

Quadratic Equations Sign Method & Double-Negative Constant Shortcut [Algebra - Quadratic Inequalities]**Formula:** $ax^2 + bx + c = 0$: | $(+,+) \Rightarrow (-,-)$, | $(-,+) \Rightarrow (+,+)$, | $(+,-) \Rightarrow (-,-)$, | $(-,-) \Rightarrow (+,+)$ The sign method allows instant identification of quadratic root signs without factorizing. For $ax^2 + bx + c = 0$: (1) If middle sign is + and constant is +, both roots are negative. (2) If middle is - and**Speed Trick:** [TRICK] 1-Second Master Rule: If the constant terms of BOTH equations are negative ($c_1 < 0$ and $c_2 < 0$)**Common Trap:** Forgetting to divide factors by the coefficient of x^2 or y^2 when leading coefficients differ.**CI & SI Difference Shortcuts (2-Year & 3-Year Annual Compounding) [Compound Interest - CI vs SI Differenc****Formula:** $D_2 = P(R/100)^2$, | $D_3 = P(R/100)^2(300 + R/100) = D_2 * (3 + (R/100))$ The difference between Compound Interest and Simple Interest over 2 years arises entirely from interest on the first year's interest. For 3 years, the additional terms yield $D_3 = D_2 * (3 + R/100)$.**Speed Trick:** [TRICK] Principal from 2-year difference: $P = (D_2 * 10,000) / R^2$.**Common Trap:** Using the 2-year formula when compounding is half-yearly (for half-yearly compounding over 1 year, use**Rule of Alligation & Replacement Ratio in Successive Dilutions [Mixture & Alligation - Successive Dilutio****Formula:** (Quantity of Cheaper / Quantity of Dearer) = $(d - m / m - c)$, | Remaining Liquid = $V(1 - (x/V))^n$ The rule of alligation is a modified form of weighted average. When a volume x of pure liquid is repeatedly drawn from initial volume V and replaced with water n times, the remaining pure liquid is**Speed Trick:** [TRICK] 10% Dilution Rule: If 8L out of 80L is drawn (10%), the remaining multiplier is 0.9. After 3 o**Common Trap:** Confusing the remaining quantity of pure liquid with the quantity of water added. Water added = Initial**Slopes of Lines: Parallel ($m_1 = m_2$) & Perpendicular ($m_1 * m_2 = -1$) [Coordinate Geometry - Slope & Lin****Formula:** $m = -(A/B) = (y_2 - y_1 / x_2 - x_1)$, | Parallel: $m_1 = m_2$, | Perpendicular: $m_1 * m_2 = -1$ The slope m of line $Ax + By + C = 0$ is $-A/B$. Two non-vertical lines are parallel if and only if their slopes are equal ($m_1 = m_2$). They are perpendicular if and only if the product of their slopes equals**Speed Trick:** [TRICK] Equation of line parallel to $Ax + By + C = 0$ is $Ax + By + k = 0$.**Common Trap:** Forgetting the negative sign in $m = -A/B$ for standard form $Ax + By + C = 0$.**Complementary Angle Products ($\tan A \tan B = 1$ when $A + B = 90^\circ$) [Trigonometry - Complementary Angle Pr****Formula:** $A + B = 90^\circ \Rightarrow A * B = 1$, | $A * B = 1$, | $\sin^2 A + \sin^2 B = 1$ When two angles sum to 90° , $\tan A = \cot B = 1/\tan B$, hence $\tan A \tan B = 1$. Similarly, $\sin B = \cos A$, so $\sin^2 A + \sin^2 B = \sin^2 A + \cos^2 A = 1$.**Speed Trick:** [TRICK] For series $\tan 1^\circ \tan 2^\circ \tan 3^\circ \dots \tan 89^\circ$: All pairs multiply to 1, leaving $\tan$ **Common Trap:** Forgetting to handle the middle term ($\tan 45^\circ$ or $\sin^2 45^\circ$) in symmetric series.**Minimum Value of Reciprocal Trig Forms: $a \sin^2 \theta + b \operatorname{cosec}^2 \theta$ [Trigonometry - Minima of Reciproca****Formula:** $\operatorname{Min}(a \sin^2 \theta + b \operatorname{cosec}^2 \theta) = 2\sqrt{ab}$ | (when $a \geq b$), | $\operatorname{Min}(a \sin^2 \theta + b \operatorname{cosec}^2 \theta) = 2\sqrt{ab}$ Using the Arithmetic Mean - Geometric Mean ($AM \geq GM$) inequality on positive quantities: $(a \sin^2 \theta + b \operatorname{cosec}^2 \theta) / 2 \geq (a \sin^2 \theta b \operatorname{cosec}^2 \theta) = (ab)$. Hence the minimum value is $2(ab)$. If $a < b$ **Speed Trick:** [TRICK] Minimum of $4 \tan^2 \theta + 9 \cot^2 \theta = 2(4 * 9) = 2 * 6 = 12$ in 2 seconds!**Common Trap:** Applying $2ab$ blindly when $a < b$ for sine and cosine forms without checking equality achievable condit**Tangent-Secant Theorem & External Chords Power [Geometry - Tangent-Secant Theorem & Intersecting Power]****Formula:** $PT^2 = PA * PB$, | $PA * PB = PC * PD$ If from an external point P , a tangent PT and a secant line PAB intersecting the circle at A and B are drawn, then $PT^2 = PA * PB$. If two secants PAB and PCD are drawn from P , then $PA * PB = PC * PD$.**Speed Trick:** [TRICK] Always remember: Distances are measured FROM the external point P ! (PA is external segment, PB **Common Trap:** Using AB instead of PB . The formula requires the FULL secant length $PB = PA + AB$.**Men-Days-Hours Work Equivalency Chain Rule (MDH/W) [Arithmetic - Men-Days-Hours Chain Rule]****Formula:** $(M_1 * D_1 * H_1 * E_1 / W_1) = (M_2 * D_2 * H_2 * E_2 / W_2)$ Where M is number of workers, D is number of days, H is working hours per day, E is relative worker efficiency, and W is total units of work completed (or wages earned, or consumption consumed).**Speed Trick:** [TRICK] W is the ONLY item in the denominator! Everything else (Men, Days, Hours, Efficiency) stays in**Common Trap:** Putting wages or units produced in the numerator instead of denominator.

Secant-Tangent Conjugate Reciprocal & Sin Ratio [Trigonometry - Secant & Tangent Reciprocal Conjugates]**Formula:** $+ = x \Leftrightarrow - = (1/x) \Rightarrow (x^2 - 1/x^2 + 1)$ Derived directly from $\sec^2\theta - \tan^2\theta = 1 = (\sec\theta + \tan\theta)(\sec\theta - \tan\theta)$. Adding both gives $2\sec\theta = x + 1/x \Rightarrow \sec\theta = (x^2 + 1)/(2x)$. Subtracting gives $2\tan\theta = x - 1/x \Rightarrow$ **Speed Trick:** [TRICK] If $\sec\theta + \tan\theta = 5$, then $\sin\theta = (5^2 - 1)/(5^2 + 1) = 24/26 = 12/13$ instantly with**Common Trap:** Forgetting that $\sec\theta + \tan\theta > 1$ in the first quadrant, so x is typically greater than 1. **$x + 1/x$ Power Ladders (Squares, Cubes, 5th & 7th Powers) [Algebra - $x + 1/x$ Power Ladders]****Formula:** $x^5 + (1/x^5) = (x^2 + (1/x^2))(x^3 + (1/x^3)) - (x + (1/x))$ When $x + 1/x = k$: $x^2 + 1/x^2 = k^2 - 2$; $x^3 + 1/x^3 = k^3 - 3k$; $x^4 + 1/x^4 = (k^2 - 2)^2 - 2$; $x^5 + 1/x^5 = (k^2 - 2)(k^3 - 3k) - k$; $x + 1/x = (x^3 + 1/x^3)(x^4 + 1/x^4) - (x + 1/x)$. When $x - 1/x = k$:**Speed Trick:** [TRICK] For $k = 3$: $x^2 + 1/x^2 = 7$; $x^3 + 1/x^3 = 18$; $x^5 + 1/x^5 = 7 * 18 - 3 = 126 - 3 = 123$!**Common Trap:** Forgetting to subtract $(x + 1/x)$ when multiplying powers to reach x^5 or x .**Perpendicular Distance from Point to Line & Area of Triangle [Coordinate Geometry - Perpendicular Distanc****Formula:** $d = \{|Ax_1 + By_1 + C|/\sqrt{A^2 + B^2}\}$, $| \text{Area} = (1/2)|x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)|$ Gives the shortest distance d from point $P(x_1, y_1)$ to line $Ax + By + C = 0$. The coordinate triangle area formula computes the enclosed polygon area from 3 vertices.**Speed Trick:** [TRICK] Distance between two parallel lines $Ax + By + C_1 = 0$ and $Ax + By + C_2 = 0$ is $d = |C_1 - C_2|$ **Common Trap:** Forgetting to normalize coefficients A and B before taking difference $|C_1 - C_2|$ for parallel lines.**Regular Polygons: Interior Angles, Exterior Angles & Total Diagonals [Geometry - Regular Polygons & Diago****Formula:** Interior Sum = $(n - 2) * 180^\circ$, | Each Exterior = $(360^\circ / n)$, | Diagonals = $(n(n - 3) / 2)$ For any n -sided regular polygon, the sum of all exterior angles is always 360° . Sum of one interior angle and one exterior angle at any vertex is always 180° . The number of unique diagonals connecting**Speed Trick:** [TRICK] Always find Exterior Angle first! If interior is 140° , exterior = $180^\circ - 140^\circ = 40^\circ$ de**Common Trap:** Using the cumbersome interior angle equation when exterior angle gives n directly.**Variance (σ^2), Standard Deviation (σ) & Coefficient of Variation (CV) [Statistics - Variance, Standard D****Formula:** $\sigma^2 = \{ (x_i - \bar{x})^2 / N \}$, $\sigma = \sqrt{\text{Variance}}$, $CV = \{ \sigma / \bar{x} \} * 100\%$ Variance is the mean of squared deviations from the arithmetic mean $\bar{x}$. Standard deviation is the positive square root of variance. Coefficient of variation (CV) measures relative dispersion: a lower**Speed Trick:** [TRICK] If every data value is multiplied by k , both mean and SD are multiplied by $|k|$, and Variance i **Common Trap:** Thinking that adding a constant increases standard deviation. Shift in origin does NOT alter dispersio**Difference Between Compound and Simple Interest (2 & 3 Years) [Arithmetic - CI vs SI 2-Year & 3-Year Diff****Formula:** $D_2 = P(R/100)^2$, $D_3 = P(R/100)^2(300 + R/100) = D_2(3 + (R/100))$ D_2 is the difference between CI and SI for 2 years on Principal P at annual rate $R\%$. For 3 years, D_3 equals D_2 multiplied by $(300 + R)/100$. Ratio of D_3 / D_2 is always $(300 + R) / 100 = 3 + R/100$, which**Speed Trick:** [TRICK] If $D_3 / D_2 = 31 / 10$, then $3 + R/100 = 3.1 \Rightarrow R/100 = 0.1 \Rightarrow R = 10\%$ in 5 seconds!**Common Trap:** Confusing 3rd year interest difference with 3 years total difference.**Repeated Removal & Replacement (Milk & Water Dilution) [Mixtures - Repeated Dilution]****Formula:** $Q_{\text{remaining}} = Q_0 (1 - (x/V))^n$ Where Q is the initial quantity of pure liquid, V is total capacity/volume, x is quantity removed & replaced with water in each operation, and n is number of operations performed.**Speed Trick:** [TRICK] Remaining Milk / Total Volume = $(1 - x/V)^n$. Directly gives final ratio of Milk to Total.**Common Trap:** Confusing "Milk : Water ratio" with "Milk : Total Mixture ratio". Always use Total in the denominator.**Legendre's Formula for Trailing Zeros in N! (Factorials) [Number System - Trailing Zeros & Cyclicity]****Formula:** $E_5(N!) = (N/5) + (N/5^2) + (N/5^3) + \dots$ Number of trailing zeros in $N!$ is governed by the exponent of 5, since 2s are abundant. Continue dividing until 5 exceeds N .**Speed Trick:** [TRICK] For $100!$ $\rightarrow 100/5 = 20$; $20/5 = 4$. Total = $20 + 4 = 24$ zeros.**Common Trap:** Forgetting power of 25 contributing two 5s, 125 contributing three 5s.**Apollonius' Theorem on Medians of a Triangle [Geometry - Triangles]****Formula:** $AB^2 + AC^2 = 2(AD^2 + BD^2) = 2(AD^2 + (BC/2)^2)$ In ABC , if AD is a median bisecting side BC at D , the sum of squares of two sides equals twice the sum of squares of the median and half the third side.**Speed Trick:** [TRICK] Length of median $AD = (1/2) \sqrt{2AB^2 + 2AC^2 - BC^2}$.**Common Trap:** Applying angle bisector theorem instead of Apollonius theorem when median is specified.

