

Mathematical Mastery: The JEE & BITSAT Formula Roadmap

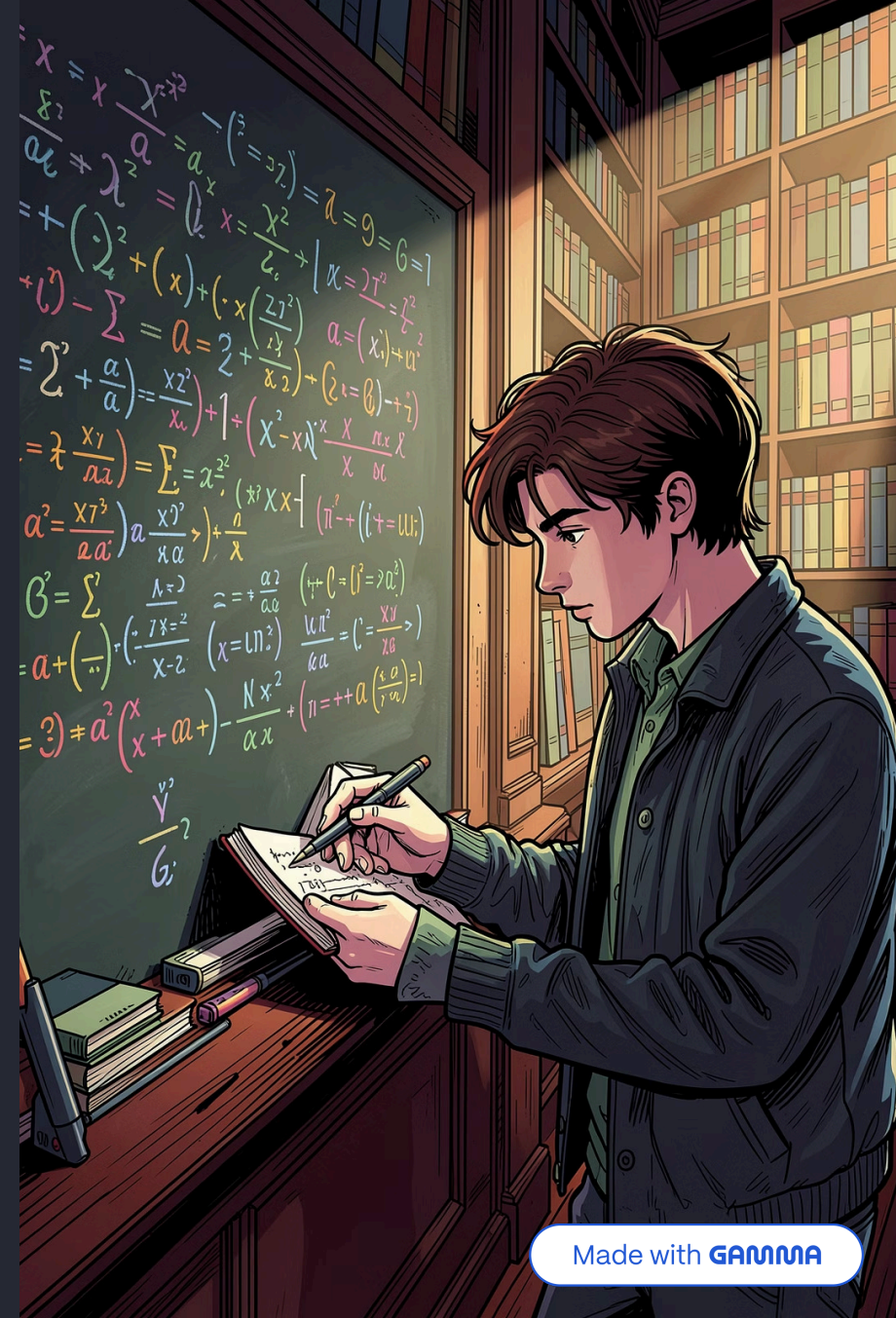
Your ultimate reference guide for IIT JEE Main & Advanced and BITSAT — covering the most critical theorems, formulas, and strategies that separate toppers from the rest. This roadmap distills years of exam pattern analysis into 10 focused pages of high-yield content. Whether you're in Class 11 building foundations or Class 12 pushing for rank, every formula here has been selected for its frequency, difficulty, and scoring potential in competitive exams.

