

CAT 2026 · QUANT · ALGEBRA

ThinkCAT Practice Book



CAT Algebra Formula Sheet

11 topics · 101 formulas · 33 common mistakes · 21 real CAT PYQs one tap away

124

Algebra questions in
CAT 2021-25

38%

of all 330 QA
questions

24

from Sequences &
Series, the
most-asked topic

45

were TITA: no
negative marks

HOW OFTEN CAT ASKED EACH TOPIC · 2021-25

Tap a topic to open its page

#	Topic	2021	2022	2023	2024	2025	Total	TITA	Page
1	● Sequences & Series	6	5	6	3	4	24	6	p.10
2	● Quadratic Equations	2	6	3	2	2	15	7	p.3
3	● Logarithms	3	1	3	4	3	14	7	p.8
4	● Modulus	5	2	2	3	1	13	5	p.11
5	● Linear Equations	2	2	3	2	3	12	5	p.2
5	● Functions	2	3	1	3	3	12	4	p.9
7	● Indices & Exponents	1	2	4	1	2	10	5	p.6
8	● Maxima & Minima	1	4	1	.	3	9	4	p.12
9	● Algebraic Identities	1	.	3	2	2	8	1	p.5
10	● Surds	.	.	1	3	.	4	1	p.7
11	● Quadratic Inequalities	1	.	1	1	.	3	0	p.4
All Algebra		24	25	28	24	23	124	45	

Counts: every official CAT QA question from 2021-2025 (15 slots, 330 questions), tagged to one main topic by ThinkCAT. Deep links open the exact question on thinkcat.in.

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Prepping with friends? Send this sheet to your CAT group in one tap.

WhatsApp

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TOPIC 14 · ALGEBRA 1 OF 11

REGULAR

Linear Equations

12 CAT questions from this topic, 2021-25

#5 (tied) of 11 in Algebra · 5 TITA



CORE FORMULAS

- Two lines $a_1x + b_1y = c_1$ and $a_2x + b_2y = c_2$: one solution when $a_1/a_2 \neq b_1/b_2$
- No solution: $a_1/a_2 = b_1/b_2 \neq c_1/c_2$ (parallel lines)
- Infinitely many: $a_1/a_2 = b_1/b_2 = c_1/c_2$ (the same line)
- Cramer: $x = (c_1b_2 - c_2b_1)/(a_1b_2 - a_2b_1)$, $y = (a_1c_2 - a_2c_1)/(a_1b_2 - a_2b_1)$
- $ax + by = c$ has integer solutions only if $\text{HCF}(a, b)$ divides c
- From one solution (x_0, y_0) : $x = x_0 + (b/g)t$, $y = y_0 - (a/g)t$, $g = \text{HCF}(a, b)$
- 3 unknowns, 2 equations: the asked expression is usually $p(\text{eq 1}) + q(\text{eq 2})$
- Word problems: one variable per unknown, one equation per fact; check whole-number answers

60-SECOND SHORTCUT

Build the target, skip the variables

$x + 2y + 3z = 10$ and $2x + y = 5$, and the question wants $x + y + z$? Add the equations: $3x + 3y + 3z = 15$, so $x + y + z = 5$. You never need x , y or z .

DON'T MAKE THESE MISTAKES

- $\times$ $a_1/a_2 = b_1/b_2 \Rightarrow$ infinitely many solutions
- $\checkmark$ Only if c_1/c_2 matches too; otherwise **no solution**
- $\times$ Positive solutions of $3x + 5y = 100$: try every x
- $\checkmark$ x must be a multiple of 5: 5, 10, ..., 30 $\rightarrow$ **6 pairs**
- $\times$ 2 equations, 3 unknowns: unsolvable
- $\checkmark$ CAT asks for one combination; **build it** from the equations

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 1

Q17 · Moderate · MCQ

CAT 2024 Slot 1

Q15 · Easy · MCQ

[Practise 75+ Linear Equations questions with solutions](#)


