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CAT Time, Speed, Distance & Work Formulas

- Time, Distance and Work is the most important topic for CAT Quant Section & all competitive exams.
- The questions from this topic vary from easy to difficult.
- This formula sheet covers the most importance tips that helps you to answer the questions in a easy, fast and accurate way

$$Distance = Speed \times Time$$

$$Speed = \frac{Distance}{Time} \quad \Big| \quad Time = \frac{Distance}{Speed}$$

- While converting the speed in m/s to km/hr, multiply it by $\left(\frac{18}{5}\right)$ $\Rightarrow$ 1 m/s = 3.6 km/h

- While converting km/hr into m/sec, we multiply by $\left(\frac{5}{18}\right)$
- If the ratio of the speeds of A and B is a : b, then

➔ The ratio of the times taken to cover the same distance is 1/a : 1/b or b : a.

➔ The ratio of distance travelled in equal time intervals is a : b ,

$$\text{Average Speed} = \frac{Total\ Distance\ Travelled}{Total\ Time\ Taken}$$

➔ If a part of a journey is travelled at speed $S_1\ km/hr$ in $T_1\ hours$ and remaining part at speed $S_2\ km/hr$ in $T_2\ hours$ then,

Total distance travelled = $S_1T_1 + S_2T_2\ km$

$$\text{Average Speed} = \frac{S_1T_1+S_2T_2}{T_1+T_2}\ \textbf{km/hr}$$

- If D_1 km is travelled at speed S_1 km/hr, and D_2 km is travelled at speed S_2 km/hr then,

$$Average\ Speed\ =\ \frac{D_1+D_2}{\frac{D_1}{S_1}+\frac{D_2}{S_2}} km/hr$$

- In a journey travelled with different speeds, if the distance covered in each stage is constant, the average speed is the harmonic mean of the different speeds.
- Suppose a man covers a certain distance at x km/hr and an equal distance at y km/hr. Then the average speed during the whole journey is $\frac{2xy}{x+y} km/hr$
- In a journey travelled with different speeds, if the time travelled in each stage is constant, the average speed is the arithmetic mean of the different speeds.

- If a man travelled for a certain distance at x km/hr and for equal amount of time at the speed of y km/hr then the average speed during the whole journey is $\frac{x+y}{2} km/hr$

Constant Distance

Let the distance travelled in each part of the journey be d_1, d_2 & d_3 and so on till d_n and the speeds in each part be s_1, s_2, s_3 and so on till s_n

If $d_1 = d_2 = d_3 =........= d_n = d$, then the average speed is the harmonic mean of the speeds s_1, s_2, s_3 and so on till s_n.

Constant Time

Let the distance travelled in each part of the journey be d_1, d_2 *and* d_3 and so on till d_n and the time taken for each part be t_1, t_2, t_3 and so on till t_n.

If $t_1 = t_2 = t_3 = \ldots\ldots = t_n = t$, then the average speed is the arithmetic mean of the speeds s_1, s_2, s_3 and so on till s_n.

Clocks

➔ Calculating the angle/position of the hands

- Speed of hour hand = 0.5^0 per minute
- Speed of minute hand = 6^0 per minute
- Relative speed of two hands = 5.5^0 per minute
- The angle (in degrees) between hour hand and minute hand at time H: M can be represented as: $\theta = \left|\frac{11}{2}M - 30H\right|^0$

➔ In a 12-hour period:

- The hour hand and the minute hand meet 11 times
- A 180^0 angle is formed between the two hands 11 times
- A 90^0 angle is formed between the two hands 22 times

➔ In a well-functioning clock, both hands meet after every $\frac{720}{11}$ Mins.

➔ It is because the relative speed of the minute hand with respect to the hour hand $= \frac{11}{2}$ degrees per minute.

Erroneous Clocks

➔ An erroneous clock is a clock which loses or gains time at a constant rate.

➔ In case of an erroneous clock losing/gaining 'x' sec per minute,

- It will lose/gain 'x' minutes per hour.
- It will show the correct time after every '720/x' hours.
- The clock will show the same time again after 'y' hours where:

$y = \frac{720}{60+x}$ if the clock gains time.

$y = \frac{720}{60-x}$ if the clock loses time.'

- If the clock is set right at ‘Q’ AM/PM. Then the time ‘T’ shown by the clock after ‘h’ hours pass on a correct clock would be:

  T = $Q + (h \times x)$ if the clock gains time.

  T = $Q - (h \times x)$ if the clock loses time.’

