IIT JEE Mathematics – Chapter-wise Concepts, Explanations & Examples

1. Sets, Relations & Functions

A set is a well-defined collection of objects. Relations describe a relationship between two sets, while functions are special relations where each input has exactly one output. Functions may be one-one, onto, or bijective.

Examples:

- Example: A = {1,2,3}. $f(x)=x^2$ is a function because each x has one output.
- Example: Relation R on A: R = {(1,2),(2,3)}.

2. Complex Numbers

Complex numbers are in the form $z = a + ib$, represented on the Argand plane. They can be expressed in polar form using $r(\cos\theta + i \sin\theta)$. De Moivre's theorem helps find powers/roots.

Examples:

- Example: $|3 + 4i| = 5$.
- Example: De Moivre: $(\cos\theta + i \sin\theta)^2 = \cos2\theta + i \sin2\theta$.

3. Quadratic Equations

A quadratic equation $ax^2 + bx + c = 0$ has solutions given by the quadratic formula. Discriminant $D = b^2 – 4ac$ decides nature of roots.

Examples:

- Example: $x^2 – 5x + 6 = 0 \rightarrow$ roots: 2 and 3.
- Example: If $D < 0 \rightarrow$ roots are complex.

4. Sequences & Series

A sequence is a list of numbers in order. AP has constant difference, GP has constant ratio. Series refers to the sum of terms.

Examples:

- Example: AP: 2,5,8,… (d=3).
- Example: GP: 3,6,12… (r=2).

5. Permutation & Combination

Permutation counts arrangements while combination counts selections. Order matters in permutation but not in combination.

Examples:

- Example: Permutations of 3 letters ABC = 6.
- Example: Combination: selecting 2 from 4: 4C2 = 6.

6. Binomial Theorem

Binomial theorem expands (a + b)^n into terms with binomial coefficients. Useful for approximation and polynomial expansion.
Examples:
- Example: $(x+1)^2 = x^2 + 2x + 1$.
- Example: General term: T(r+1) = nCr a^(n-r) b^r.

7. Probability

Probability measures the chance of an event. Conditional probability and Bayes' theorem are important for IIT JEE.
Examples:
- Example: P(getting head in coin) = 1/2.
- Example: Conditional probability: $P(A|B)=P(A\cap B)/P(B)$.

8. Trigonometry

Trigonometry deals with angles and their ratios. Identities and formulas help solve equations.
Examples:
- Example: $\sin^2\theta + \cos^2\theta = 1$.
- Example: $\tan\theta = \sin\theta / \cos\theta$.

9. Coordinate Geometry

It includes straight lines, circles, and conic sections. Important for curve properties and distances.
Examples:
- Example: Distance formula: $d = \sqrt{[(x2-x1)^2+(y2-y1)^2]}$.
- Example: Equation of circle: $(x-h)^2 + (y-k)^2 = r^2$.

10. Vector & 3D Geometry

Vectors have magnitude and direction. Dot and cross product help find projections and perpendicularity.
Examples:
- Example: Dot product: $a\cdot b = |a||b|\cos\theta$.
- Example: Cross product gives area of parallelogram.

11. Limits, Continuity & Differentiability

Limits predict the value a function approaches. Continuity ensures no breaks. Differentiability means smoothness.
Examples:
- Example: $\lim(x\to 0) \sin x/x = 1$.
- Example: If f is differentiable $\to$ f is continuous.

12. Differentiation

Differentiation gives rate of change. Includes rules like chain rule, product rule, and implicit differentiation.
Examples:
- Example: $d/dx (x^2) = 2x$.

- Example: Chain rule: d/dx [sin(3x)] = 3cos(3x).

13. Applications of Derivatives

Used to find maxima-minima, tangents, normals, increasing/decreasing intervals.
Examples:
- Example: f(x)=x^2 has minimum at x=0.
- Example: Slope of tangent = f'(x).

14. Integration

Reverse process of differentiation. Includes substitution, partial fractions, and definite integral properties.
Examples:
- Example: $\int x\,dx = x^2/2$.
- Example: $\int 1/x\,dx = \ln|x|$.

15. Differential Equations

Equations involving derivatives. Solved by methods like variable separable and linear form.
Examples:
- Example: dy/dx = y $\rightarrow$ solution: y = Ce^x.
- Example: dy/dx + y = 0 $\rightarrow$ y = Ce^{-x}.

16. Matrices & Determinants

Matrices help solve systems of equations. Determinants help check consistency and find inverses.
Examples:
- Example: det([[1,2],[3,4]]) = -2.
- Example: Inverse exists if determinant $\neq$ 0.

17. Statistics

Deals with data analysis including mean, median, variance and standard deviation.
Examples:
- Example: Mean of 2,4,6 = 4.
- Example: Variance measures spread.