TOPIC 15 · ALGEBRA 2 OF 11

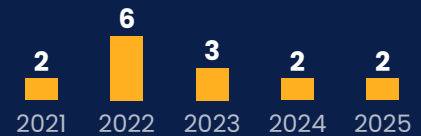
MOST ASKED

Quadratic Equations

15

CAT questions from this topic, 2021–25

#2 of 11 in Algebra · 7 TITA



CORE FORMULAS

- $ax^2 + bx + c = 0 \Rightarrow x = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$
- Sum of roots $\alpha + \beta = -b/a$; product $\alpha\beta = c/a$
- $D = b^2 - 4ac$: $D > 0$ two real roots, $D = 0$ one repeated root, $D < 0$ no real root
- Rational coefficients: D a perfect square $\Leftrightarrow$ rational roots; roots $p \pm \sqrt{q}$ come in pairs
- Equation with roots α, β : $x^2 - (\alpha + \beta)x + \alpha\beta = 0$
- $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$; $\alpha^3 + \beta^3 = (\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta)$
- $(\alpha - \beta)^2 = (\alpha + \beta)^2 - 4\alpha\beta$; $1/\alpha + 1/\beta = (\alpha + \beta)/\alpha\beta$
- Cubic $ax^3 + bx^2 + cx + d$: $\Sigma\alpha = -b/a$, $\Sigma\alpha\beta = c/a$, $\alpha\beta\gamma = -d/a$
- Common root: subtract the equations to remove x^2 , then substitute back
- Remainder theorem: $f(x) \div (x - k)$ leaves $f(k)$; $f(k) = 0 \Leftrightarrow (x - k)$ is a factor

60-SECOND SHORTCUT

Integer roots from factor pairs

Roots that add to S and multiply to P : list the pairs. $x^2 - 7x + k$ with whole-number roots: $(0, 7)$, $(1, 6)$, $(2, 5)$, $(3, 4)$ give $k = \mathbf{0, 6, 10, 12}$.

DON'T MAKE THESE MISTAKES

- $\times$ $2x^2 - 6x + k$: sum of roots $= -6/2$
- $\checkmark$ $-b/a = -(-6)/2 = \mathbf{+3}$
- $\times$ $2 + \sqrt{3}$ is a root $\Rightarrow 2 - \sqrt{3}$ is too, always
- $\checkmark$ Only when the coefficients are **rational**
- $\times$ $D < 0 \Rightarrow ax^2 + bx + c > 0$ for every x
- $\checkmark$ Also needs $\mathbf{a > 0}$; with $a < 0$ it is always negative

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 1

Q5 · Easy · TITA

CAT 2023 Slot 1

Q7 · Moderate · TITA

Solve every CAT Polynomials & Roots PYQ, free



TOPIC 16 · ALGEBRA 3 OF 11

OCCASIONAL

Quadratic Inequalities

3

CAT questions from this topic, 2021–25

#11 of 11 in Algebra · 0 TITA

1	0	1	1	0
2021	2022	2023	2024	2025

CORE FORMULAS

- $(x - a)(x - b) < 0$ with $a < b \Rightarrow a < x < b$
- $(x - a)(x - b) > 0$ with $a < b \Rightarrow x < a$ or $x > b$
- Wavy curve: write factors as $(x - k)$, mark the roots; the rightmost interval is +, then signs alternate
- A squared factor $(x - k)^2$ does not switch the sign at k
- $f(x)/g(x) > 0 \Leftrightarrow f \cdot g > 0$ with $g \neq 0$; roots of the denominator are never included
- Never cross-multiply by an expression whose sign you don't know
- $ax^2 + bx + c > 0$ for every $x \Leftrightarrow a > 0$ and $D < 0$
- $x^2 < k^2 \Leftrightarrow -k < x < k$; $x^2 > k^2 \Leftrightarrow x < -k$ or $x > k$

60-SECOND SHORTCUT

One side, factor, sign chart

$(x - 1)(x + 4)/(x - 6) \leq 0$: critical points -4, 1, 6 give signs -, +, -, + from left to right. Answer: $x \leq -4$ or $1 \leq x < 6$ (6 is out: it zeroes the denominator).

