

Time, speed, and distance

Introduction to time, speed, and distance

Introduction

Time, Speed, and Distance is an important chapter for the purpose of the Maths section in aptitude exams. The basic concepts of Time, Speed, and Distance are used in solving questions based on straight-line motion, relative motion, circular motion, problems based on trains, problems based on boats, clocks, races, etc.

Time, Speed and Distance is a situation related to the motion of a body. If a person is moving from point 'x' to point 'y', this journey is described by three variables, and every Time, Speed and Distance question has only 3 variables in it (time, speed, and distance).

Time, Speed & Distance formula :

- (a) Distance = Speed \times Time
- (b) Time = Distance/Speed
- (c) Speed = Distance/Time

Units:

Speed: m/sec, km/hr, and in some cases, you will see km/min, m/min, feet/sec, and feet/hr.

Time: min, hour and sec

Distance: km, meter and miles

Whenever you will use Speed \times Time = Distance formula, units of all three Time, Speed and Distance should be consistent with each other, which means if speed is in kmph(km/hr), you can't take time in sec or min, time will have to be in "hour" and distance will have to be in "km".

Conversion:

1 km = 1000 meters = 0.6214 mile

1 mile = 1.609 km

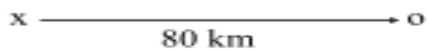
1 hr = 60 min = 60 \times 60 seconds = 3600 seconds

1 km/hr = 5/18 m/s

1 m/s = 18/5 km/hr

1 km/hr = 5/8 miles/hour

A car is travelling at 40 kmph from point 'x' to observer 'o' for a distance of 80 km.



40 kmph can be described as the rate at which a car is approaching the observer. So, every hour the car will keep coming 40 km closer to the observer.

If a journey is of 80km, so the car will take 2 hr to reach the observer.

Another way of looking it is;



The rate at which the car is moving away from the observer. And in this case, the car will reach the point x in 2hrs if the speed and distance are kept the same

The proportionality in the TSD equation:

1. $s \propto d$ if time is constant.
2. $t \propto d$ if speed is constant.
3. $s \propto 1/t$ if the distance is constant.

1. $s \propto d$ if time is constant.

In the first proportionality, time should be constant in both motions, whether the two bodies are moving or two different journeys by the same car. After observing both the motions, if the time required is the same for both of them then, you can say that this is a constant time situation.

In time constant proportionality, if the speed increases then distance also increases in the same manner.

For example:

If train 1 starts from X and train 2 starts from Y and they start moving towards each other at the same time. They meet at a point somewhere in between.

Solution:

Let's say they start at 1 pm and meet at 3 pm.

So, here we can see that there are two motions and for these motions, the value of time is 2 hours.

Let say S_x and D_x be the speed and time respectively for train 1.

& S_y and D_y be the speed and time respectively for train 2.

In this case, the following ratio will be valid:

$$\frac{S_x}{D_x} = \frac{S_y}{D_y}$$

2. $t \propto d$ if speed is constant.

Example:

A car moves for 4 hours at a speed of 25 kmph and another car moves for 5 hours at the same speed. Find the ratio of distances covered by the two cars.

Solution:

Since the speed is constant, we can directly conclude that time \propto distance.

$$\text{Hence } \frac{T_a}{T_b} = \frac{D_a}{D_b}$$

Since the times of travel are 2 and 3 hours respectively, the ratio of distances covered is also 4/5.

3. $s \propto 1/t$ if distance is constant.

Example:

A man goes from Delhi to Karnal and Comes back. In this case distance for Delhi to Karnal and Karnal to Delhi is the same i.e distance is constant. Hence, the speed will be inversely proportional to the time.

If the distance is constant it is also a product constancy situation ($s \times t = \text{constant}$). Hence you can use any of the product constancy structures.

In this case, the following ratio will be valid;

$$\frac{S_a}{S_b} = \frac{T_b}{T_a}$$

Problem Based On Proportionality:

Problem 1:

Abhishek walks at $\frac{3}{4}$ th of his normal speed and he is 16 minutes late in reaching the office. Find his normal time of reaching office.

Solution:

Let $S_1 = s$ and $T_1 = t$ be its normal speed and time respectively.

And $S_2 = \frac{3}{4}s$ and $T_2 = t+16$.

Here distance is the same i.e distance constancy situation.

Speed from ' s ' to $\frac{3}{4}s$ i.e. speed is reduced by $\frac{1}{4}$ th and time from ' t ' to $t+16$ i.e. time would be increased by $\frac{1}{3}$ rd as speed is reduced by $\frac{1}{4}$.