Volume & Curved Surface Area of Frustum of a Cone [Mensuration 3D - Frustum of Cone]**Formula:** $V = (1/3)\pi h(R^2 + r^2 + Rr)$, $CSA = \pi l(R + r)$, $l = \sqrt{h^2 + (R - r)^2}$

Where R is bottom base radius, r is top base radius, h is vertical height, and l is slant height of the frustum (bucket shape).

*Speed Trick: [TRICK] Total Surface Area = $CSA + \pi R^2 + \pi r^2 = \pi[l(R + r) + R^2 + r^2]$.**Common Trap: Squaring (R + r) in volume formula: it is $(R^2 + r^2 + Rr)$, NOT $(R + r)^2$.***Empirical Relationship: Mode, Median and Mean [Statistics & Measures of Central Tendency]****Formula:** $\text{Mode} = 3\text{Median} - 2\text{Mean}$ | $\text{Mean} - \text{Mode} = 3(\text{Mean} - \text{Median})$

For moderately asymmetrical/skewed distributions, Karl Pearson empirical formula links Mode, Median, and Mean.

Speed Trick: [TRICK] Memory Mnemonic: 3-letter word "Med" gets 3; 4-letter word "Mean" gets 2. $\text{Mode} = 3(\text{Median}) - 2$ *Common Trap: Swapping coefficients: writing 2 Median - 3 Mean is incorrect and reverses the sign.***Direct Common Tangent (DCT) & Transverse Common Tangent (TCT) [Geometry - Circles]****Formula:** $\text{DCT} = \sqrt{d^2 - (r_1 - r_2)^2}$ | and | $\text{TCT} = \sqrt{d^2 - (r_1 + r_2)^2}$ Where d is the distance between centres, and r_1 and r_2 are the radii of the two circles. DCT always exists if circles do not lie inside one another. TCT exists only if $d \geq (r_1 + r_2)$.*Speed Trick: DCT is always LONGER than or equal to TCT.**Common Trap: Using $(r_1 - r_2)$ instead of $(r_1 + r_2)$ for Transverse Tangents causes instant -0.5 negative penalty.***Conditional Identity when $a + b + c = 0$ [Algebra - Cubic & Symmetric Identities]****Formula:** $a^3 + b^3 + c^3 - 3abc = (a+b+c)(a^2 + b^2 + c^2 - ab - bc - ca) = (1/2)(a+b+c)[(a-b)^2 + (b-c)^2 + (c-a)^2]$ If $(a + b + c) = 0$, then $a^3 + b^3 + c^3 = 3abc$. Also, if $a^2 + b^2 + c^2 = ab + bc + ca$, then $a = b = c$.*Speed Trick: If $(x - a)^3 + (x - b)^3 + (x - c)^3 = 3(x - a)(x - b)(x - c)$, immediately set $(x - a) + (x - b) + (x - c) = 0$.**Common Trap: Forgetting the minus sign: $(x - 1/x = k)$ leads to $(k^3 + 3k)$, NOT $(k^3 - 3k)$.***Maximum and Minimum Values of Trigonometric Expressions [Trigonometry - Maxima & Minima]****Formula:** For $a + b$: | $\text{Max} = +\sqrt{a^2 + b^2}$, | $\text{Min} = -\sqrt{a^2 + b^2}$ For expressions like $a \sin^2\theta + b \csc^2\theta$, $a \cos^2\theta + b \sec^2\theta$, or $a \tan^2\theta + b \cot^2\theta$, the Minimum value is always $2(a b)$ when $a > 0, b > 0$.*Speed Trick: $\sin^2\theta + \cos^2\theta$ always has $\text{Max} = 1$ (at $\theta = 0$ deg or 90 deg), and Min occurs at $\theta = 45$ deg.**Common Trap: For $a \sin^2\theta + b \csc^2\theta$ when $a < b$, the minimum is $(a + b)$, NOT $2(ab)$.***Tangent-Secant Theorem & Intersecting Chord Power [Geometry - Circles & Tangents]****Formula:** $PA \cdot PB = PC \cdot PD$ | and | $PT^2 = PA \cdot PB$ If chords AB and CD intersect at P (internally or externally), $PA \cdot PB = PC \cdot PD$. If PT is a tangent from external point P and PAB is a secant, $PT^2 = PA \cdot PB$.*Speed Trick: Always measure from the intersection point P to both ends of the chord: PA and PB.**Common Trap: Writing PA AB instead of PA PB is the #1 mistake candidates make.***Incentre, Circumcentre, Orthocentre Angles & Centroid [Geometry - Triangle Centres]****Formula:** $\angle BIC = 90^\circ + (A/2)$, $\angle BOC = 2A$, $\angle BHC = 180^\circ - A$

Where I = Incentre (intersection of angle bisectors), O = Circumcentre (perpendicular bisectors), and H = Orthocentre (altitudes).

*Speed Trick: In a right triangle, Orthocentre is at the 90 deg vertex, Circumcentre is at the midpoint of hypotenuse.**Common Trap: Confusing Incentre angle $(90 \text{ deg} + A/2)$ with Circumcentre angle $(2A)$.***Inradius, Circumradius & Heron's Area Formula [Geometry - Triangle Areas & Radii]****Formula:** $s = \sqrt{s(s-a)(s-b)(s-c)}$, $r = (s/A)$, $R = (abc/4A)$ Where $s = (a + b + c)/2$ is semi-perimeter, r is inradius, R is circumradius, and A is the area of the triangle.*Speed Trick: For Equilateral Triangle of side a: $\text{Area} = (\sqrt{3}/4)a^2$, $\text{Inradius } r = a/(2\sqrt{3})$, $\text{Circumradius } R = a/\sqrt{3}$.**Common Trap: Forgetting that $r = A/s$ applies to ANY triangle (scalene, isosceles, equilateral).***Cyclic Quadrilateral: Ptolemy's & Brahmagupta's Theorems [Geometry - Quadrilaterals]****Formula:** Brahmagupta: $s = \sqrt{(s-a)(s-b)(s-c)(s-d)}$, | Ptolemy: $d_1 \cdot d_2 = ac + bd$

For a cyclic quadrilateral where all 4 vertices lie on a circle, opposite angles sum to 180 deg.

Product of diagonals equals sum of products of opposite sides.

*Speed Trick: If a cyclic quadrilateral is also circumscribed around a circle, $\text{Area} = (abcd)/r$.**Common Trap: Applying Brahmagupta's formula to non-cyclic quadrilaterals produces incorrect areas.*

Internal and External Angle Bisector Theorem & Stewart's Theorem [Geometry - Triangles]**Formula:** $(AB / AC) = (BD / CD)$ | and $| AD^2 = AB * AC - BD * CD$

An angle bisector of a triangle divides the opposite side into segments proportional to the adjacent sides. AD is the internal bisector of A.