DON'T MAKE THESE MISTAKES

- $\times 1/(x - 2) > 1/3 \Rightarrow x - 2 < 3$
- $\checkmark$ Only if $x - 2 > 0$. Bring to one side: $2 < x < 5$
- $\times x^2 > 9 \Rightarrow x > 3$
- $\checkmark x > 3$ or $x < -3$
- $\times (x - 2)^2(x - 5) < 0$ changes sign at 2
- $\checkmark$ Squared factor: $x < 5$ and $x \neq 2$

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2024 Slot 2

Q16 · Moderate · MCQ

CAT 2021 Slot 1

Q21 · Moderate · MCQ

Drill 85+ Inequalities & Modulus questions



TOPIC 17 · ALGEBRA 4 OF 11

REGULAR

Algebraic Identities

8

CAT questions from this topic, 2021-25

#9 of 11 in Algebra · 1 TITA

1	0	3	2	2
2021	2022	2023	2024	2025

CORE FORMULAS

- $(a \pm b)^2 = a^2 \pm 2ab + b^2$; $a^2 - b^2 = (a - b)(a + b)$
- $(a \pm b)^3 = a^3 \pm b^3 \pm 3ab(a \pm b)$
- $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$; $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$
- $(a + b + c)^2 = a^2 + b^2 + c^2 + 2(ab + bc + ca)$
- $a^3 + b^3 + c^3 - 3abc = (a + b + c)(a^2 + b^2 + c^2 - ab - bc - ca)$
- $a + b + c = 0 \Rightarrow a^3 + b^3 + c^3 = 3abc$
- $a^2 + b^2 + c^2 - ab - bc - ca = \frac{1}{2}[(a - b)^2 + (b - c)^2 + (c - a)^2] \geq 0$
- $x + 1/x = k \Rightarrow x^2 + 1/x^2 = k^2 - 2$ and $x^3 + 1/x^3 = k^3 - 3k$
- $x^{n+1} + 1/x^{n+1} = (x + 1/x)(x^n + 1/x^n) - (x^{n-1} + 1/x^{n-1})$
- A sum of squares equal to 0 $\Rightarrow$ every square is 0

60-SECOND SHORTCUT

Climb the powers

$$x + 1/x = 3 \Rightarrow x^2 + 1/x^2 = 9 - 2 = 7 \Rightarrow x^3 + 1/x^3 = 27 - 9 = 18 \Rightarrow x^4 + 1/x^4 = 7^2 - 2 = 47.$$

DON'T MAKE THESE MISTAKES

$$\times (a + b)^3 = a^3 + b^3$$

$$\checkmark \text{ Add } 3ab(a + b)$$

$$\times x^2 + 1/x^2 = (x + 1/x)^2$$

$$\checkmark \text{ Subtract 2: } (x + 1/x)^2 - 2$$

$$\times a^3 + b^3 + c^3 = 3abc \text{ always}$$

$$\checkmark \text{ Only if } a + b + c = 0 \text{ (or } a = b = c)$$

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 3

Q22 · Hard · MCQ

CAT 2024 Slot 2

Q21 · Moderate · TITA

Solve every CAT Algebra PYQ with step-by-step solutions



TOPIC 18 · ALGEBRA 5 OF 11

REGULAR

Indices & Exponents

10

CAT questions from this topic, 2021–25

#7 of 11 in Algebra · 5 TITA



CORE FORMULAS

- $a^m \times a^n = a^{m+n}$; $a^m \div a^n = a^{m-n}$; $(a^m)^n = a^{mn}$
- $(ab)^n = a^n b^n$; $(a/b)^n = a^n/b^n$
- $a^0 = 1$ ($a \neq 0$); $a^{-n} = 1/a^n$; $a^{1/n} = \sqrt[n]{a}$; $a^{m/n} = (\sqrt[n]{a})^m$
- Same base: $a^x = a^y \Rightarrow x = y$ ($a > 0, a \neq 1$)
- Same odd power: $x^n = y^n \Rightarrow x = y$; same even power $\Rightarrow x = \pm y$
- $a^b = 1 \Leftrightarrow b = 0$ ($a \neq 0$), or $a = 1$, or $a = -1$ with b even
- Compare powers by matching exponents: $2^{50} = 32^{10}$ vs $3^{30} = 27^{10}$
- Exponential equations: put $t = a^x$ ($t > 0$) and solve the quadratic in t
- Prime-factorise every base first: $144 = 2^4 \cdot 3^2$, $243 = 3^5$, $20 = 2^2 \cdot 5$

60-SECOND SHORTCUT

Match the exponents

Which is bigger, 2^{50} or 3^{30} ? Write both with exponent 10: 32^{10} vs 27^{10} . Same exponent, bigger base wins: **2^{50} is bigger.**

