MasterLeap Tuition CAT formula sheet

CAT QUANT OVERVIEW

Exam Pattern

Aspect	Details
Number of Questions	22 questions
Time Allotted	40 minutes
Question Types	MCQs + TITA (Type In The Answer)
Marking Scheme	+3 for correct, -1 for incorrect (MCQs only)
Difficulty Level	Moderate to High
Topics Covered	Arithmetic, Algebra, Geometry, Number System, Modern Math

Topic-wise Weightage (Expected)

Topic Category	Approximate Questions	Percentage
Arithmetic	6-8 questions	30-35%

Algebra	5-7 questions	25-30%
Geometry & Mensuration	4-5 questions	18-22%
Number System	3-4 questions	15-18%
Modern Math	2-3 questions	10-12%

Key Skills Tested

- Conceptual understanding
- Application of formulas
- Calculation speed
- Logical reasoning
- Data interpretation ability

SECTION 1: NUMBER SYSTEM

Divisibility Rules

- Divisible by 2: Last digit even (0,2,4,6,8)
- Divisible by 3: Sum of digits divisible by 3
- Divisible by 4: Last two digits divisible by 4
- Divisible by 5: Last digit 0 or 5
- Divisible by 6: Divisible by both 2 and 3
- Divisible by 8: Last three digits divisible by 8
- Divisible by 9: Sum of digits divisible by 9
- Divisible by 11: Difference between sum of digits at odd and even places = 0 or multiple of 11

Important Formulas

- HCF × LCM = Product of two numbers (for two numbers a and b)
- HCF of fractions = HCF of numerators / LCM of denominators
- LCM of fractions = LCM of numerators / HCF of denominators
- Sum of first n natural numbers = n(n+1)/2
- Sum of first n odd numbers = n^2
- Sum of first n even numbers = n(n+1)
- Sum of squares of first n numbers = n(n+1)(2n+1)/6
- Sum of cubes of first n numbers = $[n(n+1)/2]^2$

Remainder Theorems

- Remainder when ($a^n + b^n$) is divided by (a + b): For odd n, remainder = 0
- Remainder when ($a^n - b^n$) is divided by (a - b): Always divisible (remainder = 0)
- Euler's Theorem: $a^{\varphi(n)} \equiv 1 \bmod n$, where a and n are coprime
- Fermat's Little Theorem: $a^{(p-1)} \equiv 1 \bmod p$, where p is prime

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SECTION 2: PERCENTAGES

Basic Formulas

- Percentage = (Part/Whole) × 100
- Percentage Increase = (Increase/Original) × 100
- Percentage Decrease = (Decrease/Original) × 100

Successive Percentage Change

- Two successive changes of a% and b% = a + b + (ab/100)
- Three successive changes of a%, b%, and c% = [a + b + (ab/100)] + c + ([a + b + (ab/100)] × c/100)

Population Formula

- Population after n years = $P(1 + r/100)^n$

- Population n years ago = $P/(1 + r/100)^n$

Depreciation Formula

- Value after n years = $P(1 - r/100)^n$

Comparison Formulas

- If A is x% more than B, then B is = [x/(100+x)] × 100% less than A
- If A is x% less than B, then B is = [x/(100-x)] × 100% more than A

SECTION 3: PROFIT & LOSS

Basic Formulas

- Cost Price (CP) = Price at which an article is purchased
- Selling Price (SP) = Price at which an article is sold
- Profit = SP - CP (when SP > CP)
- Loss = CP - SP (when CP > SP)

Percentage Formulas

- Profit % = (Profit/CP) × 100
- Loss % = (Loss/CP) × 100
- SP when profit % given = CP × (100 + Profit%)/100
- SP when loss % given = CP × (100 - Loss%)/100
- CP when profit % given = (SP × 100)/(100 + Profit%)
- CP when loss % given = (SP × 100)/(100 - Loss%)

Discount Formulas

- Discount = Marked Price - Selling Price

- Discount % = (Discount/Marked Price) × 100
- SP after discount = MP × (100 - Discount%)/100
- Successive discounts of a% and b% = a + b - (ab/100)