Speed Trick: For external angle bisector meeting BC extended at E: $AB / AC = BE / CE$.

Common Trap: Assuming angle bisector is perpendicular to opposite side (only true in isosceles/equilateral).

Frustum of a Right Circular Cone (Bucket) [Mensuration 3D - Frustum & Cones]**Formula:** $V = (1/3)\pi h (R^2 + r^2 + Rr)$, $| CSA = \pi l (R + r)$, $| l = \sqrt{h^2 + (R - r)^2}$

Where R is base radius, r is top radius, h is vertical height, and l is slant height.

Speed Trick: When a cone of height H is cut parallel to base at height h from apex: Volume ratio = $(h / H)^3$.

Common Trap: Using $(R^2 + r^2)$ instead of $(R^2 + r^2 + Rr)$ in volume loses 2.5 marks.

Sphere, Hemisphere & Solid Melting Conservation [Mensuration 3D - Spheres & Hemispheres]**Formula:** $V_{\text{sphere}} = (4/3)\pi r^3$, $| TSA_{\text{hemi}} = 3\pi r^2$, $| CSA_{\text{hemi}} = 2\pi r^2$

Total surface area of solid hemisphere includes the circular top ($2\pi r^2 + \pi r^2 = 3\pi r^2$). When n smaller spheres of radius r are melted to form a sphere of radius R: $R^3 = n r^3$.

Speed Trick: If radius increases by x%, Volume increases by $[3x + 3x^2/100 + x^3/1000]\%$.

Common Trap: Using $2\pi r^2$ instead of $3\pi r^2$ for TOTAL surface area of a solid hemisphere.

Symmetric Quartic & Power Expansions [Algebra - Higher Polynomials]**Formula:** $x^4 + x^2 y^2 + y^4 = (x^2 + xy + y^2)(x^2 - xy + y^2)$

This identity is heavily tested in TCS SSC Tier 1 and Tier 2 papers. Given $(x^2 + xy + y^2)$ and $(x^2 - xy + y^2)$, adding them gives $2(x^2 + y^2)$, subtracting gives $2xy$.

Speed Trick: If $x^4 + x^2 y^2 + y^4 = 21$ and $x^2 + xy + y^2 = 7$, then $x^2 - xy + y^2 = 3$.

Common Trap: Forgetting that $(x^2 + y^2)$ is the arithmetic mean of the two factors.

Compound Angle & Product-to-Sum Formulas [Trigonometry - Compound & Multiple Angles]**Formula:** $(A + B) = (A + B / 1 - A B)$, $| 2A = (2A / 1 + A^2 A)$, $| 2A = (1 - A^2 A / 1 + A^2 A)$

If $A + B = 45^\circ$ or 225° , then $(1 + \tan A)(1 + \tan B) = 2$ and $(\cot A - 1)(\cot B - 1) = 2$.

Speed Trick: If $A + B + C = 180^\circ$, $\tan A + \tan B + \tan C = \tan A \tan B \tan C$.

Common Trap: Forgetting the 1/4 factor in the sin and cos triple-angle product formulas.

Height and Distance Standard Triangle Ratios [Trigonometry - Heights & Distances]**Formula:** $30^\circ - 60^\circ - 90^\circ \Rightarrow 1 : \sqrt{3} : 2$, $| 45^\circ - 45^\circ - 90^\circ \Rightarrow 1 : 1 : \sqrt{2}$, $| h = (d / 1 - 2)$

Standard ratio multipliers eliminate the need to write full tan theta equations. If angles of elevation of top of tower from two points at distances a and b are complementary, Height h = (ab).

Speed Trick: Complementary Angles: $h = (a b)$.

Common Trap: Measuring distances a and b from each other instead of from the base of the tower.

Euler's Totient Theorem & Fermat's Little Theorem [Number System - Remainders & Euler Totient]**Formula:** $a^{\phi(n)} \equiv 1 \pmod n$ | and $| a^{p-1} \equiv 1 \pmod p$ | (for prime p)

Where $\phi(n) = n(1 - 1/p_1)(1 - 1/p_2)$ is Euler's totient function. Wilson's Theorem: $(p - 1)! + 1$ is divisible by prime p, i.e., $(p - 1)! \equiv -1 \pmod p$.

Speed Trick: To find remainder of a^k / p (where p is prime): Divide power k by $(p - 1)$ and find remainder.

Common Trap: Applying Fermat's theorem when the base and divisor are not coprime.

Composite Divisibility Rules for 72, 88, 99 & 7-11-13 Oscillators [Number System - Divisibility Rules]**Formula:** $72 = 8 * 9$, $| 88 = 8 * 11$, $| 99 = 9 * 11$, $| 1001 = 7 * 11 * 13$

To test divisibility by 72: Last 3 digits must be divisible by 8, and sum of all digits must be divisible by 9. For 88: Last 3 digits div by 8, and (Sum of odd places - Sum of even places) div by 11.

Speed Trick: Divisibility by 8: If hundreds digit is EVEN, check last 2 digits. If hundreds digit is ODD, add 4 to

Common Trap: Finding multiple values of y in divisibility by 8 and picking the minimum when question asks for maxim

Total, Even, Odd Factors and Sum of Factors of N [Number System - Factors & Multiples]**Formula:** $N = p^a q^b r^c \Rightarrow \text{Total Factors} = (a+1)(b+1)(c+1)$, $| \text{Sum} = \{p^{a+1}-1\}\{q^{b+1}-1\}\{r^{c+1}-1\} / \{p-1\}\{q-1\}\{r-1\}$

Where p, q, r are prime factors. Odd factors = product of $(\text{power} + 1)$ of odd primes only. Even factors = Total - Odd factors = $a(b+1)(c+1)$ where $p=2$.

Speed Trick: Product of all factors of $N = N^{\text{Total Factors} / 2}$.

Common Trap: Counting 1 as a prime factor when prime factorizing.

Trailing Zeroes in n! (Legendre's Formula) [Number System - Trailing Zeroes]**Formula:** $Z(n!) = (n / 5) + (n / 5^2) + (n / 5^3) + \dots$ Trailing zeroes are created by pairs of (2×5) . In factorials, 2s are abundant, so the number of trailing zeroes is determined entirely by the highest power of 5 in $n!$.*Speed Trick: Keep dividing n by 5, then divide quotient by 5, and sum all quotients.**Common Trap: Adding the original number n into the sum instead of only summing the quotients.***Difference Between CI and SI for 2 Years and 3 Years [Simple & Compound Interest]****Formula:** $D_2 = P(R / 100)^2$, $D_3 = P(R / 100)^2 (300 + R / 100) = D_2 (3 + (R / 100))$ Where D_2 is difference between CI and SI for 2 years, D_3 is difference for 3 years at annual rate $R\%$ on Principal P .*Speed Trick: Ratio of D_3 to D_2 : $D_3 / D_2 = (300 + R) / 100$. If D_3/D_2 is given as $31/10$, $R = 10\%$ immediately!**Common Trap: Using $D_3 = 3 D_2$ (only true if $R=0$, actual has extra $PR^2/100^3$ term).***Compound Interest Successive Effective Rate Formula [Simple & Compound Interest]****Formula:** $R_{\text{eff}} = a + b + (ab / 100)$ | (for 2 periods), $A = P(1 + (R / 100))^n$

For standard annual rates: 5% for 2 yrs = 10.25%, 10% for 2 yrs = 21%, 10% for 3 yrs = 33.1%, 20% for 2 yrs = 44%, 20% for 3 yrs = 72.8%.

*Speed Trick: If sum doubles in n years at CI: It becomes 2^k times in $(k n)$ years.**Common Trap: Applying SI linear multiplication to CI exponential growth.***Dishonest Dealer & Faulty Weight Formula [Profit, Loss & Discount]****Formula:** $\text{Gain \%} = (\text{Error} / \text{True Value} - \text{Error}) \times 100\% = ((\text{Claimed Weight} / \text{Actual Weight}) - 1) \times 100\%$

When a shopkeeper sells at cost price but uses a faulty weight (e.g. 900g instead of 1000g), profit is earned purely on the goods given to the customer.

*Speed Trick: If dealer marks up by $m\%$ and uses g grams instead of G grams: $\text{Net Multiplier} = (1 + m/100) \times (G / g)$.**Common Trap: Dividing the error by 1000g instead of 900g (actual weight given).***Successive Discounts & Marked Price to Cost Price Ratio [Profit, Loss & Discount]****Formula:** $D_{\text{net}} = d_1 + d_2 - (d_1 d_2 / 100)$, $(MP / CP) = (100 + \text{Profit \%} / 100 - \text{Discount \%})$

The MP/CP ratio formula solves 80% of SSC Tier 1 discount problems instantly without setting variable equations.