DON'T MAKE THESE MISTAKES

- $\times$ $2^3 \times 3^2 = 6^5$
- $\checkmark$ Bases differ: $8 \times 9 = 72$
- $\times$ $a^b = 1 \Rightarrow b = 0$
- $\checkmark$ Also **$a = 1$** , or **$a = -1$** with b even
- $\times$ $(a + b)^n = a^n + b^n$
- $\checkmark$ $(2 + 3)^2 = 25$, not $4 + 9 = 13$

SOLVE THE REAL ONES

PYQs and practice on thinkcat.in

CAT 2022 Slot 2

Q2 · Hard · TITA

Indices & Surds set

60+ practice questions

Put the index laws to work on real CAT Algebra PYQs



TOPIC 19 · ALGEBRA 6 OF 11

REGULAR

Surds

4 CAT questions from this topic, 2021-25

#10 of 11 in Algebra · 1 TITA

2021	2022	2023	2024	2025
0	0	1	3	0

CORE FORMULAS

- $\sqrt{a} \times \sqrt{b} = \sqrt{ab}$; $\sqrt{a} \div \sqrt{b} = \sqrt{a/b}$
- $\sqrt{a} + \sqrt{b}$ is **not** $\sqrt{a+b}$
- $(\sqrt{a} + \sqrt{b})(\sqrt{a} - \sqrt{b}) = a - b$
- Rationalise: $1/(\sqrt{a} + \sqrt{b}) = (\sqrt{a} - \sqrt{b})/(a - b)$
- $\sqrt{(x + 2\sqrt{y})} = \sqrt{m} + \sqrt{n}$, where $m + n = x$ and $mn = y$
- $\sqrt{(x - 2\sqrt{y})} = \sqrt{m} - \sqrt{n}$ with $m > n$ (same m, n)
- Compare different roots by raising to the LCM power: $\sqrt[3]{3}$ vs $\sqrt{2} \rightarrow 3^2 = 9$ vs $2^3 = 8$
- $a + b\sqrt{n} = c + d\sqrt{n}$ (rationals, $\sqrt{n}$ irrational) $\Rightarrow a = c$ and $b = d$
- $\sqrt{(a^2)} = |a|$

60-SECOND SHORTCUT

Square roots of $p + q\sqrt{r}$

$\sqrt{(7 + 4\sqrt{3})}$: write $4\sqrt{3}$ as $2\sqrt{12}$, so $m + n = 7$ and $mn = 12 \Rightarrow m = 4, n = 3 \Rightarrow \sqrt{(7 + 4\sqrt{3})} = 2 + \sqrt{3}$.

DON'T MAKE THESE MISTAKES

- $\times \sqrt{9} + \sqrt{16} = \sqrt{25}$
- $\checkmark 3 + 4 = 7$, not 5
- $\times \sqrt{(x - 2\sqrt{y})} = \sqrt{m} + \sqrt{n}$
- $\checkmark$ Minus inside $\Rightarrow \sqrt{m} - \sqrt{n}$ with $m > n$
- $\times \sqrt{((-3)^2)} = -3$
- $\checkmark$ Square roots are never negative: $|-3| = 3$

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2024 Slot 3

Q10 · Moderate · MCQ

CAT 2024 Slot 2

Q5 · Moderate · TITA

[Practise 60+ Indices & Surds questions ↗](#)


Logarithms

14

CAT questions from this topic, 2021–25

#3 of 11 in Algebra · 7 TITA



CORE FORMULAS

- $\log_a x = y \Leftrightarrow a^y = x$ ($a > 0, a \neq 1, x > 0$)
- $\log mn = \log m + \log n$; $\log(m/n) = \log m - \log n$; $\log m^k = k \log m$
- Change of base: $\log_a x = \log x / \log a$, and $\log_a x = 1/\log_x a$
- Chain: $\log_a x \times \log_x y = \log_a y$
- Base a^k , argument x^m : the log is (m/k) $\log_a x$
- $a^{\log_a x} = x$; $\log_a 1 = 0$; $\log_a a = 1$
- Base > 1 : $\log_a x > \log_a y \Leftrightarrow x > y$. Base between 0 and 1: the sign flips
- Domain: every argument > 0 , base > 0 and $\neq 1$; reject roots that break it
- Digits in $N = \lfloor \log_{10} N \rfloor + 1$; $\log_{10} 2 \approx 0.301$, $\log_{10} 3 \approx 0.477$

60-SECOND SHORTCUT

Chains collapse

$\log_2 3 \times \log_3 4 \times \log_4 5 \times \log_5 6 \times \log_6 7 \times \log_7 8 = \log_2 8 = 3$. Each argument cancels the next base.