Special Cases

- If two items are sold at same price, one at x% profit and other at x% loss: Overall loss % = $(x^2/100)\%$
- If CP of x articles = SP of y articles: Profit % = [(x - y)/y] × 100

SECTION 4: SIMPLE & COMPOUND INTEREST

Simple Interest

- SI = (P × R × T)/100
- Amount (A) = P + SI = P[1 + (R×T)/100]
- Principal (P) = (100 × SI)/(R × T)
- Rate (R) = (100 × SI)/(P × T)
- Time (T) = (100 × SI)/(P × R)

Compound Interest

- Amount (A) = $P[1 + R/100]^n$
- CI = A - P = $P[(1 + R/100)^n - 1]$
- When interest compounded half-yearly: A = $P[1 + (R/2)/100]^{2n}$
- When interest compounded quarterly: A = $P[1 + (R/4)/100]^{4n}$
- When rates are different for different years: A = $P(1 + R_1/100)(1 + R_2/100)(1 + R_3/100)...$

Difference between CI and SI

- For 2 years: CI - SI = $P(R/100)^2$
- For 3 years: CI - SI = $P(R/100)^2(3 + R/100)$

SECTION 5: RATIO, PROPORTION & VARIATION

Ratio Basics

- Ratio $a : b = a/b$
- Duplicate ratio of $a : b = a^2 : b^2$
- Triplicate ratio of $a : b = a^3 : b^3$
- Sub-duplicate ratio of $a : b = \sqrt{a} : \sqrt{b}$
- Sub-triplicate ratio of $a : b = \sqrt[3]{a} : \sqrt[3]{b}$

Proportion

- If $a : b = c : d$, then a, b, c, d are in proportion
- Product of extremes = Product of means ($ad = bc$)
- Fourth proportional to a, b, c = $(b \times c)/a$
- Third proportional to a, b = b^2/a
- Mean proportional between a and b = $\sqrt{(ab)}$

Variation

- Direct Variation: $y \propto x \rightarrow y = kx$
- Inverse Variation: $y \propto 1/x \rightarrow y = k/x$
- Joint Variation: $y \propto xz \rightarrow y = kxz$

SECTION 6: TIME, SPEED & DISTANCE

Basic Formulas

- Speed = Distance/Time
- Distance = Speed × Time

- Time = Distance/Speed

Unit Conversions

- km/hr to m/s = Multiply by 5/18
- m/s to km/hr = Multiply by 18/5

Average Speed

- When distances are equal (two speeds x and y): Average Speed = $2xy/(x + y)$
- When times are equal (two speeds x and y): Average Speed = $(x + y)/2$
- For three equal distances (speeds x, y, z): Average Speed = $3xyz/(xy + yz + zx)$

Relative Speed

- Same direction: Relative Speed = $|x - y|$
- Opposite direction: Relative Speed = $x + y$
- Time to meet = Distance between them/Relative Speed

Trains

- Time to cross a pole/man = Length of train/Speed
- Time to cross a platform = (Length of train + Length of platform)/Speed
- Time to cross another train:
    - Same direction: $(L_1 + L_2)/|S_1 - S_2|$
    - Opposite direction: $(L_1 + L_2)/(S_1 + S_2)$

Boats & Streams

- Downstream Speed = Speed in still water + Speed of stream
- Upstream Speed = Speed in still water - Speed of stream
- Speed in still water = (Downstream + Upstream)/2
- Speed of stream = (Downstream - Upstream)/2

SECTION 7: TIME & WORK

Basic Formula

- Work = Rate × Time
- Rate = Work/Time
- Time = Work/Rate

Work Equivalence

- If M_1 persons can do W_1 work in D_1 days:
  $M_1D_1/W_1 = M_2D_2/W_2$ (constant)
- With working hours: $M_1D_1H_1/W_1 = M_2D_2H_2/W_2$

Efficiency

- Efficiency $\propto$ 1/Time taken
- Ratio of work done = Ratio of efficiencies
- If A is twice as good as B: A takes half the time B takes

Pipes & Cisterns

- Inlet pipe: Rate = 1/Time to fill
- Outlet pipe: Rate = -1/Time to empty
- Net rate = Sum of all rates (inlet positive, outlet negative)
- Time to fill = 1/Net rate