($s \times t = \text{constant}$, is ' s ' reduced by $\frac{1}{4}$ then ' t ' increased by $\frac{1}{3}$)

time from ' t ' to $t+16$ i.e. time is increased by $\frac{1}{3}$ rd means $\frac{1}{3}$ rd of normal time ' t ' = 16 min

Therefore, Normal time = $16 \times 3 = 48$ min.

2nd method:

We know ratio;

$$\frac{S_1}{S_2} = \frac{T_2}{T_1}$$

$$T_1 = \frac{S_1}{S_2} \times T_2$$

$$t = \frac{3}{4} \times (t+16)$$

Therefore, the normal time ' t ' = 48 min.

Problem 2:

Two people X and Y travelled the same distance at speeds of 6 kmph and 10 kmph respectively. If X takes 1 hour longer than Y then, what is the distance being travelled?

Solution:

Lets ' t ' be the time taken by Y. So, time taken by X is $t+1$.

Speed of X = 6 kmph and speed of Y = 10 kmph.

We can solve this problem by following methods:

Method 1:

Here given that;

Difference of time = 1

$$d/6 - d/10 = 1$$

$$10d - 6d = 60, d = 15 \text{ km.}$$

Therefore distance travelled = 15 km

Method 2:

Distance is constant so;

$$S_1 \times t_1 = S_2 \times t_2$$

$$6(t+1) = 10t$$

$$t = 3/2 \text{ hr}$$

$$\begin{aligned} \text{Therefore distance} &= \text{speed} \times \text{time} \\ &= 10 \times 3/2 = 15 \text{ km} \end{aligned}$$

Concept Of Relative Speed:

We already discussed the movement of a body with respect to a stationary point. And now, we need to determine the movement and its relationships with respect to a moving point/body. In such situations, we have to take into account the movement of the body w.r.t. which we are trying to determine relative motion.

"Relation motion of a body is the motion of one body/point with respect to other body/point"

Case 1: Two cars C1 & C2 are moving in opposite directions. C1 moving at S_1 kmph and C2 moving at S_2 kmph.

So, Relative speed $S = S_1 + S_2$.

Problem 1:

Two cars C1 & C2 are moving towards each other. C1 at 50 kmph and C2 at 30 kmph. The initial distance between them is 280 km. After how much time they will meet?

Solution:

$$S_1 = 50 \text{ kmph}$$

$$S_2 = 30 \text{ kmph}$$

The speed with which they are approaching $S = S_1 + S_2$

$$S = 50 + 30 = 80 \text{ kmph}$$

They have to approach each other and reach the meeting point.

So, approaching distance/Relative distance = 280 km

Hence, Relative Speed \times Time = Relative Distance

$$80 \times t = 280$$

$$t = 3.5 \text{ hours.}$$

Therefore; they will meet after 3.5 hours

Case 2: Two bodies are moving in the same direction.

So, the Relative Speed $S = S_1 - S_2$

Problem 1:

Two cars C1 & C2 are moving in the same direction at a speed 50 kmph and 30 kmph respectively from the same point and they start moving at 2 pm. After how many hours will C1 be 140 km ahead of C2?

Solution:

$$S_1 = 50 \text{ kmph}$$

$$S_2 = 30 \text{ kmph}$$

$$\text{The Relative Speed } S = S_1 - S_2$$

$$S = 50 - 30 = 20 \text{ kmph}$$

$$\text{Relative Distance} = 140 \text{ km}$$

$$\text{So, Relative Speed} \times \text{Time} = \text{Relative Distance}$$

$$20 \times t = 140$$

$$t = 7 \text{ hours.}$$

Therefore, after 7 hours C1 ahead 140 km of C2.

Problem 2:

Two cars C1 & C2 are moving in the same direction. Car C2 going at 30 kmph and C1 catching up at 50 kmph, starting distance between them is 120 km. In how many hours does C1 catch C2?

Solution:

$$S_1 = 50 \text{ kmph}$$

$$S_2 = 30 \text{ kmph}$$

$$\text{The Relative Speed } S = S_1 - S_2$$

$$S = 50 - 30 = 20 \text{ kmph}$$

$$\text{Relative Distance} = 120 \text{ km}$$

$$\text{So, Relative Speed} \times \text{Time} = \text{Relative Distance}$$

$$20 \times t = 120$$

$t = 6$ hours.

Therefore, in 7 hours C1 catches C2.