DON'T MAKE THESE MISTAKES

- $\times \log(a + b) = \log a + \log b$
- $\checkmark \log a + \log b = \log(ab)$
- $\times \log_{1/2} x > 1 \Rightarrow x > 1/2$
- $\checkmark$ Base below 1 flips it: $0 < x < 1/2$
- $\times$ Every root of the final equation counts
- $\checkmark$ Reject roots that make a base or argument **invalid**

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2024 Slot 3

Q1 · Easy · TITA

CAT 2023 Slot 1

Q1 · Moderate · MCQ

14 log questions in 5 years: solve every CAT Logarithms PYQ

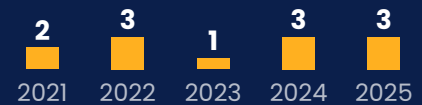


TOPIC 21 · ALGEBRA 8 OF 11

REGULAR

Functions

12 CAT questions from this topic, 2021–25
#5 (tied) of 11 in Algebra · 4 TITA



CORE FORMULAS

- 1 Domain: no zero denominators, no negatives under even roots, log arguments > 0
- 2 Range of $y = f(x)$: solve for x in terms of y ; keep the y values that give a real x
- 3 $f(g(x))$: apply g first. Domain: x in dom g and $g(x)$ in dom f
- 4 Inverse: swap x and y , solve for y ; $f(f^{-1}(x)) = x$
- 5 Even: $f(-x) = f(x)$, mirror in the y -axis. Odd: $f(-x) = -f(x)$, symmetric about the origin
- 6 $f(x) + k \cdot f(1/x) = g(x)$: replace x by $1/x$, then solve the two equations
- 7 Functional equations: try $x = 0, 1, -1$ first, then look for a pattern
- 8 Greatest integer $[x]$: $[x] \leq x < [x] + 1$; $[x + n] = [x] + n$ for integer n
- 9 Shifts: $f(x - a)$ moves right by a ; $f(x) + b$ moves up by b ; $f(|x|)$ mirrors the right half
- 10 Range of a ratio of quadratics: set it equal to y , get a quadratic in x , need $D \geq 0$

60-SECOND SHORTCUT

Swap x for $1/x$

$f(x) + 3f(1/x) = x^2$. Replace x by $1/x$:
 $f(1/x) + 3f(x) = 1/x^2$. Eliminate $f(1/x)$:
 $f(x) = (3/x^2 - x^2)/8$.

DON'T MAKE THESE MISTAKES

- ✗ $f(g(x)) = g(f(x))$
- ✓ Order matters: x^2 and $x + 1$ give **$(x + 1)^2$** vs **$x^2 + 1$**
- ✗ $[-2.3] = -2$
- ✓ The greatest integer ≤ -2.3 is **-3**
- ✗ Domain of $f(g(x)) = \text{domain of } g$
- ✓ Also drop x where $g(x)$ falls **outside dom f**