Speed Trick: "Buy x, Get y Free" Equivalent Discount $\% = [y / (x + y)] \times 100\%$. E.g. Buy 4 Get 1 Free = $(1/5) \times 100 = 20$ *Common Trap: Writing $[y / x]$ instead of $[y / (x + y)]$ in "Buy x Get y Free".***Mean, Third, and Fourth Proportional [Ratio, Proportion & Variation]****Formula:** Mean Proportional $(b) = \sqrt{ac}$, | Third Proportional $(c) = (b^2 / a)$, | Fourth Proportional $(d) = (bc / a)$ In continued proportion $a:b = b:c$, b is the mean proportional. In $a:b = c:d$, d is the fourth proportional.*Speed Trick: If $(a + x) / (b + x) = (c + x) / (d + x)$, then $x = (ad - bc) / [(a + d) - (b + c)]$.**Common Trap: Mixing up Third Proportional (needs 2 terms) with Fourth Proportional (needs 3 terms).***Rule of Alligation & Repeated Replacement Formula [Mixtures & Alligations]****Formula:** $(Q_1 / Q_2) = \{C_2 - C_{\text{mean}}\} / \{C_{\text{mean}} - C_1\}$, | Final Qty of Pure Liquid = $\text{Initial} \times (1 - (y / x))^n$ Where x is total capacity of vessel, y is quantity drawn out and replaced with water each time, and n is number of replacement operations.*Speed Trick: Alligation can be applied to Average Speeds, Interest Rates, Profit/Loss % on items, and Class Test Av**Common Trap: Thinking alligation gives ratio of Selling Prices instead of Cost Prices.***Men-Days-Hours Formula (MDH / W Rule) [Time and Work - Men & Machines]****Formula:** $(M_1 \times D_1 \times H_1 \times E_1 / W_1) = (M_2 \times D_2 \times H_2 \times E_2 / W_2)$ Where M = Number of workers, D = Days, H = Hours per day, E = Efficiency, W = Work done (or wages earned, food eaten, trenches dug).*Speed Trick: If A is $x\%$ more efficient than B: $\text{Ratio of Efficiency} = (100 + x) : 100$, $\text{Ratio of Days taken} = 100 : ($* *Common Trap: Putting wages/work done in the numerator instead of denominator.*

Alternate Day Work & Leakage Pipes [Time and Work - Pipes & Cisterns]**Formula:** $\text{Net Work per Hour} = (1/A) + (1/B) - (1/\text{Leak})$ When Inlet Pipe A fills in a hours and Outlet/Leak B empties in b hours (where $b > a$), net filling time = $(ab) / (b - a)$.*Speed Trick: Always convert into Total LCM Units of tank capacity.**Common Trap: Letting the cycle overshoot full tank capacity and then subtracting overfilled water.***Average Speed & Distance When Time Difference is Given [Speed, Time & Distance]****Formula:** $v_{\text{avg}} = (2xy / (x + y))$ | (for equal distances), $D = (s_1 s_2 / |s_1 - s_2|) * t$ Where s_1 and s_2 are two speeds, and t is the difference in arrival times (e.g. 10 min late vs 5 min early = 15 min difference).*Speed Trick: For 3 equal distances at speeds x, y, z: Average Speed = $(3xyz) / (xy + yz + zx)$.**Common Trap: Forgetting to convert time in minutes to hours (divide by 60) when speeds are in km/h.***Trains Crossing Objects & Relative Speeds [Speed, Time & Distance - Trains]****Formula:** $T_{\text{pole}} = \{L_{\text{train}}\} / \{S_{\text{train}}\}$, $T_{\text{plat}} = \{L_{\text{train}} + L_{\text{plat}}\} / \{S_{\text{train}}\}$, $T_{\text{cross}} = (L_1 + L_2 / S_1 \pm S_2)$

Use (+) in relative speed when trains move in OPPOSITE directions. Use (-) when moving in the SAME direction. Speed conversion: 1 km/h = 5/18 m/s, 1 m/s = 18/5 km/h.

*Speed Trick: Two trains start at same time from A and B towards each other. After meeting, they reach destinations**Common Trap: Multiplying by 18/5 instead of 5/18 when converting km/h to m/s.***Boats and Streams Upstream & Downstream Velocity [Speed, Time & Distance - Boats & Streams]****Formula:** $u = (D + U / 2)$ | (Boat in still water), $v = (D - U / 2)$ | (Stream speed)Where D = Downstream Speed ($u + v$), and U = Upstream Speed ($u - v$). Total round trip time for distance d : $T = d/(u+v) + d/(u-v) = (2du) / (u^2 - v^2)$.*Speed Trick: If boat takes k times as long to row upstream as to row downstream: $u / v = (k + 1) / (k - 1)$.**Common Trap: Adding stream speed in upstream instead of subtracting.***Distance, Section Formula & Perpendicular Lines [Coordinate Geometry]****Formula:** $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$, $P(x,y) = ((m x_2 + n x_1 / m+n), (m y_2 + n y_1 / m+n))$, $m_1 m_2 = -1$ Slope of line $ax + by + c = 0$ is $m = -a/b$. Two lines are parallel if $m_1 = m_2$. Two lines are perpendicular if $m_1 m_2 = -1$.*Speed Trick: Area of triangle with vertices (x_1, y_1) , (x_2, y_2) , (x_3, y_3) : Area = $(1/2)|x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)|$.**Common Trap: Forgetting the negative sign in the slope formula of general line $m = -a/b$.***Empirical Relationship: Mode, Median & Mean [Statistics & Measures of Central Tendency]****Formula:** $\text{Mode} = 3\text{Median} - 2\text{Mean}$, $s^2 = \text{Variance} = \{ (x_i - \bar{x})^2 / N \}$

Karl Pearson's empirical formula relates Mode, Median, and Mean for moderately skewed distributions.

Standard Deviation = $\sqrt{\text{Variance}}$.*Speed Trick: Coefficient of Variation (CV) = $(\text{Standard Deviation} / \text{Mean}) * 100\%$.**Common Trap: Writing Mode = $2\text{Median} - 3\text{Mean}$ instead of $3\text{Median} - 2\text{Mean}$.***Arithmetic (AP) & Geometric (GP) Progression Sums [Algebra - Progressions (AP & GP)]****Formula:** $S_n(\text{AP}) = (n/2)[2a + (n-1)d] = (n/2)(a + l)$, $S_n(\text{GP}) = (a/1-r) | (|r| < 1)$ Nth term of AP: $T_n = a + (n-1)d$. Nth term of GP: $T_n = a r^{(n-1)}$. Sum of first n natural numbers = $n(n+1)/2$. Sum of squares = $n(n+1)(2n+1)/6$. Sum of cubes = $[n(n+1)/2]^2$.*Speed Trick: Sum of first n ODD numbers = n^2 .**Common Trap: Applying S_n formula when common ratio $r \geq 1$ (series diverges).***Apollonius' Theorem & Length of Medians [Geometry - Triangles & Medians]****Formula:** $AB^2 + AC^2 = 2(AD^2 + BD^2) = 2AD^2 + (1/2)BC^2$ Relates the sides of a triangle ABC to the length of median AD drawn to side BC. Also: $3(AB^2 + BC^2 + CA^2) = 4(m_a^2 + m_b^2 + m_c^2)$.*Speed Trick: In a right triangle, the median to hypotenuse = Hypotenuse / 2 = Circumradius R.**Common Trap: Using Apollonius for angle bisectors instead of medians.*

Intersecting Chords & Secant-Tangent Theorem [Geometry - Circles & Tangents]**Formula:** $PA \cdot PB = PC \cdot PD$ | and $|PT|^2 = PA \cdot PB$

When two chords AB and CD intersect at P (inside or outside the circle), $PA \cdot PB = PC \cdot PD$. If PT is a tangent from external point P and PAB is a secant, then $PT^2 = PA \cdot PB$.

Speed Trick: Always measure lengths from the intersection point P (P to A and P to B, NOT A to B).

Common Trap: Multiplying PA AB instead of PA PB.

Inradius (r) and Circumradius (R) Formulations [Geometry - Inradius & Circumradius]**Formula:** $r = (A/s)$, $|R = (abc/4)|$, $|r_{\text{right}} = (P + B - H/2)|$, $|R_{\text{right}} = (H/2)|$

For any triangle with area and semi-perimeter s, inradius $r = A/s$ and circumradius $R = abc/(4A)$. For an equilateral triangle of side a: $r = a/(2\sqrt{3})$, $R = a/\sqrt{3}$ ($R = 2r$).

Speed Trick: Distance between circumcentre and incentre: $d = (R^2 - 2Rr)$ (Euler's Triangle Formula).

Common Trap: Using s as perimeter instead of semi-perimeter $(a+b+c)/2$.

Frustum of a Cone - Slant Height, CSA & Volume [Mensuration - 3D Frustum of a Cone]**Formula:** $V = (1/3)\pi h(R^2 + r^2 + Rr)$, $|CSA = \pi(R + r)l|$, $|l = \sqrt{h^2 + (R - r)^2}|$

Where R is bottom radius, r is top radius, h is vertical height, and l is slant height. Total Surface

Area (TSA) = $\pi l(R + r) + \pi R^2 + \pi r^2$.

Speed Trick: If a cone is cut into two parts by a plane parallel to base at midpoint of height, the ratio of volume

Common Trap: Using $(R^2 + r^2)$ in volume instead of $(R^2 + r^2 + Rr)$.

Right Prism & Right Pyramid Standard Formulas [Mensuration - Prism & Pyramid]**Formula:** Prism: $V = \text{Base Area} \cdot h$, $|LSA = \text{Base Perim} \cdot h|$; Pyramid: $V = (1/3) \text{Base Area} \cdot h$, $|LSA = (1/2) \text{Base Perim} \cdot l|$

For a right prism, cross-sections are identical throughout. For a right pyramid, slant height $l = \sqrt{h^2 + r^2}$ where r is inradius of the base.

Speed Trick: Regular Tetrahedron (all 4 faces equilateral triangles of side a): Volume = $(a^3 \sqrt{2})/12$, Height = $a/\sqrt{3}$

Common Trap: Using vertical height h instead of slant height l for Lateral Surface Area of a pyramid.

Total Factors, Sum of Factors & Product of Factors [Number System - Factors & Multiples]**Formula:** If $N = p^a q^b r^c$: | No. of Factors = $(a+1)(b+1)(c+1)$, | Sum = $\{p^{a+1}-1\}\{q^{b+1}-1\}\{r^{c+1}-1\} / \{p-1\}\{q-1\}\{r-1\}$

Where p, q, r are distinct prime factors of N. Number of odd factors = $(b+1)(c+1)$ where p=2 is omitted.

Number of even factors = $a(b+1)(c+1)$. Product of all factors = $N^{(\text{Total Factors} / 2)}$.

Speed Trick: Perfect squares always have an ODD number of factors; all other integers have an EVEN number of factor

Common Trap: Forgetting to prime-factorize completely before applying exponents (e.g. $12 = 2^2 \cdot 3$, NOT $4 \cdot 3$).

