

ADVANCE MATHEMATICS MASTER FORMULA VAULT

Algebra, Geometry, Circles, Triangles & Coordinate Theorems for SSC CGL Tier-1/Tier-2 & Railways

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1. High-Yield Algebraic Identities & Power Recursion

Master algebraic transformations tested consistently in SSC CGL Tier-2 and RRB NTPC exams:

Condition / Form	Expansion / Transformation Formula	Exam Application & Short-trick
Basic Expansion	$(a + b + c)^2 = a^2 + b^2 + c^2 + 2(ab + bc + ca)$	Substitute $ab + bc + ca = 0$ to obtain $a^2 + b^2 + c^2 = (a+b+c)^2$.
Euler Sum Form	$a^3 + b^3 + c^3 - 3abc = (a+b+c)(a^2 + b^2 + c^2 - ab - bc - ca)$ $= \frac{1}{2}(a+b+c)[(a-b)^2 + (b-c)^2 + (c-a)^2]$	If $a+b+c = 0$ or $a = b = c$, then $a^3 + b^3 + c^3 = 3abc$. Crucial for Tier-2 consecutive integers.
Reciprocal $x + 1/x = k$	$x^2 + 1/x^2 = k^2 - 2$ $x^3 + 1/x^3 = k^3 - 3k$ $x^4 + 1/x^4 = (k^2 - 2)^2 - 2$ $x^5 + 1/x^5 = (x^2+1/x^2)(x^3+1/x^3) - (x+1/x)$	If $x + 1/x = 1 \Rightarrow x^3 = -1$ If $x + 1/x = 2 \Rightarrow x = 1$ If $x + 1/x = \sqrt{3} \Rightarrow x^3 = -1$
Symmetric Difference	$(x - 1/x = m)$ $x^2 + 1/x^2 = m^2 + 2$ $x^3 - 1/x^3 = m^3 + 3m$	Relation between sums: $(x - 1/x)^2 = (x + 1/x)^2 - 4$

2. Triangle Centers & Pure Geometry Theorems

Geometric relationships governing medians, angle bisectors, and perpendiculars:

Triangle Center / Theorem	Governing Formula / Property	Critical Exam Takeaway
Incenter (I) Intersection of Angle Bisectors	$\angle BIC = 90^\circ + \angle A / 2$ - Inradius $r = \Delta / s$ (where s = semi-perimeter) - For Right Triangle: $r = (a + b - c) / 2$	Incenter is equidistant from all three sides. Tangent touchpoints create equal segments.
Circumcenter (O) Intersection of Perpendicular Bisectors	$\angle BOC = 2\angle A$ - Circumradius $R = abc / (4\Delta)$ - For Right Triangle: $R = \text{Hypotenuse} / 2$	Circumcenter is equidistant from all three vertices. In right triangle, midpoint of hypotenuse.
Orthocenter (H) Intersection of Altitudes	$\angle BHC = 180^\circ - \angle A$ - For Right Triangle: Orthocenter lies exactly on the vertex with 90°.	Distance between H and O: In equilateral triangle, H, G, I, and O coincide.

Centroid (G) Intersection of Medians	- Divides each median in 2 : 1 ratio Appollonius Theorem: $AB^2 + AC^2 = 2(AD^2 + BD^2)$ - Area of 3 medians triangle: $\Delta_{\text{orig}} = 4/3 \times \Delta_{\text{medians}}$	Medians divide triangle into 6 equal areas. Centroid divides triangle into 3 equal areas.
Euler Line Property	Orthocenter (H), Centroid (G), and Circumcenter (O) are collinear: HG : GO = 2 : 1	Tested directly in SSC CGL Tier-2 2024 & 2025 shift questions.

3. Circles, Tangents & Cyclic Quadrilaterals

Circle Theorem	Formula & Standard Expression	Application Case
Tangent-Secant Theorem	$PT^2 = PA \times PB$ (where PT is tangent from external point P, and PAB is secant)	Applies whether secant passes through center or not.
Intersecting Chords	$PA \times PB = PC \times PD$ (for chords intersecting internally or externally at P)	Constant power of point with respect to circle.
Direct Common Tangent (DCT)	$DCT = \sqrt{d^2 - (r_1 - r_2)^2}$ (where d = distance between centers)	When circles touch externally, $DCT = 2\sqrt{r_1 r_2}$.
Transverse Common Tangent (TCT)	$TCT = \sqrt{d^2 - (r_1 + r_2)^2}$	Only exists if $d \geq r_1 + r_2$.
Cyclic Quadrilateral (Ptolemy)	- Opposite angles sum to 180° Ptolemy Theorem: $AC \times BD = (AB \times CD) + (BC \times AD)$ - Area = $\sqrt{[(s-a)(s-b)(s-c)(s-d)]}$ (Brahmagupta)	Diagonals product equals sum of opposite side products.