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 3

Q3 · Moderate · MCQ

CAT 2024 Slot 3

Q15 · Moderate · MCQ

Practise 75+ Functions & Graphs questions



TOPIC 22 · ALGEBRA 9 OF 11

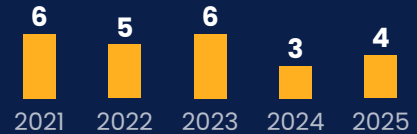
MOST ASKED

Sequences & Series

24

CAT questions from this topic, 2021-25

#1 of 11 in Algebra · 6 TITA



CORE FORMULAS

- 1 AP: $a_n = a + (n-1)d$; $S_n = (n/2)[2a + (n-1)d] = (n/2)(\text{first} + \text{last})$
- 2 Any series: $a_n = S_n - S_{n-1}$
- 3 3 terms in AP: $a-d, a, a+d$; the average of an AP = average of first and last
- 4 GP: $a_n = ar^{n-1}$; $S_n = a(r^n - 1)/(r - 1)$; $S_\infty = a/(1-r)$ when $|r| < 1$
- 5 3 terms in GP: $a/r, a, ar$
- 6 $AM = (a+b)/2 \geq GM = \sqrt{ab} \geq HM = 2ab/(a+b)$; $GM^2 = AM \times HM$
- 7 $1 + 2 + \dots + n = n(n+1)/2$; $\Sigma n^2 = n(n+1)(2n+1)/6$; $\Sigma n^3 = [n(n+1)/2]^2$
- 8 Sum of the first n odd numbers = n^2
- 9 Common terms of two APs form an AP with $d = \text{LCM}(d_1, d_2)$
- 10 Recursions: write 5-6 terms and spot the cycle. Telescoping: $1/(n(n+1)) = 1/n - 1/(n+1)$

60-SECOND SHORTCUT

Any term from the sum

$S_n = 3n^2 + n \Rightarrow a_n = S_n - S_{n-1} = 6n - 2$,
so the series is 4, 10, 16, ...
(an AP with $d = 6$).

DON'T MAKE THESE MISTAKES

- ✗ $S_\infty = a/(1-r)$ for any GP
- ✓ Only when $|r| < 1$
- ✗ n th term of 3, 7, 11, ... is $3 + 4n$
- ✓ $a + (n-1)d = 4n - 1$
- ✗ APs with $d = 4$ and $d = 6$ meet every 24 steps
- ✓ Common terms step by $\text{LCM}(4, 6) = 12$

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 3

Q1 · Moderate · TITA



CAT 2025 Slot 2

Q3 · Moderate · MCQ



The most-asked Algebra topic: practise 70+ Progressions questions



TOPIC 23 · ALGEBRA 10 OF 11 **REGULAR**

Modulus

13 CAT questions from this topic, 2021-25
#4 of 11 in Algebra · 5 TITA



CORE FORMULAS

- $|x| = x$ for $x \geq 0$ and $-x$ for $x < 0$; $|x| = \sqrt{x^2}$
- $|x - a|$ is the distance of x from a on the number line
- $|x| = k \Rightarrow x = \pm k$; $|x| < k \Leftrightarrow -k < x < k$; $|x| > k \Leftrightarrow x < -k$ or $x > k$
- $|a + b| \leq |a| + |b|$, with equality when $ab \geq 0$
- $|x - a| + |x - b|$ ($a < b$) is smallest, equal to $b - a$, for every x from a to b
- A sum of $|x - a_i|$ terms is smallest at the median of the a_i
- Several moduli: split at each critical point, solve each piece, keep roots inside it
- $|f(x)| = k$: solve $f(x) = k$ and $f(x) = -k$
- $|x| + |y| = k$ is a square with corners $(\pm k, 0)$, $(0, \pm k)$; area $2k^2$

60-SECOND SHORTCUT

Think distance

$|x - 2| + |x - 8| = 6$ holds for **every x from 2 to 8**: the distances to 2 and to 8 always add up to the gap between them.

DON'T MAKE THESE MISTAKES

- ✗ $|x - 3| = 5 \Rightarrow x = 8$
- ✓ Also **$x = -2$**
- ✗ $|x| < -2$ has solutions
- ✓ A modulus is never negative: **no solution**
- ✗ Solve $|x - 1| + |x - 5| = 10$ in one go
- ✓ Split at 1 and 5: **$x = -2$ or $x = 8$**