Alternate Day Work

- Work done in 2 days = Work by A in 1 day + Work by B in 1 day
- Time to complete = Total work/Work per cycle × Cycle length

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SECTION 8: AVERAGES, MIXTURES & ALLIGATIONS

Averages

- Average = Sum of observations/Number of observations
- Weighted Average = $(w_1x_1 + w_2x_2 + ...)/(w_1 + w_2 + ...)$
- If each observation increased/decreased by k: Average increases/decreases by k
- If each observation multiplied/divided by k: Average multiplied/divided by k

Mixtures

- Quantity of pure liquid in mixture = Total quantity × (Percentage of pure/100)
- After removing and replacing:
  Final quantity = Initial × $(1 - r/t)^n$
  where r = quantity replaced, t = total quantity, n = number of operations

Alligation Rule

- For two mixtures:
  (Cheaper Quantity)/(Dearer Quantity) = (Dearer Price - Mean Price)/(Mean Price - Cheaper Price)
- Or: (Quantity of cheaper)/(Quantity of dearer) = (d - m)/(m - c)

SECTION 9: ALGEBRA

Basic Identities

- $(a + b)^2 = a^2 + 2ab + b^2$
- $(a - b)^2 = a^2 - 2ab + b^2$
- $a^2 - b^2 = (a + b)(a - b)$
- $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$
- $(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$

- $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$
- $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$
- $(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$
- $a^3 + b^3 + c^3 - 3abc = (a + b + c)(a^2 + b^2 + c^2 - ab - bc - ca)$

Quadratic Equations

- Standard form: $ax^2 + bx + c = 0$
- Roots: $x = [-b \pm \sqrt{(b^2 - 4ac)}]/2a$
- Sum of roots = $-b/a$
- Product of roots = c/a
- Discriminant (D) = $b^2 - 4ac$
    - $D > 0$: Real and distinct roots
    - $D = 0$: Real and equal roots
    - $D < 0$: Imaginary roots

Linear Equations

- Two variables: $a_1x + b_1y = c_1$ and $a_2x + b_2y = c_2$
- Consistent if $a_1/a_2 \neq b_1/b_2$ (unique solution)
- Inconsistent if $a_1/a_2 = b_1/b_2 \neq c_1/c_2$ (no solution)
- Dependent if $a_1/a_2 = b_1/b_2 = c_1/c_2$ (infinite solutions)

Inequalities

- If $a > b$ and $b > c$: $a > c$
- If $a > b$: $a + c > b + c$
- If $a > b$ and $c > 0$: $ac > bc$
- If $a > b$ and $c < 0$: $ac < bc$

Logarithms

- $\log_a(xy) = \log_a x + \log_a y$
- $\log_a(x/y) = \log_a x - \log_a y$
- $\log_a(x^n) = n \log_a x$
- $\log_a a = 1$

- $\log_a 1 = 0$
- $\log_a b = 1/\log_b a$
- $\log_a b = \log_c b/\log_c a$ (change of base)

SECTION 10: PROGRESSIONS

Arithmetic Progression (AP)

- nth term: $T_n = a + (n-1)d$
- Sum of n terms: $S_n = n/2[2a + (n-1)d] = n/2(a + l)$
- Arithmetic Mean: $AM = (a + b)/2$

Geometric Progression (GP)

- nth term: $T_n = ar^{n-1}$
- Sum of n terms: $S_n = a(r^n - 1)/(r - 1)$ for $r \neq 1$
- Sum to infinity ($|r| < 1$): $S_\infty = a/(1 - r)$
- Geometric Mean: $GM = \sqrt{(ab)}$

Harmonic Progression (HP)

- nth term: $T_n = 1/[a + (n-1)d]$ where a is first term of corresponding AP
- Harmonic Mean: $HM = 2ab/(a + b)$

Relationship

- For two positive numbers a and b:
  $AM \geq GM \geq HM$
  $GM^2 = AM \times HM$

SECTION 11: GEOMETRY

Triangles

- Area = ½ × base × height
- Area = √[s(s-a)(s-b)(s-c)] where s = (a+b+c)/2 (Heron's formula)
- Area = ½ × ab × sin C
- Perimeter = a + b + c

