trigonometric, exponential and logarithmic functions.

Tangents and normals, increasing and decreasing functions, derivatives of order two, maximum and minimum values of a function, Rolle's theorem and Lagrange's mean value theorem, geometric interpretation of the two theorems, derivatives up to order two of implicit functions, geometric interpretation of derivatives.

### **Integral Calculus**

Integration as the inverse process of differentiation, indefinite integrals of standard functions, definite integrals as the limit of sums, definite integral and their properties, fundamental theorem of integral calculus.

Integration by parts, integration by the methods of substitution and partial fractions, application of definite integrals to the determination of areas bounded by simple curves. Formation of ordinary differential equations, solution of homogeneous differential equations of first order and first degree, separation of variables method, linear first order differential equations.

### **Vectors**

Addition of vectors, scalar multiplication, dot and cross products, scalar and vector triple products, and their geometrical interpretations.

## Syllabus for JEE (Main) - 2024

### Syllabus for JEE Main Paper 1 (B.E./B.Tech.)- Mathematics, Physics, and Chemistry

## MATHEMATICS

### UNIT 1: SETS, RELATIONS, AND FUNCTIONS:

Sets and their representation: Union, intersection, and complement of sets and their algebraic properties; Power set; Relation, Type of relations, equivalence relations, functions; one-one, into and onto functions, the composition of functions.

### UNIT 2: COMPLEX NUMBERS AND QUADRATIC EQUATIONS:

Complex numbers as ordered pairs of reals, Representation of complex numbers in the form  $a + ib$  and their representation in a plane, Argand diagram, algebra of complex number, modulus, and argument (or amplitude) of a complex number, Quadratic equations in real and complex number system and their solutions Relations between roots and co-efficient, nature of roots, the formation of quadratic equations with given roots.

### UNIT3: MATRICES AND DETERMINANTS:

Matrices, algebra of matrices, type of matrices, determinants, and matrices of order two and three, evaluation of determinants, area of triangles using determinants, Adjoint, and evaluation of inverse of a square matrix using determinants and, Test of consistency and solution of simultaneous linear equations in two or three variables using matrices.

### UNIT 4: PERMUTATIONS AND COMBINATIONS:

The fundamental principle of counting, permutation as an arrangement and combination as section, Meaning of  $P(n,r)$  and  $C(n,r)$ , simple applications.

### UNIT 5: BINOMIAL THEOREM AND ITS SIMPLE APPLICATIONS:

Binomial theorem for a positive integral index, general term and middle term, and simple applications.

### UNIT 6: SEQUENCE AND SERIES:

Arithmetic and Geometric progressions, insertion of arithmetic, geometric means between two given numbers, Relation between A.M and G.M.

### UNIT 7: LIMIT, CONTINUITY, AND DIFFERENTIABILITY:

Real-valued functions, algebra of functions, polynomials, rational, trigonometric, logarithmic, and exponential functions, inverse function. Graphs of simple functions. Limits, continuity, and differentiability. Differentiation of the sum, difference, product, and quotient of two functions. Differentiation of trigonometric, inverse trigonometric, logarithmic, exponential, composite, and implicit functions; derivatives of order up to two, Applications of derivatives: Rate of change of quantities, monotonic-Increasing and decreasing functions, Maxima and minima of functions of one variable,



## UNIT 8: INTEGRAL CALCULAS:

Integral as an anti-derivative, Fundamental integral involving algebraic, trigonometric, exponential, and logarithmic functions. Integrations by substitution, by parts, and by partial functions. Integration using trigonometric identities.

Evaluation of simple integrals of the type

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

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

The fundamental theorem of calculus, properties of definite integrals. Evaluation of definite integrals, determining areas of the regions bounded by simple curves in standard form.

## UNIT 9: DIFFERENTIAL EQUATIONS

Ordinary differential equations, their order, and degree, the solution of differential equation by the method of separation of variables, solution of a homogeneous and linear differential equation of the type

$$\frac{dy}{dx} + p(x)y = q(x)$$

## UNIT 10: CO-ORDINATE GEOMETRY

Cartesian system of rectangular coordinates in a plane, distance formula, sections formula, locus, and its equation, the slope of a line, parallel and perpendicular lines, intercepts of a line on the co-ordinate axis.

