TIME, SPEED & DISTANCE

Ultimate Masterclass Guide for CAT Aspirants

1. INTRODUCTION & PURPOSE

Time, Speed, and Distance (TSD) is arguably the most heavily tested arithmetic area in the quantitative aptitude section of the Common Admission Test (CAT). Each year, CAT features 3 to 5 questions directly or indirectly mapped to TSD subconcepts. The purpose of this guide is to strip away mechanical formula memorization and substitute it with an intuitive, ratio-based structural understanding. This guide is curated specifically for high-level management aspirants who need to make rapid, logical decisions under stringent timed conditions.

2. CORE CONCEPTS & PROPORTIONALITY

The governing foundation of all TSD questions is the fundamental relationship:

$$\textit{Distance (D)} = \textit{Speed (S)} \times \textit{Time (T)}$$

While this equation is trivial, the application of its proportional variations is what resolves advanced 99th percentile CAT problems within 45 seconds:

- **Constant Distance (D is Constant):** Speed and Time are inversely proportional to each other.

  $$S \propto 1/T \Rightarrow S_1 / S_2 = T_2 / T_1$$

  If a person increases their speed by x/y, the time taken decreases by $x/(x + y)$ of the original time.
- **Constant Time (T is Constant):** Distance and Speed are directly proportional.

  $$D \propto S \Rightarrow D_1 / D_2 = S_1 / S_2$$

  Commonly observed in "meeting points" where two individuals start at the same time and travel until they cross each other.
- **Constant Speed (S is Constant):** Distance and Time are directly proportional.

  $$D \propto T \Rightarrow D_1 / D_2 = T_1 / T_2$$

3. IMPORTANT FORMULAS & FRAMEWORKS

SUB-CONCEPT	GOVERNING FORMULA	STRATEGIC APPLICATION
Average Speed	***Avg Speed = Total Distance / Total Time*** • Equal Distances: $2S_1S_2 / (S_1 + S_2)$ • Equal Times: $(S_1 + S_2) / 2$	Do NOT average speeds algebraically unless travel times are strictly equal.
Relative Speed	• Opposite Dir: $S_{Rel} = S_1 + S_2$ • Same Dir: $S_{Rel} = \lvert S_1 - S_2 \rvert$	Crucial for trains, escalators, and chase scenarios. Ensure same units are used.
Circular Tracks	• Time for 1st meeting: $T = \text{Circumference} / S_{Rel}$ • Distinct meeting points: $a : b$ speed ratio yields $a - b$ (same direction) or $a + b$ (opposite) points.	Ensure the speed ratio is simplified to its lowest terms before calculating points.
Boats & Streams	• Downstream: $D = U + V$ • Upstream: $U = U - V$ • Boat Speed: $U = (D + U) / 2$ | Stream: $V = (D - U) / 2$	U is the speed of boat in still water; V is the stream speed.

4. CAT TRAP IDENTIFIER

TRAP 1: THE MISLEADING AVERAGE SPEED

The Trap: "A commuter drives to office at 40 km/h and returns at 60 km/h. What is the average speed?" Most candidates immediately mark 50 km/h.

The Escape: Because the distance is constant, you must use the Harmonic Mean formula: $2 \times 40 \times 60 / (40 + 60) = 48$ km/h.

TRAP 2: CIRCULAR TRACK "STARTING POINT" VS "ANYWHERE"

The Trap: Confusing the time taken to meet *at any point* on a circular track with the time taken to meet specifically *at the starting point*.

The Escape: For the starting point, calculate the LCM of individual times taken to complete a full lap: $LCM(L/S_1, L/S_2)$. For meeting anywhere, use L / S_{Rel}.

5. SPEED TECHNIQUES & SHORTCUTS

1. THE INVERSE RATIO (SCALE FACTOR) APPROACH

If a person travels at $5/6$ of their usual speed, their speed factor is $5/6$. Since distance is constant, their time factor must be $6/5$ of the usual time. Therefore, they will take $1/5$ more than their usual time. If they are 10 minutes late:

$1/5 \times T_{Usual} = 10$ mins &Arr; $T_{Usual} = 50$ mins.

2. MEETING AND GOING ONWARD THEOREM

Two bodies start simultaneously from points A and B towards each other. After meeting, they take time t_1 and t_2 respectively to reach their destinations. Their speed relation is strictly defined as: $S_1 / S_2 = \sqrt{(t_2 / t_1)}$

6. COMMON MISTAKES TO AVOID

- **Unit Inconsistencies:** Mixing *km/h* with seconds or meters. Always multiply $km/h \times 5/18$ to get *m/s*, and $m/s \times 18/5$ to get *km/h* immediately.
- **Incorrect Relative Speeds in Trains:** When calculating relative speed for overtaking or crossing trains, forget to add their lengths. Always remember: $Total\ Distance = Length_1 + Length_2$.
- **Escalator Sign Missteps:** Treat escalators like Boats & Streams. Walking in the same direction as the escalator movement means $S_{Total} = S_{Man} + S_{Escalator}$. Walking against it means $S_{Total} = S_{Man} - S_{Escalator}$.

7. QUICK REVISION CARD

TSD CHEAT CARD — POCKET VERSION

Core Formula Relationships:

- $D = S \times T$
- Constant D: $S_1T_1 = S_2T_2$
- Constant T: $D_1/S_1 = D_2/S_2$
- Constant S: $D_1/T_1 = D_2/T_2$

Speed Conversions:

- *18 km/h = 5 m/s*
- *36 km/h = 10 m/s*
- *54 km/h = 15 m/s*

Circular Track Meetings:

- First meet anywhere: $T = C / (S_1 \pm S_2)$
- First meet at start: $T = LCM(C/S_1, C/S_2)$

Linear Races:

- A beats B by x meters: when A is at finish line L, B is at $L - x$.
- A beats B by t seconds: A completes in T, B completes in $T + t$.