Properties

- Angle sum: ∠A + ∠B + ∠C = 180°
- Exterior angle = Sum of opposite interior angles
- Pythagoras theorem: In right triangle, $h^2 = p^2 + b^2$
- Apollonius theorem: $AB^2 + AC^2 = 2(AD^2 + BD^2)$ where AD is median

Similarity of Triangles

- If ΔABC ~ ΔPQR:
    - Corresponding angles equal
    - Corresponding sides proportional: AB/PQ = BC/QR = AC/PR
    - Ratio of areas = (ratio of corresponding sides)²

Circles

- Circumference = 2πr
- Area = πr^2
- Arc length = (θ/360°) × 2πr
- Sector area = (θ/360°) × πr^2
- Segment area = Sector area - Triangle area

Circle Theorems

- Angle in semicircle = 90°

- Angle at center = 2 × Angle at circumference
- Angles in same segment are equal
- Power of a point: PA × PB = PC × PD (for intersecting chords)

Quadrilaterals

- Square: Area = a^2, Perimeter = 4a, Diagonal = $a\sqrt{2}$
- Rectangle: Area = l × b, Perimeter = 2(l + b), Diagonal = $\sqrt{(l^2 + b^2)}$
- Parallelogram: Area = b × h, Perimeter = 2(a + b)
- Rhombus: Area = ½ × d_1 × d_2, Perimeter = 4a
- Trapezium: Area = ½ × (a + b) × h
- Kite: Area = ½ × d_1 × d_2

SECTION 12: MENSURATION (3D)

Cube

- Volume = a^3
- Surface Area = $6a^2$
- Diagonal = $a\sqrt{3}$

Cuboid

- Volume = l × b × h
- Surface Area = 2(lb + bh + hl)
- Diagonal = $\sqrt{(l^2 + b^2 + h^2)}$

Cylinder

- Volume = $\pi r^2 h$
- Curved Surface Area = $2\pi rh$
- Total Surface Area = $2\pi r(h + r)$

Cone

- Volume = $\frac{1}{3}\pi r^2 h$
- Slant height (l) = $\sqrt{(r^2 + h^2)}$
- Curved Surface Area = $\pi r l$
- Total Surface Area = $\pi r(l + r)$

Sphere

- Volume = $\frac{4}{3}\pi r^3$
- Surface Area = $4\pi r^2$

Hemisphere

- Volume = $\frac{2}{3}\pi r^3$
- Curved Surface Area = $2\pi r^2$
- Total Surface Area = $3\pi r^2$

Frustum of Cone

- Volume = $\frac{1}{3}\pi h(R^2 + Rr + r^2)$
- Curved Surface Area = $\pi l(R + r)$ where $l = \sqrt{[h^2 + (R - r)^2]}$
- Total Surface Area = $\pi l(R + r) + \pi R^2 + \pi r^2$

SECTION 13: COORDINATE GEOMETRY

Distance and Section

- Distance between $P(x_1,y_1)$ and $Q(x_2,y_2)$: $d = \sqrt{[(x_2-x_1)^2 + (y_2-y_1)^2]}$
- Section formula (internal division): $[(m_2x_1 + m_1x_2)/(m_1 + m_2), (m_2y_1 + m_1y_2)/(m_1 + m_2)]$

- Section formula (external division): $[(m_2x_1 - m_1x_2)/(m_2 - m_1), (m_2y_1 - m_1y_2)/(m_2 - m_1)]$
- Midpoint: $[(x_1 + x_2)/2, (y_1 + y_2)/2]$

Area of Triangle

- Area = $\frac{1}{2}|x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)|$
- Collinearity: If area = 0, points are collinear

Straight Line

- Slope (m) = $(y_2 - y_1)/(x_2 - x_1) = \tan \theta$
- Slope of parallel lines: $m_1 = m_2$
- Slope of perpendicular lines: $m_1 \times m_2 = -1$

Forms of Equation

- Slope-intercept: $y = mx + c$
- Point-slope: $y - y_1 = m(x - x_1)$
- Two-point: $(y - y_1)/(y_2 - y_1) = (x - x_1)/(x_2 - x_1)$
- Intercept form: $x/a + y/b = 1$
- General form: $ax + by + c = 0$