Euler's Totient Function & Remainder Theorem [Number System - Euler Totient & Remainder]**Formula:** $(N) = N(1 - (1/p_1))(1 - (1/p_2))\dots$, $|a^{(N)} \equiv 1 \pmod N|$ (if $(a,N)=1$)

Euler's Totient (N) counts integers up to N coprime to N. By Euler's Theorem, remainder of a^k divided by N = remainder of $a^{(k \bmod N)}$ divided by N.

Speed Trick: Fermat's Little Theorem: If p is prime, $a^{(p-1)} \bmod p = 1$.

Common Trap: Using Euler's theorem when a and N are not coprime ($\gcd > 1$).

Unit Digit Cyclicity of Exponents [Number System - Unit Digit Cyclicity]**Formula:** Cycle of 2, 3, 7, 8 = 4; | Cycle of 4, 9 = 2; | Cycle of 0, 1, 5, 6 = 1

To find the unit digit of N^k , divide power k by 4. If remainder is r (1, 2, 3), unit digit = (unit digit of N)^r. If remainder is 0, use power 4.

Speed Trick: $4^{(\text{odd})} = 4$, $4^{(\text{even})} = 6$.

Common Trap: Using power 0 when power is exactly divisible by 4; power must be 4.

High-Order Algebraic Identities ($x^5 + 1/x^5$ & $x + 1/x$) [Algebra - Higher Order Polynomial Shortcuts]**Formula:** $x^5 + (1/x^5) = (x^2 + (1/x^2))(x^3 + (1/x^3)) - (x + (1/x))$, $|x^7 + (1/x^7) = (x^3 + (1/x^3))(x^4 + (1/x^4)) - (x + (1/x))|$

Direct 10-second shortcuts to evaluate 5th and 7th power symmetric polynomials without full expansion.

Speed Trick: If $x + 1/x = 3$: $x^2 + 1/x^2 = 7$, $x^3 + 1/x^3 = 18 \Rightarrow x^5 + 1/x^5 = 7(18) - 3 = 126 - 3 = 123$.

Common Trap: Adding $(x + 1/x)$ at the end instead of subtracting.

Roots Relations & Conditions for Common Roots [Algebra - Quadratic Equations]**Formula:** For $ax^2 + bx + c = 0$: $|+ = -(b/a), |- = (c/a), ||-| = \{\sqrt{b^2 - 4ac}\}/|a|$ Condition for two equations $a_1x^2 + b_1x + c_1 = 0$ and $a_2x^2 + b_2x + c_2 = 0$ to have BOTH roots common: $a_1/a_2 = b_1/b_2 = c_1/c_2$. Condition for ONE common root: $(c_1a_2 - c_2a_1)^2 = (a_1b_2 - a_2b_1)^2$ **Speed Trick:** If one root is $p + q$, other root is conjugate $p - q$ (when coefficients are rational).**Common Trap:** Forgetting the negative sign in sum of roots: $\alpha + \beta = -b/a$.**Cosine Continuous Double Angle Product [Trigonometry - Continuous Product Series]****Formula:** $2\theta \cdot 4\theta \cdot (2^{n-1}\theta) = (2^n \theta) / 2^n$

High-speed reduction formula for trigonometric products where angle doubles in each successive term.

Speed Trick: $\cos 20^\circ \cos 40^\circ \cos 80^\circ = 1/8$.**Common Trap:** Forgetting the $1/4$ multiplier in sin/cos triple angle products.**Heights & Distances - Fixed Angle Ratio Matrix [Trigonometry - Heights & Distances]****Formula:** $30^\circ : 60^\circ : 90^\circ \Rightarrow 1 : \sqrt{3} : 2$, $45^\circ : 45^\circ : 90^\circ \Rightarrow 1 : 1 : \sqrt{2}$ Ratio method eliminates 90% of height and distance algebra in TCS exams. If distance between two elevation angles α and β from opposite sides of tower of height h is d , $h = d / (\cot \alpha + \cot \beta)$ **Speed Trick:** When angle changes from 30° to 45° moving distance d towards tower: $h = d / (3 - 1) = d(3 + 1)$ **Common Trap:** Using $d / (3 + 1)$ when moving towards tower instead of $(3 - 1)$.**Repeated Removal and Replacement Formula [Arithmetic - Mixture & Alligation]****Formula:** $Q_{\text{remaining}} = Q_{\text{initial}} (1 - (x/C))^n$ Where C is total capacity of vessel, x is quantity drawn out and replaced with water in each operation, and n is number of times operation is performed.**Speed Trick:** Ratio of pure liquid remaining to total mixture $= (1 - x/C)^n$.**Common Trap:** Dividing by the remaining quantity instead of total capacity C in $(1 - x/C)$.**Average Speed & Early / Late Distance Shortcut [Arithmetic - Time, Speed & Distance]****Formula:** Avg Speed $= (2S_1 S_2 / (S_1 + S_2))$, Distance $= (S_1 \cdot S_2 / |S_1 - S_2|) \cdot T$ If a person travels at S_1 and is t_1 minutes late, and at S_2 is t_2 minutes early: $T = (t_1 + t_2)/60$ hours. Distance is directly computed in 5 seconds.**Speed Trick:** If both are late or both are early, $T = |t_1 - t_2|$.**Common Trap:** Forgetting to convert minutes T to hours by dividing by 60.**After-Crossing Time vs Speed Ratio Theorem [Arithmetic - Trains & Meeting Speeds]****Formula:** $(S_1 / S_2) = \sqrt{T_2 / T_1}$ Two trains start at the same time from stations A and B towards each other. After crossing each other, they take T_1 and T_2 hours to reach B and A respectively.**Speed Trick:** Time elapsed until they met from start: $T_{\text{meeting}} = (T_1 T_2)$.**Common Trap:** Writing $S_1/S_2 = (T_1/T_2)$ instead of inverse (T_2/T_1) .**Circular Track Racing & Meeting Points [Arithmetic - Circular Track Races]****Formula:** $T_{\text{first meet}} = (L / (S_1 \pm S_2))$, $T_{\text{start point}} = \text{LCM}((L / S_1), (L / S_2))$ On a circular track of length L : Time to first meet $= L / (\text{Relative Speed})$. $S_1 - S_2$ if running in same direction; $S_1 + S_2$ if running in opposite directions. Time to meet at starting point $= \text{LCM of}$ **Speed Trick:** Number of distinct meeting points on track $= (a - b)$ if same direction, $(a + b)$ if opposite direction**Common Trap:** Using relative speed for meeting at starting point instead of LCM of lap times.**Equal Annual Installments in Compound Interest [Arithmetic - Compound Interest Installments]****Formula:** $P = (x / (1 + (R/100))) + (x / (1 + (R/100))^2) + \dots + (x / (1 + (R/100))^n)$ Where P is principal borrowed, x is equal annual installment paid at end of each year for n years at annual compound rate $R\%$.**Speed Trick:** Ratio Method: If $R = 10\% = 1/10$, Principal : Installment for Year 1 is 10 : 11, Year 2 is 100 : 121. M **Common Trap:** Confusing CI installment with Simple Interest installment formula $P = nx + [Rx n(n-1)] / 200$.**Efficiency Ratios & Alternate Filling/Emptying Cycles [Arithmetic - Pipes & Cisterns]****Formula:** $\{1\}T_{\text{net}} = (1/A) + (1/B) - (1/C)$, Cycle Time $= 2 \cdot \text{Pairs}$

Fill pipes take positive work; leak/drain pipes take negative work. In alternate hour cycles, calculate work completed before the last positive filling burst to avoid overshoot.

Speed Trick: Safety Margin Rule: In alternate hours where A fills in x and B empties in y ($x < y$), stop the cyclic**Common Trap:** Letting the cycle run past full capacity and applying emptying work when cistern is already full.

True Discount (TD), Present Worth (PW) & Banker's Gain (BG) [Arithmetic - True Discount & Banker's Gain]

Formula: $BG = BD - TD = (TD \wedge 2 / PW) = (TD * R * T / 100)$, $PW = (Amount * 100 / 100 + RT)$, $TD = (Amount * RT / 100 + RT)$

Banker's Discount (BD) is simple interest on face value. True Discount (TD) is simple interest on Present Worth (PW). Banker's Gain (BG) is simple interest on True Discount.

Speed Trick: $Amount = (BD * TD) / (BD - TD) = (BD * TD) / BG$.

Common Trap: Treating True Discount as discount on Face Value instead of Present Worth.

Dishonest Shopkeeper & Faulty Weights Formula [Arithmetic - Profit, Loss & Dishonest Dealer]

Formula: $Gain \% = (Error / True Value - Error) * 100\% = ((True Weight / False Weight) - 1) * 100\%$

When a dealer sells at cost price but uses a false weight of w grams instead of 1000g, Profit % = $[(1000 - w) / w] * 100\%$.

Speed Trick: If dealer claims $p\%$ profit AND uses false weight w instead of W : Net % = $[(100 + p)/100 * W/w - 1] * 1$

Common Trap: Dividing error by 1000g instead of the actual false weight delivered to customer.

Work and Wages Division & Men-Women-Children Equivalence [Arithmetic - Work & Wages]

Formula: $Wages Ratio = Work Ratio = E_1 * T_1 : E_2 * T_2 : E_3 * T_3$, $(M_1 D_1 H_1 / W_1) = (M_2 D_2 H_2 / W_2)$

Wages are divided in proportion to the total work done by each individual (Efficiency * Time), NOT simply by number of days worked unless efficiencies are equal.

Speed Trick: If A can do work in a days and B in b days, ratio of 1-day work = $b : a$. Wages share of A = $[b / (a +$

Common Trap: Dividing wages in inverse ratio of days when workers worked for different number of days.

Apollonius' Theorem (Length of Median) [Geometry - Triangles & Medians]

Formula: $b^2 + c^2 = 2(m_a^2 + (a/2)^2) \Rightarrow m_a = (1/2)\sqrt{2b^2 + 2c^2 - a^2}$

In triangle ABC with median AD (length m) drawn to side BC (length a), the sum of squares of the other two sides equals twice the square of the median plus twice the square of half the base.