Question-Based On Relative Motion:

Type 1: Policeman and theft question

Problem 1:

The theft is committed at 2 A.M and the thief after committing the theft starts escaping at a speed of 80 kmph. The theft is discovered at 6 A.M and the policeman gives pursuit of the thief at 100 kmph. Find at what time the policeman will catch the thief?

Solution:

Speed of Thief = 80 kmph

Speed of policeman = 100 kmph

According to question,

Distance between thief and policeman after 4 hours (2 A.M to 6 A.M) = $80 \times 4 = 320$ km.

Speed at which policeman approaches thief = $100 - 80 = 20$ kmph

So, Relative Speed \times Time = Relative Distance

$$20 \times t = 320$$

$$t = 16 \text{ hours}$$

Therefore, police caught thief at 10 P.M (6 A.M + 16 hours = 10 P.M)

Problem 2:

At what distance from the original point did the thief get caught?

Solution:

To answer this question we have to find out the policeman's journey.

Speed of policeman = 100 kmph

Time taken by the policeman to catch the thief = 16 hours.

So, distance = $100 \times 16 = 1600$ km.

Type 2: Train question

Problem 1:

Two trains T1 and T2, T1 starting from point X to Y and T2 starting from point Y to X 2 hours later. T1 moving at 50 kmph and T2 at 30 kmph. Distance between point X and Y is 500 km. Find the distance from X, after which they will meet.

Solution:

Speed of T1 = 50 kmph

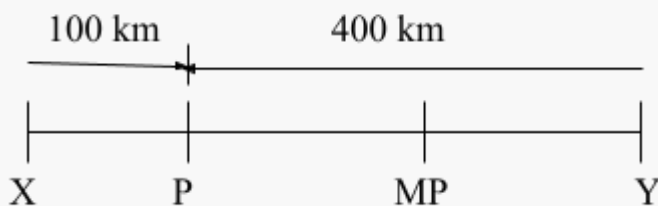
Speed of T2 = 30 kmph

Distance between X and Y = 500 km

Train T1 starts 2 hours before train T2.

Distance covered by T1 in 2 hours = $50 \times 2 = 100$ km

Let us say T1 reaches at point P in 2 hours.



Distance left from point P to Y = $500 - 100 = 400$ km

Speed at which they approaching = $50 + 30 = 80$ kmph

Approach required to get the meeting point (MP), the total distance they have to approach together = 400 km

So, Relative Speed \times Time = Relative Distance

$$80 \times t = 400$$

$$t = 5 \text{ hours}$$

So, distance from P to MP = $50 \times 5 = 250$ km

Therefore, they will meet 350 km ($100 + 250 = 350$) from point X.

Concept Of Circular Motion:

The movement of an object along a circle is called circular motion. When we talk about circular motion, there are 3 variables inside the questions. 1. Speed 2. Circumference 3. Time.

Units:

Speed: m/sec, kmph or it can also be measured in %/sec, %/min and %/hr.

Circumference: meter, km or % (if circle as 100%)

Problem 1:

Three people A, B, and C running around a circle, whose circumference is 100 km. Speed of A is 20 kmph and the speed of B is 15 kmph and speed of C is 12 kmph.

- After how much time they will meet at the starting point.
- How many rounds were done by A?
- The time required for the first meeting at any point.

Solution:

Speed of A = 20 kmph

Speed of B = 15 kmph

Speed of C = 12 kmph

Circumference = 100 km

(a) Let T_a , T_b and T_c be the time taken by A, B and C respectively to cover the circle.

So, $T_a = 100/20 = 5$ hours

$T_b = 100/15 = 20/3$ hours

$T_c = 100/12 = 25/3$ hours

Time required to meet at starting point = $\text{LCM}(T_a, T_b, T_c)$

We know, LCM of fraction = LCM of numerator / HCF of denominator

= $\text{LCM}(5, 20/3, 25/3) = 100/1 = 100$ hours

Hence, they meet at the starting point after 100 hours.

(b) A done one round in 5 hours.

So, In 100 hours A done = $100/5 = 20$ rounds.

(c) A is fastest, A would be overlapping each of B & C after some time.

Let T_{ab} and T_{ac} be the time in which A overlap B and C respectively.

The time required for the first meeting at any point = $\text{LCM}(T_{ab}, T_{ac})$

Relative speed between A and B ' S_{ab} ' = $20 - 15 = 5$ kmph

Relative speed between A and C ' S_{ac} ' = $20 - 12 = 8$ kmph

So, $T_{ab} = 100/5 = 20$ hours and $T_{ac} = 100/8 = 12.5$ hours.

$\text{LCM}(20, 25/2) = 100$ hours

Hence, they will meet at any point after 100 hours.