IIT JEE MAIN

IIT JEE ADVANCED

BITSAT

CLASS 11 & 12



The 70% Rule: Know Where Your Marks Come From

Understanding the weightage distribution of JEE and BITSAT is the first step toward a strategic preparation plan. Not all chapters are created equal — some carry dramatically more marks than others. Data from past years consistently shows that four core areas dominate the Mathematics paper, and mastering them is non-negotiable for a top percentile score.

70%

Combined Weightage

Calculus, Coordinate Geometry, Algebra, and Trigonometry together account for 65–70% of total Mathematics marks in both JEE and BITSAT.

60+

Score Threshold

Mastery of these four sections alone can secure a 60-plus score — the benchmark for a strong rank in JEE Main and a competitive BITSAT score.

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Core Pillars

Focus your 70% study time on these four pillars: Calculus, Coordinate Geometry, Algebra, and Trigonometry — the rest follows naturally.

High-Priority Topics

- Calculus (Differentiation, Integration, Limits)
- Coordinate Geometry (Conic Sections, Locus)
- Algebra (Binomial, Sequences, Complex Numbers)
- Trigonometry (Identities, Inverse Functions)

Supporting Topics

These areas contribute the remaining 30% and are essential for a complete score:

- Vector Algebra & 3D Geometry
- Probability & Statistics
- Matrices & Determinants
- Permutations & Combinations

i BITSAT Tip: Coordinate Geometry and Calculus questions appear in higher frequency on BITSAT compared to JEE Main. Allocate extra practice time accordingly.

Calculus: The Heavyweight Champion

Calculus is the single most important topic in JEE Mathematics. It appears in direct questions, as part of multi-concept problems, and as the backbone of Physics applications. A thorough command of differentiation, integration, and limits is essential for cracking both JEE and BITSAT.

⚡ Differentiation Formulas

Power Rule: $d/dx(x^n) = n \cdot x^{n-1}$

Exponential: $d/dx(e^x) = e^x$ | $d/dx(a^x) = a^x \cdot \ln(a)$

Logarithmic: $d/dx(\ln x) = 1/x$ | $d/dx(\log_a x) = 1/(x \cdot \ln a)$

Chain Rule: $dy/dx = (dy/du) \cdot (du/dx)$ — apply for composite functions

Product Rule: $d(uv)/dx = u \cdot dv/dx + v \cdot du/dx$

Quotient Rule: $d(u/v)/dx = (v \cdot du/dx - u \cdot dv/dx) / v^2$

1 2 3 4 Standard Limits

$\lim_{x \rightarrow 0} \sin x / x = 1$ — the most tested limit in JEE

$\lim_{x \rightarrow 0} (1 + x)^{1/x} = e$ — exponential limit definition

$\lim_{x \rightarrow 0} (e^x - 1) / x = 1$

$\lim_{x \rightarrow 0} (a^x - 1) / x = \ln a$

$\lim_{x \rightarrow \infty} (1 + 1/x)^x = e$

L'Hôpital's Rule: For $0/0$ or ∞/∞ forms, differentiate numerator and denominator separately until a determinate form is reached.

∫ Integration Essentials

Power Rule: $\int x^n dx = x^{n+1}/(n+1) + C$ ($n \neq -1$)

Exponential: $\int e^x dx = e^x + C$ | $\int a^x dx = a^x / \ln a + C$

Trigonometric: $\int \sin x dx = -\cos x + C$ | $\int \cos x dx = \sin x + C$

Integration by Parts (ILATE Rule):

$\int u \cdot dv = uv - \int v \cdot du$

Order of preference: Inverse → Logarithmic → Algebraic → Trigonometric → Exponential

⚠ **JEE Advanced Alert:** Definite integration questions frequently use King's Property: $\int_0^a f(x) dx = \int_0^a f(a-x) dx$. Combine with substitution for elegant solutions.