Speed Trick: Sum of squares of all 3 medians: $4(m^2 + m_b^2 + m_c^2) = 3(a^2 + b^2 + c^2)$.

Common Trap: Forgetting the factor 2 outside the parenthesis: writing $b^2 + c^2 = m^2 + (a/2)^2$

Stewart's Theorem (General Cevian Length) [Geometry - Triangles & Cevians]

Formula: $b^2 m + c^2 n = a(d^2 + mn)$ | or mnemonic: $man + dad = bmb + cnc$

Yields the length of any cevian d from vertex A to base a dividing side BC into segments m and n (where $m + n = a$).

Speed Trick: When $m = n = a/2$ (median), Stewart's theorem reduces directly to Apollonius' theorem.

Common Trap: Swapping m and n with the opposite adjacent sides b and c .

Ptolemy's Theorem for Cyclic Quadrilateral [Geometry - Cyclic Quadrilaterals]

Formula: $AC * BD = (AB * CD) + (BC * AD)$

In a cyclic quadrilateral ABCD, the product of the lengths of the two diagonals equals the sum of the products of opposite sides.

Speed Trick: Ratio of diagonals in cyclic quad: $AC / BD = (AB AD + BC CD) / (AB BC + AD CD)$.

Common Trap: Applying Ptolemy's theorem to non-cyclic quadrilaterals (where $AC BD \leq AB CD + BC AD$ by Ptolemy's ine

Euler's Distance Formula (Distance between Circumcentre and Incentre) [Geometry - Triangle Centres]

Formula: $d^2 = R^2 - 2Rr = R(R - 2r) \Rightarrow d = \sqrt{R(R - 2r)}$

Where d is the distance between the circumcentre (O) and incentre (I) of a triangle, R is the circumradius, and r is the inradius. This also proves Euler's inequality: $R \geq 2r$.

Speed Trick: In an equilateral triangle, $d = 0$ because circumcentre and incentre coincide ($R = 2r$).

Common Trap: Using $R^2 + 2Rr$ instead of $R^2 - 2Rr$, which would give a distance greater than R .

Area of Triangle from Lengths of Three Medians [Geometry - Triangles & Medians]

Formula: $= (4/3) \sqrt{s_m(s_m - m_a)(s_m - m_b)(s_m - m_c)}$, | where $s_m = (m_a + m_b + m_c) / 2$

The area of a triangle formed by the three medians as its sides is equal to 3/4 of the original triangle area. Hence, Area(ABC) = $(4/3) * \text{Heron's Formula applied to medians}$.

Speed Trick: If medians form a Pythagorean triplet (e.g. 9, 12, 15): Area = $(4/3) * (1/2 * 9 * 12) = (4/3) * 54 = 7$

Common Trap: Multiplying by 3/4 instead of 4/3 to get the area of the original triangle.

Angle Between Bisectors of Adjacent and Opposite Angles in Quadrilateral [Geometry - Quadrilateral Angle]

Formula: $\theta = (1/2)(C + D)$ | (Adjacent Bisectors), $\theta = (1/2)|B - D|$ | (Opposite Bisectors)

The angle formed by the internal bisectors of adjacent angles A and B in quadrilateral ABCD equals half the sum of the remaining angles (C + D).

Speed Trick: The quadrilateral formed by the angle bisectors of any convex quadrilateral is always CYCLIC.

Common Trap: Subtracting angles instead of adding when dealing with adjacent angle bisectors.

Frustum of Right Circular Cone (Volume, CSA, TSA & Slant Height) [Mensuration 3D - Frustum of Cone]

Formula: $V = (1/3)\pi h(R^2 + r^2 + Rr)$, $l = \sqrt{h^2 + (R - r)^2}$, $CSA = \pi(R + r)l$, $TSA = \pi[(R + r)l + R^2 + r^2]$

Where R is bottom base radius, r is top base radius, h is vertical height, and l is slant height.

Speed Trick: Ratio of volumes when cone is cut parallel to base at height h_1 and h_2 : $V_1/V_2 = (h_1/h_2)^3$.

Common Trap: Using $(R^2 + r^2 + 2Rr)$ instead of $(R^2 + r^2 + Rr)$ in volume formula.

Spherical Cap, Zone & Hollow Shell [Mensuration 3D - Spherical Cap & Zone]

Formula: $V_{\text{cap}} = (\pi h^2/3)(3R - h)$ = $(\pi h/6)(3a^2 + h^2)$, $CSA_{\text{cap}} = 2\pi Rh$, $V_{\text{shell}} = (4/3)\pi(R^3 - r^3)$

Where R is sphere radius, h is cap height, and a is base radius of the cap ($a^2 = h(2R - h)$).

Speed Trick: CSA of a spherical zone/cap depends ONLY on height h and sphere radius R ($CSA = 2\pi Rh$), independent of

Common Trap: Using $4/3 \pi h^3$ instead of the exact cap formula.

Regular Tetrahedron (Height, Volume, Inradius, Circumradius, TSA) [Mensuration 3D - Regular Tetrahedron]

Formula: $h = \sqrt{2/3}$, $V = \{a^3\}/6\sqrt{2}$ = $\{\sqrt{2}/12\}a^3$, $TSA = \sqrt{3}a^2$, $r = \{a\}/\sqrt{24}$, $R = \sqrt{3/8}a$

A regular tetrahedron consists of 4 congruent equilateral triangles of edge a. Ratio of circumradius to inradius R : r = 3 : 1.

Speed Trick: Slant height = $(3/2)a$.

Common Trap: Confusing tetrahedron volume ($a^3/6$) with square pyramid volume.

Brahmagupta's Formula & Cyclic Quadrilateral Circumradius [Mensuration 2D - Cyclic Quadrilateral]

Formula: $\text{Area} = \sqrt{(s-a)(s-b)(s-c)(s-d)}$, $R = (1/4)\sqrt{(ab+cd)(ac+bd)(ad+bc)}$

Where $s = (a + b + c + d)/2$ is semi-perimeter of cyclic quadrilateral ABCD. If quadrilateral is also tangential ($a+c = b+d$), $\text{Area} = (abcd)$.

Speed Trick: When $d = 0$, Brahmagupta's formula reduces directly to Heron's formula for triangles.

Common Trap: Applying Brahmagupta's formula to non-cyclic quadrilaterals without the $\cos^2(\theta/2)$ Bretschneider c

Vieta's Formulas for Cubic & Quartic Equations [Algebra - Polynomials & Vieta's Formulas]

Formula: $ax^3 + bx^2 + cx + d = 0 \Rightarrow -b/a, | c/a, | -d/a$

For cubic polynomial $ax^3 + bx^2 + cx + d = 0$ with roots α, β, γ : Sum of roots $S_1 = -b/a$; Sum of pairwise products $S_2 = c/a$; Product of roots $S_3 = -d/a$.

Speed Trick: Sum of squares of roots: $\alpha^2 + \beta^2 + \gamma^2 = (\alpha + \beta + \gamma)^2 - 2(\alpha\beta + \beta\gamma + \alpha\gamma) = (-b/a)^2 - 2(c/a)$

Common Trap: Forgetting alternating signs: $-b/a, +c/a, -d/a, +e/a$.

Newton's Sums Formula for Power of Roots [Algebra - Newton's Sums Method]

Formula: $aS_n + bS_{n-1} + cS_{n-2} = 0$, where $S_n = \alpha^n + \beta^n + \gamma^n$ for $ax^2 + bx + c = 0$

Allows instant computation of $\alpha^n + \beta^n + \gamma^n$ without solving for the roots individually. For cubic

$ax^3 + bx^2 + cx + d = 0$: $aS_n + bS_{n-1} + cS_{n-2} + dS_{n-3} = 0$.

Speed Trick: For $x^2 - 5x + 1 = 0$: $S_n = 5S_{n-1} - S_{n-2}$. With $S = 2$, $S_1 = 5 \Rightarrow S_2 = 5(5) - 2 = 23$, $S_3 = 5(23) - 5 = 115$

Common Trap: Setting $S = 0$ instead of $S = \alpha^0 + \beta^0 + \gamma^0 = 1 + 1 + 1 = 3$.

Higher Powers of $(x + 1/x = k)$ up to Power 7 [Algebra - Symmetric Identities & Higher Powers]

Formula: $x^5 + (1/x^5) = (x^2 + (1/x^2))(x^3 + (1/x^3)) - (x + (1/x))$, $x^7 + (1/x^7) = (x^3 + (1/x^3))(x^4 + (1/x^4)) - (x + (1/x))$

Standard recurrence for odd powers of $(x + 1/x)$. For $x^5 + 1/x^5 = (k^2 - 2)(k^3 - 3k) - k$.

Speed Trick: If $x + 1/x = 3$: $x^2 + 1/x^2 = 7$, $x^3 + 1/x^3 = 18 \Rightarrow x^5 + 1/x^5 = 7 \cdot 18 - 3 = 126 - 3 = 123$.

Common Trap: Forgetting to subtract $(x + 1/x)$ after multiplying lower powers.

Extreme Values of Quadratic Function $ax^2 + bx + c$ [Algebra - Quadratic Optimization]

Formula: $y_{\min} = (4ac - b^2 / 4a) = -(D / 4a)$ at $x = -(b / 2a) \mid (a > 0)$, $y_{\max} = (4ac - b^2 / 4a) \mid (a < 0)$

A parabola opens upward if $a > 0$ (minimum at vertex) and downward if $a < 0$ (maximum at vertex). Vertex coordinates are $(-b/(2a), -D/(4a))$.

Speed Trick: Short derivative trick: Set $dy/dx = 2ax + b = 0 \Rightarrow x = -b/(2a)$, then substitute back.

Common Trap: Assuming a quadratic with negative a has a minimum value (it tends to $-\infty$).