### Straight line

Various forms of equations of a line, intersection of lines, angles between two lines, conditions for concurrence of three lines, the distance of a point from a line, co-ordinate of the centroid, orthocentre, and circumcentre of a triangle,

### Circle, conic sections

A standard form of equations of a circle, the general form of the equation of a circle, its radius and central, equation of a circle when the endpoints of a diameter are given, points of intersection of a line and a circle with the centre at the origin and sections of conics, equations of conic sections (parabola, ellipse, and hyperbola) in standard forms,

## UNIT 11: THREE DIMENSIONAL GEOMETRY

Coordinates of a point in space, the distance between two points, section formula, direction ratios, and direction cosines, and the angle between two intersecting lines. Skew lines, the shortest distance between them, and its equation. Equations of a line

## UNIT 12: VECTOR ALGEBRA

Vectors and scalars, the addition of vectors, components of a vector in two dimensions and three-dimensional space, scalar and vector products,

### **UNIT 13: STATISTICS AND PROBABILITY**

Measures of discretion; calculation of mean, median, mode of grouped and ungrouped data calculation of standard deviation, variance, and mean deviation for grouped and ungrouped data.

Probability: Probability of an event, addition and multiplication theorems of probability, Baye's theorem, probability distribution of a random variate,

### **UNIT 14: TRIGONOMETRY**

Trigonometrical identities and trigonometrical functions, inverse trigonometrical functions, and their properties,

## KEAM - SYLLABUS - MATHEMATICS

### UNIT I: ALGEBRA

#### **Sets, Relations and Functions**

Sets and their representations: Finite and Infinite sets; Empty set; Equal sets; Subsets; Universal set; Venn Diagrams; Complement of a set; Operations on Sets (Union, Intersection and Difference of Set); Applications of sets: Ordered Pairs, Cartesian Product of Two sets; Relations, reflexive, symmetric, transitive and equivalence relations. Domain, Co-domain and Range; Functions: into, onto, one - one into, one-one onto Functions; Constant Function; Identity Function; composition of Functions; Invertible Functions.

#### **Complex Numbers**

Complex Numbers in the form  $a+ib$ ; Real and Imaginary Parts of a complex Number; Complex Conjugate, Argand Diagram, Representation of Complex Number as a point in the plane; Modulus of a Complex Number; Algebra of Complex Numbers.

#### **Sequences and Series**

Geometric Progression (G.P): first Term, Common Ratio and  $n^{\text{th}}$  term, Sum to  $n$  Terms. Geometric Mean (G.M); Insertion of Geometric Means, Relation between AM and GM. between any two given numbers.

#### **Permutations, Combinations, Binomial Theorem**

Fundamental Principle of Counting; The Factorial Notation; Permutation as an Arrangement; Meaning of  $P(n, r)$ ; Combination: Meaning of  $C(n,r)$ ; Applications of Permutations and Combinations. Statement of Binomial Theorem; Proof of Binomial Theorem for positive integral Exponent using Principle of Mathematical Induction and also by combinatorial Method; General and Middle Terms in Binomial Expansions; Properties of Binomial Coefficients.

#### **Matrices and Determinants**

Concept of a Matrix; Types of Matrices; Equality of Matrices (only real entries may be considered); Operations of Addition, Scalar Multiplication and Multiplication of Matrices; Statement of Important Results on operations of Matrices and their Verifications by Numerical Problem only; Determinant of a Square Matrix; Minors and Cofactors; singular and non-singular Matrices; Applications of Determinants in finding the Area of a Triangle. Transpose, Adjoint and Inverse of a Matrix; Consistency and Inconsistency of a system of Linear Equations; Solving System of Linear Equations in Two or Three variables using Inverse of a Matrix (only up to  $3 \times 3$  Determinants and Matrices should be considered).

## Linear Inequalities

Solutions of Linear Inequalities in one variable and its Graphical Representation; solution of system of Linear Inequalities in one variable.

## UNIT II : TRIGONOMETRY

Trigonometric functions and Inverse Trigonometric functions

Degree measures and Radian measure of positive and negative angles; relation between degree measure and radian measure, definition of trigonometric functions with the help of a unit circle, periodic functions, concept of periodicity of trigonometric functions, value of trigonometric functions of  $x$  for  $x = 0, \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi$ ; trigonometric functions of sum and difference of numbers.