Coordinate Geometry: Precision in Every Point

Coordinate Geometry is the most formula-intensive chapter in JEE Mathematics. Conic sections, in particular, are a favorite of exam setters because they combine algebraic manipulation with geometric intuition. BITSAT frequently tests locus problems and tangent properties. Master the standard forms and you can solve most questions in under 90 seconds.

Core Formulas

Distance Formula:

$$d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]}$$

Section Formula (Internal):

$$x = \frac{mx_2 + nx_1}{m+n}, \quad y = \frac{my_2 + ny_1}{m+n}$$

Slope of a Line: $m = \frac{y_2 - y_1}{x_2 - x_1} = \tan \theta$

Equation of Line (Point-Slope):

$$y - y_1 = m(x - x_1)$$

Perpendicular Distance from (x_1, y_1) to $ax + by + c = 0$:

$$d = \frac{|ax_1 + by_1 + c|}{\sqrt{a^2 + b^2}}$$

Angle Between Two Lines:

$$\tan \theta = \left| \frac{m_1 - m_2}{1 + m_1 m_2} \right|$$

Conic Sections – Standard Forms

Circle: $(x-h)^2 + (y-k)^2 = r^2$

Parabola: $y^2 = 4ax$ (focus at $(a,0)$, directrix $x = -a$)

Ellipse: $x^2/a^2 + y^2/b^2 = 1$ ($a > b$; eccentricity $e = \sqrt{1 - b^2/a^2}$)


Hyperbola: $x^2/a^2 - y^2/b^2 = 1$ (eccentricity $e = \sqrt{1 + b^2/a^2}$)

Tangent to Parabola $y^2 = 4ax$ at (x_1, y_1) :

$$yy_1 = 2a(x + x_1)$$

Condition for Tangency: For line $y = mx + c$ to touch $y^2 = 4ax$, $c = a/m$

Locus Problems: Always eliminate the parameter and express in x, y .
Common trick: use $t = \tan(\theta/2)$ substitution.

 **BITSAT Special:** Locus problems involving a moving point with a fixed ratio of distances (e.g., distance from point / distance from line = e) directly yield conic sections. Recognize $e < 1 \rightarrow$ ellipse, $e = 1 \rightarrow$ parabola, $e > 1 \rightarrow$ hyperbola.

Algebra: The Foundation of Speed

Algebra questions in JEE and BITSAT reward speed and pattern recognition. The Binomial Theorem, Sequences & Series, and Complex Numbers are high-frequency topics that can be solved in seconds if you know the right formulas. These chapters also appear inside Probability and Calculus problems, making them doubly important.

Binomial Theorem

General Term:

$$T(r+1) = {}^nC_r \cdot x^{n-r} \cdot a^r$$

Middle Term(s):

If n is even \rightarrow single middle term at $r = n/2$

If n is odd \rightarrow two middle terms at $r = (n-1)/2$
and $r = (n+1)/2$

Greatest Term: Find r where $T(r+1)/T(r) \geq 1$

Sum of Coefficients: Put $x = 1$ in the expansion

Sequences & Series

AP — nth term: $a_n = a + (n-1)d$

AP — Sum: $S_n = n/2[2a + (n-1)d]$

GP — nth term: $a_n = a \cdot r^{n-1}$

GP — Sum: $S_n = a(r^n - 1)/(r - 1), r \neq 1$

Infinite GP: $S_\infty = a/(1-r), |r| < 1$

AM \geq GM \geq HM — frequently used in inequality problems

Complex Numbers

Polar Form: $z = r(\cos \theta + i \sin \theta) = re^{i\theta}$

Modulus: $|z| = \sqrt{x^2 + y^2}$

Argument: $\arg(z) = \tan^{-1}(y/x)$

De Moivre's Theorem:

$$(\cos \theta + i \sin \theta)^n = \cos(n\theta) + i \sin(n\theta)$$

Cube Roots of Unity:

$1, \omega, \omega^2$ where $\omega = e^{i2\pi/3}$

$$1 + \omega + \omega^2 = 0 \quad | \quad \omega^3 = 1$$

Quick Tips for Algebra

- For binomial coefficient sums, use $(1+x)^n$ and substitute $x = 1, -1, i$ strategically
- In GP problems, always check if $|r| < 1$ before applying S_∞ formula
- For complex numbers, convert to polar form before raising to powers — De Moivre's saves time
- AM-GM inequality is a shortcut for maximum/minimum problems without calculus

Trigonometry: The Language of Angles

Trigonometry is the connective tissue of JEE Mathematics — it appears inside Calculus, Coordinate Geometry, and Vector problems. A solid grasp of identities and inverse trigonometric functions will dramatically reduce your solution time. The key is not memorizing every identity, but knowing how to derive them quickly from a few core formulas.

Core Identities

Pythagorean: $\sin^2\theta + \cos^2\theta = 1$

Double Angle:

$$\sin 2\theta = 2 \sin \theta \cos \theta$$

$$\cos 2\theta = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$$

Half Angle:

$$\sin(\theta/2) = \pm\sqrt{[(1-\cos \theta)/2]}$$

$$\cos(\theta/2) = \pm\sqrt{[(1+\cos \theta)/2]}$$

Sum-to-Product:

$$\sin A + \sin B = 2 \sin[(A+B)/2] \cdot \cos[(A-B)/2]$$

Angle Sum (Polygon):

$$\text{Sum of interior angles} = (n-2) \times 180^\circ$$

Inverse Trigonometric Functions

Domain & Range are critical for JEE:

$$\sin^{-1} x: \text{Domain } [-1, 1], \text{Range } [-\pi/2, \pi/2]$$

$$\cos^{-1} x: \text{Domain } [-1, 1], \text{Range } [0, \pi]$$

$$\tan^{-1} x: \text{Domain } \mathbb{R}, \text{Range } (-\pi/2, \pi/2)$$

Key Identities:

$$\sin^{-1} x + \cos^{-1} x = \pi/2$$

$$\tan^{-1} x + \cot^{-1} x = \pi/2$$

$$\tan^{-1} x + \tan^{-1} y = \tan^{-1}[(x+y)/(1-xy)] \quad (xy < 1)$$

$$2 \tan^{-1} x = \tan^{-1}[2x/(1-x^2)] \quad (|x| < 1)$$

$$\sin^{-1} x + \sin^{-1} y = \sin^{-1}[x\sqrt{1-y^2} + y\sqrt{1-x^2}]$$

→ Strategy 1: Convert to Half-Angles

When stuck on a trig equation, express everything in terms of $\tan(\theta/2)$ using the Weierstrass substitution: $\sin \theta = 2t/(1+t^2)$, $\cos \theta = (1-t^2)/(1+t^2)$ where $t = \tan(\theta/2)$. This converts trig equations to algebraic ones.

→ Strategy 2: Use Inverse Trig in Calculus

Many integration problems simplify dramatically with substitutions like $x = \sin \theta$, $x = \tan \theta$, or $x = \sec \theta$. Recognize the pattern: $\sqrt{a^2-x^2} \rightarrow x = a \sin \theta$; $\sqrt{a^2+x^2} \rightarrow x = a \tan \theta$; $\sqrt{x^2-a^2} \rightarrow x = a \sec \theta$.

→ Strategy 3: Memorize the Unit Circle

Know exact values of \sin , \cos , \tan at 0° , 30° , 45° , 60° , 90° and their radian equivalents. This eliminates calculator dependency and saves precious seconds in time-pressured exams like BITSAT.

Geometry & Vectors: Thinking in 3D

Vector Algebra and 3D Geometry are conceptually rich topics that test spatial reasoning. They appear in both Mathematics and Physics papers, making them high-value areas to master. The key insight is that most 3D problems reduce to vector operations — dot product, cross product, and parametric equations.