- If the clock is set right at ‘Q’ AM/PM. If ‘h’ hours pass on the erroneous clock, then the actual time ‘T’ shown by a correct clock would be:

T=Q+y ; y(in hours)

$$= \frac{60h}{60+x} \text{ if the clock gains time}$$

$$= \frac{60h}{60-x} \text{ if the clock loses time.}$$

Circular Tracks

If two people are running on a circular track with speeds in ratio a:b where a and b are co-prime, then

➔ They will meet at $a + b$ distinct points if they are running in opposite directions.

➔ They will meet at $|a - b|$ distinct points if they are running in same direction

- If two people are running on a circular track having perimeter ‘l’, with speeds ‘m’ and ‘n’,

The time for their first meeting = $\frac{l}{(m+n)}$

(when they are running in opposite directions)

The time for their first meeting = $\frac{l}{|(m-n)|}$

(when they are running in the same direction)

- If a person P starts from A and heads towards B and another person Q starts from B and heads towards A and they meet after a time 't' then,

$$t = \sqrt{(x \times y)}$$

where x = time taken (after meeting) by P to reach B and y = time taken (after meeting) by Q to reach A.

- A and B started at a time towards each other. After crossing each other, they took $T_1 hrs,\ T_2 hrs$ respectively to reach their destinations. If they travel at constant speed S_1 and S_2 respectively all over the journey, then $\frac{S_1}{S_2} = \sqrt{\frac{T_2}{T_1}}$

Trains

Two trains of length L_1 and L_2 travelling at speeds S_1 and S_2 cross each other in a time

$$=\frac{L_1 + L_2}{S_1 + S_2}$$ (If they are going in opposite directions)

$$=\frac{L_1 + L_2}{\left|S_1 - S_2\right|}$$ (If they are going in the same directions)

Time & Work

$\Rightarrow$ If X can do a work in ‘n’ days, the fraction of work X does in a day is $\frac{1}{n}$

$\Rightarrow$ If X can do work in ‘x’ days, and Y can do work in ‘y’ days, then the number of days taken by both of them together is $\frac{x \times y}{\ }$

⟹ If M_1 men work for H_1 $hours$ per day and worked for D_1 days and completed W_1 work, and if M_2 men work for H_2 hours per day and worked for D_2 days and completed W_2 work, then

$$\frac{M_1H_1D_1}{W_1} = \frac{M_2H_2D_2}{W_2}$$

Boats & Streams

⟹ If the speed of water is 'W' and speed of a boat in still water is 'B'

⟹ Speed of the boat (downstream) is B+W

⟹ Speed of the boat (upstream) is B-W

The direction along the stream is called **downstream.**

And, the direction against the stream is called **upstream.**

$\Rightarrow$ If the speed of the boat downstream is x km/hr and the speed of the boat upstream is y km/hr, then

$\Rightarrow$ Speed of the boat in still water = $\frac{x+y}{2}$km/hr

$\Rightarrow$ Rate of stream = $\frac{x-y}{2}$km/hr

$\Rightarrow$ While converting the speed in m/s to km/hr, multiply it by $\left(\frac{18}{5}\right) \Rightarrow$ 1 m/s = 3.6 km/h

$\Rightarrow$ While converting km/hr into m/sec, we multiply by $\left(\frac{5}{18}\right)$

Pipes & Cisterns

$\Rightarrow$ Inlet Pipe : A pipe which is used to fill the tank is known as Inlet Pipe.

$\Rightarrow$ Outlet Pipe : A pipe which can empty the tank is known as outlet pipe.

- If a pipe can fill a tank in 'x' hours then the part filled per hour $=\frac{1}{x}$
- If a pipe can empty a tank in 'y' hours, then the part emptied per hour $=\frac{1}{y}$
- If a pipe A can fill a tank in 'x' hours and pipe can empty a tank in 'y' hours, if they are both active at the same time, then

The part filled per hour = $\frac{1}{x} - \frac{1}{y}$ $(If\ y > x)$

The part emptied per hour = $\frac{1}{y} - \frac{1}{x}$ $(If\ x > y)$

Some Tips and Tricks

- Some of the questions may consume a lot of time. While solving, write down the equations without any errors once you fully understand the given problem. The few extra seconds can help you avoid silly mistakes.

- Check if the units of distance, speed and time match up. If you see yourself adding a unit of distance like m to a unit of speed m/s, you would realise you have possibly missed a term.
- Choose to apply the concept of relative speed wherever possible since it can greatly reduce the complexity of the problem.
- In time and work, while working with equations, ensure that you convert all terms to consistent units like man-hours.