Triple Angle Formulas & Special Product Identities [Trigonometry - Product & Triple Angles]

Formula: $3\theta = 3 - 4^3\theta$, $| 3\theta = 4^3\theta - 3$, $| (60^\circ - \theta) (60^\circ + \theta) = (1/4) 3\theta$

Key identity: $\sin \theta \sin(60^\circ - \theta) \sin(60^\circ + \theta) = (1/4) \sin 3\theta$; $\cos \theta \cos(60^\circ - \theta) \cos(60^\circ + \theta) = (1/4) \cos 3\theta$; $\tan \theta \tan(60^\circ - \theta) \tan(60^\circ + \theta) = \tan 3\theta$

Speed Trick: $\tan 20^\circ \tan 40^\circ \tan 80^\circ = \tan(3 \times 20^\circ) = \tan 60^\circ = 3$.

Common Trap: Including $1/4$ factor for tan product (tan product has NO $1/4$ factor!).

Sum of Sine and Cosine Series in Arithmetic Progression [Trigonometry - Series & AP of Angles]

Formula: $\sum_{k=0}^{n-1} (\sin(k\alpha + \beta)) = (\sin(n\alpha/2) \sin(\alpha/2)) / (\sin(\alpha/2))$

Calculates the sum of sines or cosines when angles form an AP with common difference β and n terms.

Speed Trick: For cosine series: $\sum = [\sin(n\beta/2) / \sin(\beta/2)] \times \cos[\alpha + (n-1)\beta/2]$.

Common Trap: Using $n\beta$ instead of $n\beta/2$ in numerator angle.

Ladder Crossing / Two Vertical Poles Intersection Height [Trigonometry - Heights & Distances]

Formula: $(1/h) = (1/h_1) + (1/h_2) \Rightarrow h = (h_1 h_2 / (h_1 + h_2))$

When lines/wires are drawn from the tops of two vertical poles of heights h_1 and h_2 to the feet of each other, their intersection point is at height h above the ground, regardless of the distance.

Speed Trick: Identical to harmonic mean formula in parallel resistors / combined work!

Common Trap: Thinking height h depends on the distance d between the two poles.

Euler's Totient Function $\phi(n)$ & Euler's Theorem [Number System - Euler's Totient & Remainder]

Formula: $\phi(n) = n \prod_{p|n} (1 - 1/p)$, $| a^{\phi(n)} \equiv 1 \pmod n$ if $\gcd(a, n) = 1$

Euler's Totient $\phi(n)$ counts the positive integers up to n coprime to n . If $\gcd(a, n) = 1$, the remainder when a^k is divided by n is $a^{(k \bmod \phi(n))} \bmod n$.

Speed Trick: If p is prime, $\phi(p) = p - 1$ (Fermat's Little Theorem: $a^{p-1} \equiv 1 \pmod p$).

Common Trap: Applying Euler's theorem when $\gcd(a, n) \neq 1$.

Wilson's Theorem for Factorial Remainder [Number System - Wilson's Theorem]

Formula: $(p-1)! \equiv -1 \pmod p$ and $(p-2)! \equiv 1 \pmod p$

A natural number $p > 1$ is a prime if and only if $(p-1)! + 1$ is divisible by p . Corollary: $(p-2)!$ divided by prime p always leaves remainder 1.

Speed Trick: $(p-3)!$ divided by prime p leaves remainder $(p-1)/2$.

Common Trap: Applying Wilson's theorem to composite divisors.

Number, Sum, and Product of Factors / Divisors [Number System - Sum & Product of Divisors]

Formula: $N = p_1^{a_1} p_2^{a_2} \Rightarrow (N) = \{p_1^{a_1+1}-1\} \{p_2^{a_2+1}-1\} \dots \{p_k^{a_k+1}-1\} / (p_1-1) \dots (p_k-1)$, **Product** = $N^{d(N)/2}$

Where $d(N) = (a_1+1)(a_2+1)\dots$ is the number of factors, (N) is the sum of factors, and Product of factors = $N^{d(N)/2}$.

Speed Trick: Number of ways to write N as product of two factors = $d(N)/2$ (if N is not perfect square) or $(d(N)+1)/2$.

Common Trap: Including 2^0 (which is 1) when computing the sum of even factors.

Successive Division & Reconstruction of Dividend [Number System - Successive Division]

Formula: $N = d_1 q_1 + r_1$, $| q_1 = d_2 q_2 + r_2$, $| q_2 = d_3 q_3 + r_3$

In successive division, the quotient obtained in the first step is divided by the second divisor, and that subsequent quotient is divided by the third divisor.

Speed Trick: To find the smallest number N , set final quotient $k = 0$ or $k = 1$.

Common Trap: Dividing the original number N repeatedly instead of dividing successive quotients.

Successive Replacement with Unequal / Variable Draw Amounts [Arithmetic - Mixtures & Multiple Replacement]**Formula:** Final Pure = Initial Pure * $(1 - (x_1 / C))(1 - (x_2 / C)) \dots (1 - (x_n / C))$ When different quantities $x_1, x_2, \dots, x_n$ are successively removed from total capacity C and replaced by another liquid (or water), the pure content multiplier is $(1 - x_i / C)$.*Speed Trick: If equal volume x is drawn n times: Final Pure = Initial Pure * $(1 - x/C)^n$.**Common Trap: Using the reducing remaining volume in denominator instead of constant total capacity C .***Circular Track Races (Meeting at Starting Point & Anywhere) [Arithmetic - Circular Races]****Formula:** $T_{\text{start}} = \text{LCM}((L / v_1), (L / v_2)), | T_{\text{first}} = (L / |v_1 \pm v_2|), | \text{Distinct}$ **Points = $|a \pm b|$ for coprime $v_1:v_2=a:b$** On a circular track of length L : Time to meet at start is LCM of individual lap times. Time to first meet is $L / (\text{relative speed})$. Number of distinct meeting points on track = $(a - b)$ in same direction,*Speed Trick: Same direction: Relative speed = $|v_1 - v_2|$; Number of meeting points = $|a - b|$.**Common Trap: Confusing meeting at starting point (LCM of lap times) with meeting anywhere on track.***Linear Races: Distance and Time Headstarts & Dead Heats [Arithmetic - Linear Races & Headstarts]****Formula:** Ratio of Speeds = (Distance covered by A / Distance covered by B) * (Time taken by B / Time taken by A)In a race of distance D : "A gives B a start of x metres" means B starts at distance x ahead (B runs $D - x$). "A beats B by t seconds" means when A finishes at time T , B takes time $(T + t)$.*Speed Trick: If A beats B by x metres and B beats C by y metres in race D : A beats C by $x + y - (xy/D)$ metres.**Common Trap: Simply adding headstarts $x + y$ instead of subtracting the fractional overlap (xy/D) .***Escalator Problems (Steps Counted & Speed) [Arithmetic - Escalators (Moving Walkways)]****Formula:** Total Steps $N = n_1 + e * t_1 = n_2 + e * t_2 = t * (v_{\text{person}} \pm v_{\text{escalator}})$ Where N is total stationary visible steps. If walking in direction of moving escalator: Total Steps = Visible Steps Taken + Escalator Steps. In opposite direction: Total = Steps Taken - Escalator Steps.*Speed Trick: Equate total steps N : $N = n_1 (1 + v/v_1) = n_2 (1 + v/v_2)$.**Common Trap: Adding escalator speed when walking against the motion of the escalator.***Average Speed for n Equal Distances (Harmonic Mean) [Arithmetic - Harmonic Mean in Average Speed]****Formula:** $v_{\text{avg}} = (n / (1/v_1 + 1/v_2 + \dots + 1/v_n)), | \text{For 3 equal distances: } v_{\text{avg}} = (3 v_1 v_2 v_3 / (v_1 v_2 + v_2 v_3 + v_3 v_1))$ When equal distances are covered at speeds $v_1, v_2, \dots, v_n$, average speed is the Harmonic Mean of speeds, NOT the arithmetic mean.*Speed Trick: Distance LCM method: Assume each equal segment = $\text{LCM}(v_1, v_2, v_3)$. Total time = sum of (Segment / v_i)**Common Trap: Taking simple arithmetic mean $(v_1 + v_2 + v_3)/3$ when distances are equal (arithmetic mean only apply)***Clock Gaining / Losing Time & Correct Time Formula [Arithmetic - Faulty & Gaining/Losing Clocks]****Formula:** Normal Coincidence Period = $65(5/11) \text{ min} = (720/11) \text{ min}, | \text{Gain/Loss in 24h} = (((720/11) - M) / M) * (24 * 60) \text{ min}$ In a correct clock, the two hands coincide every $65 \frac{5}{11}$ minutes ($720/11 \text{ min}$). If hands coincide every M minutes: If $M < 720/11$, clock is GAINING; if $M > 720/11$, clock is LOSING.*Speed Trick: If clock loses $x \text{ min}$ on day 1 and gains $y \text{ min}$ on day 2, total shift = $x + y \text{ min}$ in total elapsed hours**Common Trap: Using 65 minutes instead of $65 \frac{5}{11}$ ($720/11$) minutes for normal coincidence interval.***Circular Permutations & Flip Invariant Necklaces [Combinatorics - Circular Permutations & Necklaces]****Formula:** $P_{\text{circular}} = (n - 1)!, | P_{\text{necklace/garland}} = ((n - 1)! / 2)$ When arranging n distinct items in a circle where clockwise and anticlockwise orderings are distinct (e.g. people at round table), ways = $(n-1)!$. When arrangement can be flipped over (necklaces, beads),*Speed Trick: Arranging n men and n women alternatively at a round table = $(n-1)! * n!$.**Common Trap: Dividing by 2 for table seating arrangements where looking from above distinguishes clockwise from counter-clockwise.***Derangements Formula $!D_n$ (Subfactorial $!n$) [Combinatorics - Derangements Formula]****Formula:** $D_n = n! \sum_{k=0}^n ((-1)^k / k!) = n! (1 - (1/1!) + (1/2!) - (1/3!) + \dots + ((-1)^n / n!))$ A derangement is a permutation where none of the n elements appears in its original/natural position.Recurrence: $D_n = (n - 1)(D_{n-1} + D_{n-2})$.*Speed Trick: Standard values to memorize: $D_1 = 0, D_2 = 1, D_3 = 2, D_4 = 9, D_5 = 44, D_6 = 265$.**Common Trap: Confusing derangements with normal permutations ($n!$).*

Conditional Probability & Bayes' Theorem [Probability - Bayes' Theorem & Conditional Probability]

Formula: $P(A|B) = (P(A \cap B) / P(B))$, $P(A_i|B) = \{P(B|A_i) P(A_i)\} / \sum_{j=1}^k P(B|A_j) P(A_j)$

Calculates the posterior probability of event A_i given that evidence B has occurred. Base probabilities $P(A_i)$ are updated using conditional likelihoods $P(B|A_i)$.