Vector Algebra Essentials

Dot Product: $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}||\mathbf{b}|\cos \theta = a_1b_1 + a_2b_2 + a_3b_3$

Used for: finding angle between vectors, projection, work done

Cross Product: $\mathbf{a} \times \mathbf{b} = |\mathbf{a}||\mathbf{b}|\sin \theta \cdot \hat{n}$

Result is a vector perpendicular to both \mathbf{a} and \mathbf{b}

Scalar Triple Product: $[\mathbf{a} \ \mathbf{b} \ \mathbf{c}] = \mathbf{a} \cdot (\mathbf{b} \times \mathbf{c})$

Equals volume of parallelepiped; zero if vectors are coplanar

Vector Triple Product:

$$\mathbf{a} \times (\mathbf{b} \times \mathbf{c}) = (\mathbf{a} \cdot \mathbf{c})\mathbf{b} - (\mathbf{a} \cdot \mathbf{b})\mathbf{c}$$

Unit Vector: $\hat{a} = \mathbf{a}/|\mathbf{a}|$

3D Geometry Formulas

Distance Between Two Points:

$$d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]}$$

Equation of Line:

$$(x - x_1)/a = (y - y_1)/b = (z - z_1)/c$$

Equation of Plane:

$$a(x - x_1) + b(y - y_1) + c(z - z_1) = 0$$

Shortest Distance Between Skew Lines:

$$d = |(\mathbf{a}_2 - \mathbf{a}_1) \cdot (\mathbf{b}_1 \times \mathbf{b}_2)| / |\mathbf{b}_1 \times \mathbf{b}_2|$$

Angle Between Two Planes:

$$\cos \theta = |\mathbf{n}_1 \cdot \mathbf{n}_2| / (|\mathbf{n}_1||\mathbf{n}_2|)$$

Triangle Theorem — Exterior Angle:

Exterior angle = Sum of 2 remote interior angles

1

Direction Cosines

$$l = \cos \alpha, m = \cos \beta, n = \cos \gamma$$

$$\text{Key identity: } l^2 + m^2 + n^2 = 1$$

2

Centroid of Triangle

$$G = (A + B + C)/3$$

Divides each median in 2:1 ratio

3

Circumcenter & Incenter

Circumcenter: Equidistant from all vertices

$$\text{Incenter: } (aA + bB + cC)/(a+b+c)$$

4

Sine & Cosine Rules

$$a/\sin A = b/\sin B = c/\sin C = 2R$$

$$\cos A = (b^2 + c^2 - a^2)/(2bc)$$

Probability & Statistics: The Logic of Uncertainty

Probability and Statistics questions are among the most scoring in JEE and BITSAT because they follow predictable patterns. Once you internalize the core theorems — Bayes' Theorem, the Addition and Multiplication rules, and statistical measures — you can solve these questions faster than any other topic. They also test logical reasoning, which is heavily weighted in BITSAT.

Statistics — Measures

Mean (Grouped Data):

$$\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$$

Median (Grouped Data):

$$L + \left[\frac{(n/2 - cf)}{f} \right] \times h$$

Mode (Grouped Data):

$$L + \left[\frac{(f_1 - f_0)}{(2f_1 - f_0 - f_2)} \right] \times h$$

Variance:

$$\sigma^2 = \frac{\sum f_i (x_i - \bar{x})^2}{\sum f_i}$$

Standard Deviation: $\sigma = \sqrt{\text{Variance}}$

Relation: Mean – Mode = 3(Mean – Median)

Probability Theorems

Basic Probability: $P(A) = \frac{\text{Favorable outcomes}}{\text{Total outcomes}}$

Addition Rule:

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

For mutually exclusive events: $P(A \cup B) = P(A) + P(B)$

Multiplication Rule:

$$P(A \cap B) = P(A) \cdot P(B|A)$$

For independent events: $P(A \cap B) = P(A) \cdot P(B)$

Conditional Probability:

$$P(B|A) = \frac{P(A \cap B)}{P(A)}$$

Bayes' Theorem (Critical for JEE):

$$P(A_i|B) = \frac{P(B|A_i) \cdot P(A_i)}{\sum [P(B|A_j) \cdot P(A_j)]}$$



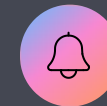
Combinatorics Link

Use nCr and nPr to count favorable and total outcomes. Remember: order matters \rightarrow permutation; order doesn't matter \rightarrow combination.