SOLVE THE REAL ONES

Official CAT questions on thinkcat.in

CAT 2025 Slot 2

Q20 · Moderate · MCQ

CAT 2024 Slot 3

Q13 · Moderate · TITA

Practise 85+ Modulus & Inequalities questions



TOPIC 24 · ALGEBRA 11 OF 11

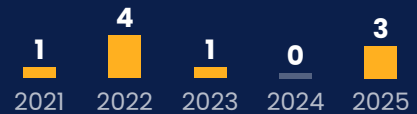
REGULAR

Maxima & Minima

9

CAT questions from this topic, 2021–25

#8 of 11 in Algebra · 4 TITA



CORE FORMULAS

- $ax^2 + bx + c$: vertex at $x = -b/2a$, value $c - b^2/4a$ (min if $a > 0$, max if $a < 0$)
- AM $\geq$ GM: $(a + b)/2 \geq \sqrt{ab}$ for $a, b \geq 0$, equal when $a = b$
- Fixed sum $\Rightarrow$ the product is largest when the parts are equal
- Fixed product $\Rightarrow$ the sum is smallest when the parts are equal
- $px + q/x \geq 2\sqrt{pq}$ for $x > 0$, with equality at $x = \sqrt{q/p}$
- $x + y$ fixed $\Rightarrow x^m y^n$ is largest when $x : y = m : n$
- Complete the square: $x^2 - 6x + 10 = (x - 3)^2 + 1 \geq 1$
- Integers: make them as equal as possible (sum 50 over 4 integers $\rightarrow 12, 12, 13, 13$)
- Restricted range? Check the end points as well as the vertex

60-SECOND SHORTCUT

Equal parts win

Maximise xy when $2x + 3y = 24$: make the parts equal, $2x = 3y = 12$, so $x = 6$, $y = 4$ and **$xy = 24$** .

DON'T MAKE THESE MISTAKES

- $\times$ $x + 1/x \geq 2$ for every $x \neq 0$
- $\checkmark$ Only for $x > 0$; for $x < 0$ it is ≤ -2
- $\times$ The vertex value is the minimum
- $\checkmark$ It is the **maximum** when $a < 0$
- $\times$ AM-GM on terms that can be negative
- $\checkmark$ AM-GM needs **non-negative** terms

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12× = asked 12 times in CAT 2021-25

The Algebra Formula Wall

14 Linear Equations

12×

p.2

- Unique: $a_1/a_2 \neq b_1/b_2$
- None: $a_1/a_2 = b_1/b_2 \neq c_1/c_2$; infinite: all equal
- Integer solutions need HCF(a, b) to divide c

15 Quadratic Equations

15×

p.3

- $x = [-b \pm \sqrt{D}]/2a, D = b^2 - 4ac$
- $\alpha + \beta = -b/a, \alpha\beta = c/a$
- $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$

16 Quadratic Inequalities

3×

p.4

- $(x - a)(x - b) < 0 \Rightarrow$ between the roots
- $(x - a)(x - b) > 0 \Rightarrow$ outside the roots
- Wavy curve: rightmost interval +

17 Algebraic Identities

8×

p.5

- $(a \pm b)^3 = a^3 \pm b^3 \pm 3ab(a \pm b)$
- $a + b + c = 0 \Rightarrow a^3 + b^3 + c^3 = 3abc$
- $x + 1/x = k \Rightarrow x^2 + 1/x^2 = k^2 - 2$

18 Indices & Exponents

10×

p.6

- $a^m \cdot a^n = a^{m+n}; (a^m)^n = a^{mn}; a^{-n} = 1/a^n$
- $a^b = 1: b = 0, a = 1, \text{ or } a = -1 \text{ with } b \text{ even}$
- Compare powers with equal exponents

19 Surds

4×

p.7

- $\sqrt{x \pm 2\sqrt{y}} = \sqrt{m} \pm \sqrt{n}; m + n = x, mn = y$
- $1/(\sqrt{a} + \sqrt{b}) = (\sqrt{a} - \sqrt{b})/(a - b)$
- Compare roots via the LCM power

20 Logarithms

14×

p.8

- $\log mn = \log m + \log n; \log m^k = k \log m$
- $\log_a x = 1/\log_x a; \log_a x \times \log_x y = \log_a y$
- Base below 1 flips inequalities

21 Functions

12×

p.9

- $f(g(x))$: g first; $g(x)$ must lie in dom f
- Inverse: swap x and y , solve
- $f(x) + k f(1/x)$: substitute $1/x$

22 Sequences & Series

24×

p.10

- AP: $a_n = a + (n - 1)d; S_n = n/2$ (first + last)
- GP: $ar^{n-1}; S_\infty = a/(1 - r), |r| < 1$
- $\Sigma n^3 = [n(n + 1)/2]^2$

23 Modulus

13×

p.11

- $|x - a|$ = distance from a
- $|x| < k \Leftrightarrow -k < x < k$
- $\Sigma |x - a_i|$ is least at the median

24 Maxima & Minima

9×

p.12

- Vertex $x = -b/2a$, value $c - b^2/4a$
- $AM \geq GM$, equality at equal parts
- $px + q/x \geq 2\sqrt{(pq)}$ for $x > 0$

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