Distance from Point to Line

- Distance from (x_1,y_1) to $ax + by + c = 0$: $d = |ax_1 + by_1 + c|/\sqrt{(a^2 + b^2)}$

Circle

- Center (h,k), radius r: $(x - h)^2 + (y - k)^2 = r^2$
- Center at origin: $x^2 + y^2 = r^2$
- General form: $x^2 + y^2 + 2gx + 2fy + c = 0$
    - Center = $(-g, -f)$
    - Radius = $\sqrt{(g^2 + f^2 - c)}$

SECTION 14: TRIGONOMETRY

Basic Ratios

- $\sin \theta$ = Opposite/Hypotenuse
- $\cos \theta$ = Adjacent/Hypotenuse
- $\tan \theta$ = Opposite/Adjacent = $\sin \theta / \cos \theta$
- $\text{cosec } \theta = 1/\sin \theta$
- $\sec \theta = 1/\cos \theta$
- $\cot \theta = 1/\tan \theta = \cos \theta / \sin \theta$

Values at Standard Angles

Angle	0°	30°	45°	60°	90°
sin	0	1/2	1/√2	√3/2	1
cos	1	√3/2	1/√2	1/2	0
tan	0	1/√3	1	√3	∞

Identities

- $\sin^2 \theta + \cos^2 \theta = 1$
- $\sec^2 \theta - \tan^2 \theta = 1$
- $\text{cosec}^2 \theta - \cot^2 \theta = 1$

Compound Angles

- $\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$

- $\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$
- $\tan(A \pm B) = (\tan A \pm \tan B)/(1 \mp \tan A \tan B)$

Double Angle

- $\sin 2A = 2 \sin A \cos A$
- $\cos 2A = \cos^2 A - \sin^2 A = 2 \cos^2 A - 1 = 1 - 2 \sin^2 A$
- $\tan 2A = 2 \tan A/(1 - \tan^2 A)$

SECTION 15: PERMUTATION & COMBINATION

Permutations (nPr)

- Number of permutations = $n!/(n - r)!$
- Permutations with repetitions = n^r
- Circular permutations = $(n - 1)!$
- Number of ways to arrange n items with p alike, q alike, ... = $n!/(p!\ q!\ ...)$

Combinations (nCr)

- Number of combinations = $n!/[r!(n - r)!]$
- Properties: $nCr = nC(n-r)$, $nC_0 = nC_n = 1$
- $nCr + nC(r-1) = (n+1)Cr$

Selection

- Number of ways to select zero or more from n items = 2^n
- Number of ways to select at least one = $2^n - 1$
- Number of ways to select r from n with repetitions allowed = $(n+r-1)Cr$

Important Results

- Number of diagonals in n-sided polygon = $n(n-3)/2$
- Number of triangles from n points (no three collinear) = nC_3
- Number of rectangles in m×n grid = $(mC_2) \times (nC_2)$

SECTION 16: PROBABILITY

Basic Formula

- P(Event) = Number of favorable outcomes/Total number of outcomes
- $0 \leq P(E) \leq 1$
- P(E) + P(not E) = 1

Types of Events

- Mutually Exclusive: P(A or B) = P(A) + P(B)
- Independent Events: P(A and B) = P(A) × P(B)
- Conditional Probability: P(A|B) = P(A and B)/P(B)

Addition Theorem

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

Binomial Distribution

- P(r successes in n trials) = $nCr \times p^r \times q^{n-r}$
  where p = probability of success, q = 1-p

Expectation

- Expected value = $\Sigma[x \times P(x)]$

SECTION 17: SET THEORY

Basic Formulas

- $n(A \cup B) = n(A) + n(B) - n(A \cap B)$
- $n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(B \cap C) - n(C \cap A) + n(A \cap B \cap C)$
- $n(A') = n(U) - n(A)$

De Morgan's Laws

- $(A \cup B)' = A' \cap B'$
- $(A \cap B)' = A' \cup B'$

Venn Diagram Concepts

- Only A = $n(A) - n(A \cap B) - n(A \cap C) + n(A \cap B \cap C)$
- Exactly two = $n(A \cap B) + n(B \cap C) + n(C \cap A) - 3n(A \cap B \cap C)$
- At least one = $n(A \cup B \cup C)$