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y; \cos(x \pm y) = \cos x \cos y \mp \sin x \sin y; \tan(x + y) = \frac{\tan x + \tan y}{1 \mp \tan x \tan y};$$

$$\sin(2\pi \pm x) = \pm \sin x, \cos(2\pi \pm x) = \cos x; \cos(-x) = \cos x, \sin(-x) = -\sin x; \cos\left(\frac{\pi}{2} + x\right) = -\sin x$$

$$\sin\left(\frac{\pi}{2} - x\right) = \cos x; \cos(\pi \pm x) = -\cos x, \sin(\pi \pm x) = \pm \sin x$$

Trigonometric functions of multiple and submultiples of numbers.

$$\sin 2x = 2 \sin x \cos x; \sin 3x = 3 \sin x - 4 \sin^3 x; \cos 2x = \cos^2 x - \sin^2 x = 1 - 2 \sin^2 x = 2 \cos^2 x - 1;$$

$$\cos 3x = 4 \cos^3 x - 3 \cos x$$

$$\tan 3x = \frac{3 \tan x - \tan^3 x}{1 - 3 \tan^2 x}; \sin x + \sin y = 2 \sin\left(\frac{x+y}{2}\right) \cos\left(\frac{x-y}{2}\right); \cos x + \cos y = 2 \cos\left(\frac{x+y}{2}\right) \cos\left(\frac{x-y}{2}\right)$$

$$\sin x - \sin y = 2 \cos\left(\frac{x+y}{2}\right) \sin\left(\frac{x-y}{2}\right); \cos x - \cos y = -2 \sin\left(\frac{x+y}{2}\right) \sin\left(\frac{x-y}{2}\right)$$

Inverse Trigonometric functions. Range, domain, principal value branch and graphs of inverse trigonometric functions.

(i)  $\sin^{-1}(\sin x) = x$  and other similar formula (ii)  $\sin^{-1}\left(\frac{1}{x}\right) = \operatorname{cosec}^{-1} x$  and other similar formula.

$$\sin^{-1}(-x) = -\sin^{-1} x, \tan^{-1}(-x) = -\tan^{-1} x; \operatorname{cosec}^{-1}(-x) = -\operatorname{cosec}^{-1} x, \operatorname{cosec}^{-1}(-x) = \pi - \operatorname{cosec}^{-1}(x);$$

$$\sec^{-1}(-x) = \pi - \sec^{-1}(x), \cot^{-1}(-x) = \pi - \cot^{-1}(x)$$

$$\sin^{-1} x + \cos^{-1} x = \frac{\pi}{2}, \tan^{-1} x + \cot^{-1} x = \frac{\pi}{2}; \operatorname{cosec}^{-1}(x) + \sec^{-1}(x) = \frac{\pi}{2};$$

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

$$\tan^{-1} x + \tan^{-1} y = \tan^{-1}\left(\frac{x+y}{1-xy}\right), xy < 1; 2 \tan^{-1} x = \sin^{-1}\left(\frac{2x}{1+x^2}\right) = \cos^{-1}\left(\frac{1-x^2}{1+x^2}\right) = \tan^{-1}\left(\frac{2x}{1-x^2}\right), |x| < 1$$

## Simple problems

Graph of the following trigonometric functions;

$$y = \sin x; y = \cos x; y = \tan x$$



### **UNIT III: GEOMETRY**

#### **Lines**

Cartesian system of coordinates in a plane. Distance formula, Slope of line, parallel and perpendicular lines. Various forms of equations of a line parallel to axes, slope-intercept form, The Slope point form, Intercept form, Normal form, General form, Intersection of lines. Angles between two lines, condition for concurrency of three lines, Distance of a point from a line.

#### **Conic sections**

Sections of a cone. Circles, standard form of the equation of a circle, its radius and centre. Equations of conic sections [Parabola, Ellipse and Hyperbola] in standard form and simple properties.

#### **Vectors**

Vectors and scalars, Magnitude and Direction of a vector, Types of vectors (Equal vectors, unit vector, Zero vector). Position vector of a point, Localized and free vectors, parallel and collinear vectors, Negative of a vector, components of a vector, Addition of vectors, multiplication of a vector by a scalar, position vector of point dividing a line segment in a given ratio, Application of vectors in geometry. Scalar product of two vectors, projection of a vector on a line, vector product of two vectors.