Tree Diagrams

For multi-stage probability problems, draw a tree diagram. Multiply along branches for joint probability; add across branches for total probability.



Binomial Distribution

$$P(X = r) = {}^n C_r \cdot p^r \cdot q^{n-r}$$

Mean = np , Variance = npq

Used when trials are independent with fixed probability p .

Topper Tips: Execute Like a Champion

Knowing formulas is only half the battle. The difference between a 90 percentile and a 99 percentile score often comes down to execution strategy — how quickly you recall formulas, how you manage time, and how you avoid repeated mistakes. These tips are distilled from the habits of students who cracked IIT and BITS on their first attempt.

1 Build Instant Formula Recall

In JEE Advanced and BITSAT, multi-concept questions require you to recall 3–4 formulas simultaneously under time pressure. Practice "formula sprints" — set a timer for 2 minutes and write down every formula you remember from a single chapter. Do this daily. The goal is zero hesitation when a formula is needed mid-solution.

2 Master the ILATE Rule for Integration

Integration by Parts is one of the most time-consuming operations if done wrong. The ILATE rule (Inverse → Logarithmic → Algebraic → Trigonometric → Exponential) tells you which function to set as "u" and which as "dv." Students who apply ILATE consistently save 2–3 minutes per integration problem — that's 15+ minutes saved across a full paper.

3 Maintain a Personal Error Log

Every mistake you make in practice is a gift — it reveals a gap before the exam does. Maintain a dedicated notebook where you record: (1) the question type, (2) the formula you misapplied, (3) the correct approach. Review this log every Sunday. Students who do this consistently reduce their error rate by 40–50% within 6 weeks.

4 Use Dimensional Analysis as a Check

In Physics-linked Math problems (especially in BITSAT), check if your answer has the right dimensions. If you're calculating a distance and your formula gives units of time, you've made an error. This 5-second check catches 30% of careless mistakes before you mark your answer.

✔ **Pro Tip:** Create formula flashcards organized by chapter. Review them during "dead time" — commuting, waiting, before sleep. Spaced repetition is the most scientifically validated method for long-term retention.

Final Push: Secure Your Rank

You now have the complete formula arsenal. The final step is execution — consistent, disciplined, and strategic. Remember: 60% of JEE Mathematics questions are directly formula-based. Speed and accuracy on these questions determine your percentile. Here is your battle plan for the final stretch.

Speed

Practice timed mock tests daily. Aim to solve formula-based questions in under 60 seconds. Use shortcut methods and mental math wherever possible. BITSAT rewards raw speed — practice on a computer interface to build familiarity.

Accuracy

Never sacrifice accuracy for speed in JEE Advanced — negative marking punishes careless attempts. In JEE Main and BITSAT, attempt all questions you're 80% confident about. Leave genuinely unknown questions rather than guessing randomly.

Consistency

Revise the Top 50 most-repeated formulas every single day without exception. Consistency over 90 days beats cramming over 7 days. Your brain consolidates memory through repetition, not intensity.

60%

Formula-Based Questions

Of all JEE Mathematics questions are directly solvable with formula recall — master them first.

50

Top Formulas to Revise Daily

The 50 most frequently repeated formulas across 10 years of JEE papers — these are your highest ROI study material.

90

Days of Consistent Revision

90 days of daily formula revision before the exam is the sweet spot for long-term retention and exam-day confidence.

"Accuracy, speed, and these core theorems are your path to the IIT and BITS campus. The formulas are your weapons — now go win your battle."

ALL THE BEST!

IIT / BITS 2025