Speed Trick: For two independent events A and B: $P(A \cap B) = P(A) P(B)$ and $P(A|B) = P(A)$.

Common Trap: Confusing $P(A|B)$ (probability of A given B) with $P(B|A)$ (probability of B given A).

Length of Direct (DCT) & Transverse (TCT) Common Tangents [Geometry - Circles: Direct & Transverse Common]

Formula: $DCT = \sqrt{d^2 - (r_1 - r_2)^2}$, $TCT = \sqrt{d^2 - (r_1 + r_2)^2}$

For two circles with radii r_1 and r_2 separated by center distance d: The Direct Common Tangent (DCT) length is $\sqrt{d^2 - (r_1 - r_2)^2}$. The Transverse Common Tangent (TCT) length is $\sqrt{d^2 - (r_1 + r_2)^2}$.

Speed Trick: [TRICK] Touching Externally: When $d = r_1 + r_2$, $DCT = 2(r_1 r_2)$ and $TCT = 0$.

Common Trap: Accidentally swapping the signs: subtracting radii for TCT instead of adding radii.

Tangent-Secant Theorem ($PT^2 = PA \cdot PB$) & Intersecting Chords [Geometry - Circles: Tangent-Secant & Intersecting Chords]

Formula: $PT^2 = PA \cdot PB$, $PA \cdot PB = PC \cdot PD$, $AE \cdot EB = CE \cdot ED$

From an external point P, if PT is a tangent touching the circle at T, and PAB is a secant intersecting the circle at A and B, then $PT^2 = PA \cdot PB$. If two secants PAB and PCD are drawn from P, then $PA \cdot PB = PC \cdot PD$.

Speed Trick: [TRICK] Crucial Rule: Always measure distances from the intersection point P, NEVER between the intercepts.

Common Trap: Multiplying PA by AB instead of the whole secant segment $PB = PA + AB$.

Angle Relations at Incenter, Circumcenter, Excenter & Orthocenter [Geometry - Triangles: Incenter, Circumcenter, Excenter & Orthocenter]

Formula: $\angle BIC = 90^\circ + (A/2)$, $\angle BEC = 90^\circ - (A/2)$, $\angle BOC_{\text{circum}} = 2A$, $\angle BOC_{\text{ortho}} = 180^\circ - A$

In $\triangle ABC$ with incenter I, excenter E opposite to A, circumcenter C, and orthocenter H: Incenter angle $\angle BIC = 90^\circ + A/2$; Excenter angle $\angle BEC = 90^\circ - A/2$; Circumcenter angle $\angle BOC = 2A$; Orthocenter angle $\angle BOC = 180^\circ - A$.

Speed Trick: [TRICK] Incenter angle is ALWAYS obtuse ($> 90^\circ$).

Common Trap: Mixing up the orthocenter ($180^\circ - A$) and circumcenter ($2A$) formulas.

Trapezium Diagonals & Rhombus Area-Diagonal Invariants [Mensuration 2D - Trapezium & Rhombus Special Geom]

Formula: $\text{Area}_{\text{trap}} = (1/2)(a+b)h$, $d_1^2 + d_2^2 = c^2 + d^2 + 2ab$, $\text{Area}_{\text{rhombus}} = (1/2)d_1 d_2$, $4a^2 = d_1^2 + d_2^2$

In a trapezium with parallel sides a, b and oblique sides c, d: $\text{Area} = 1/2(a+b)h$. The sum of squares of diagonals is $d_1^2 + d_2^2 = c^2 + d^2 + 2ab$. For a rhombus with side a and diagonals d_1, d_2 : $\text{Area} = 1/2 d_1 d_2$.

Speed Trick: [TRICK] Length of line segment joining midpoints of diagonals in a trapezium = $|a - b| / 2$.

Common Trap: Using $a^2 = d_1^2 + d_2^2$ for rhombus instead of $4a^2 = d_1^2 + d_2^2$.

Master Calendar Day & Century Codes Formula [Calendar & Odd Days Algorithm]

Formula: $\text{Day Code} = (A + B + C + D + E) \mod 7$

Master Calendar Formula: $(A + B + C + D + E) \mod 7$, where A = Century Code (4, 2, 0, 6 for remainder 1, 2, 3, 0 when century digits divided by 4); B = Last 2 digits of year; C = Quotient of B / 4 (leap year); D = Day of year; E = Day of week.

Speed Trick: [TRICK] Month Codes Mnemonic: 033 (Jan-Mar), 614 (Apr-Jun), 625 (Jul-Sep), 035 (Oct-Dec). For Leap Year, add 1 for Jan and Feb.

Common Trap: Forgetting to use Jan=6 and Feb=2 when dealing with dates in January or February of a LEAP year.

Clock Angle, Coincidence & Mirror Image Invariants [Clock Angles & Reflections]

Formula: $\theta = |30H - (11/2)M|$, $\text{Mirror} = 11:60 - T$, $\text{Water} = 18:30 - T$

Angle between hands at H hours and M minutes is given by $\theta = |30H - (11/2)M|$. Relative speed between minute and hour hand is 5.5 deg per minute ($11/2$ deg/min).

Mirror image time in a 12-hour clock: $\text{Mirror} = 11:60 - T$.

Speed Trick: [TRICK] Ratio 1:4 (e.g. 4:16, 7:28): Angle $\theta = \text{Minutes} \times 2$. At 4:16, $\theta = 16 \times 2 = 32^\circ$.

Common Trap: Subtracting from 12:00 instead of 11:60 for mirror time, which leads to arithmetic borrow mistakes.

Cube & Dice Laws & Painting-Cutting Formulas [Cube & Dice Geometry]

Formula: $N_{\text{corners}} = 8$, $N_{\text{edges}} = 12(n-2)$, $N_{\text{faces}} = 6(n-2)^2$, $N_{\text{core}} = (n-2)^3$

1. Standard Die: Sum of opposite faces = 7 ($1 \leftrightarrow 6, 2 \leftrightarrow 5, 3 \leftrightarrow 4$). Adjacent faces NEVER sum to 7.

General Die Clockwise Rule: Identify the single common face and write digits clockwise to identify other faces.

Speed Trick: [TRICK] Two Common Faces Rule: When two positions share two common digits, the remaining single digits are opposite faces.

Common Trap: Assuming a die is standard when two adjacent visible faces add up to 7 (e.g. showing 3 and 4 adjacent).

Counting of Figures: Triangles, Squares & Rectangles [Geometric Figure Counting]**Formula:** $\{tri\} = (n(n+1) / 2)$, $\{quad\} = 2n$, $\{n * n\} = \sum_{i=1}^n i^2 = (n(n+1)(2n+1) / 6)$ Key Figure Counting Invariants: 1. Vertically divided triangle with n sectors: Total = $n(n+1)/2$. 2.Square with both diagonals and internal rays intersecting at center: Total = $2n$, where n is the count**Speed Trick:** [TRICK] Diagonal Quadrilateral Shortcut: If a box has 8 small triangles inside, total triangles = $8 * 8$ **Common Trap:** Counting squares as non-rectangles (every square is mathematically a rectangle).**Order & Ranking Placement Invariants [Order & Ranking]****Formula:** $T = L + R - 1$, $R = T - L + 1$, $T_{\{ \}} = (L + R) - (\text{between} + 2)$

Core Ranking Invariants: 1. Total persons = Left Rank + Right Rank - 1. 2. Rank from Right = Total -

Rank from Left + 1. 3. Position Interchange: Total = (New Rank of person A) + (Old Rank of person B) -

Speed Trick: [TRICK] Interchange Trick: Increase in A's rank = Increase in B's rank. If A moves from 10 to 18 (+8),**Common Trap:** Forgetting the "- 2" in the overlapping formula $T_{\min} = (L + R) - (\text{between} + 2)$.**Direction Vectors, Pythagoras Distance & Shadow Rules [Direction & Distance]****Formula:** $d = \sqrt{x^2 + y^2}$, | Sunrise Shadow West, | Sunset Shadow EastDisplacement calculation uses the Pythagoras theorem: $d = (\sqrt{x^2 + y^2})$. Shadow Rules: At Sunrise, Sun

is in East => Shadows fall to the WEST. If facing South, shadow is to your RIGHT. If facing North,

Speed Trick: [TRICK] Coordinate Vector Method: Write steps as (N10, E5, S10, W2). N10 and S10 cancel. $E5 - W2 = E3$ **Common Trap:** Mixing up shadow direction at sunrise vs sunset.**Alphabet Place Values & Reverse Pair Invariants [Coding-Decoding & Letter Series]****Formula:** Forward + Reverse = 27, | EJOTY = (5, 10, 15, 20, 25)

Alphabetical indexing invariants: 1. Forward Position + Reverse Position = 27 (e.g. A=1, Z=26 =>

1+26=27). 2. EJOTY Anchor: E(5), J(10), O(15), T(20), Y(25). 3. CFILORUX Anchor: Multiples of 3 (C=3,

Speed Trick: [TRICK] Reverse Pair Memory Mnemonics: AZ (Azad), BY (Boy), CX (Crax), DW (Dew), EV (Evening), FU (Fun)**Common Trap:** Subtracting from 26 instead of 27 to find reverse alphabetical rank.