#### **Three-Dimensional Geometry**

Coordinate axes and coordinate planes in three dimensional space, coordinate of a point in space, distance between two points, section formula, direction cosines, and direction ratios of a line joining two points, projection of the join of two points on a given line, Angle between two lines whose direction ratios are given, Cartesian and vector equation of a line through (i) a point and parallel to a given vector (ii) through two points, coplanar and skew lines, Shortest distance between two lines, Condition for the intersection of two lines,

### **Unit IV: STATISTICS**

#### **Statistics and probability**

Mean deviation, variance, standard deviation for grouped and ungrouped data. Random experiments and sample space, Events as subset of a sample space, occurrence of an event, sure and impossible events, Exhaustive events, Algebra of events, Meaning of equally likely outcomes, mutually exclusive events. Probability of an event; Theorems on probability; Addition rule, Multiplication rule, Independent experiments and events. Finding  $P(A \text{ or } B)$ ,  $P(A \text{ and } B)$ , Bayes' theorem.



**UNIT V : CALCULUS****Functions, Limits and continuity**

Concept of a real function; its domain and range; Modulus Function, Greatest integer function; Signum functions; Trigonometric functions and inverse trigonometric functions and their graphs; composite functions, Inverse of a function.

Limit of a function; meaning and related notations; Left and right hand limits; Fundamental

$$\lim_{x \rightarrow a} \frac{x^n - a^n}{x - a} = na^{n-1}, a > 0; \lim_{x \rightarrow 0} \frac{\sin x}{x} = 1;$$

theorems on limits without proof

(without proof);

Continuity of a function at a point, Sum, Product and quotient of continuous functions; Continuity of special functions- Polynomial, Trigonometric, exponential, Logarithmic and Inverse trigonometric functions.

**Differentiation**

Derivative of a function; its geometrical and physical significance; Relationship between continuity and differentiability; Derivatives of polynomial, basic trigonometric, exponential, logarithmic and inverse trigonometric functions from first principles; derivatives of sum, difference, product and quotient of functions; derivatives of polynomial, trigonometric, exponential, logarithmic, inverse trigonometric and implicit functions; Logarithmic differentiation; derivatives of functions expressed in parametric form; chain rule and differentiation by substitution; Derivatives of Second order.

**Application of Derivatives**

Rate of change of quantities; increasing and decreasing functions and sign of the derivatives; maxima and minima; Greatest and least values;

**Indefinite Integrals**

Integration as inverse of differentiation; properties of integrals; Integrals involving algebraic, trigonometric, exponential and logarithmic functions; Integration by substitution; Integration by parts; Integrals of the type:

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

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

**Integration of rational functions; Partial fractions and their use in integration; Integrals of the type**

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

**Definite Integrals**

Fundamental theorems of integral calculus without proof; Evaluation of definite integrals by substitution and by using the following properties.

$$\int_a^b f(x) dx = - \int_b^a f(x) dx; \int_a^b f(x) dx = \int_a^c f(x) dx + \int_c^b f(x) dx$$

$$\int_a^b f(x) dx = \int_a^b f(a+b-x) dx; \int_0^a f(x) dx = \int_0^a f(a-x) dx$$

$$\int_a^b f(x) dx = \int_a^b f(a+b-x) dx; \int_0^a f(x) dx = \int_0^a f(a-x) dx$$

$$\int_a^b f(x) dx = \int_a^b f(a+b-x) dx; \int_0^a f(x) dx = \int_0^a f(a-x) dx$$

$$\int_0^{2a} f(x) dx = \int_0^a f(x) dx + \int_0^a f(2a-x) dx; \int_0^{2a} f(x) dx = 2 \int_0^a f(x) dx, \text{ if } f(2a-x) = f(x)$$

$$\int_0^{2a} f(x) dx = 0, \text{ if } f(2a-x) = -f(x)$$

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

Application of definite integrals in finding areas bounded by a curve, circle, parabola and ellipse in standard form between two ordinates and x-axis; Area between two curves, line and circle; line and parabola; line and ellipse.

### Differential Equations

Definition; order and degree; general and particular solutions of a differential equation; solution of differential equations by method of Separation of variables; Homogeneous differential equations of first order and their solutions; Solution of linear differential

equations of the type  $\frac{dy}{dx} + P(x)y = Q(x)$  where P (x), Q (x) are functions of x or constants.

### Linear Programming

Introduction, related terminology such as constraints, Objective function, optimisation, different types of linear programming problems, graphical method of solution for problems in two variables, feasible and infeasible regions, feasible and infeasible solutions, optimal feasible solutions ( up to three non-trivial constraints).