Chapter 6

SPEED, TIME AND DISTANCE

You have already solved simple problems on speed, distance and time in the previous class. In this chapter, we shall develop those ideas a little further. We shall also take up problems on relative speed and average speed.

***Speed** of an object is the distance covered by it in a unit time.*

For example :

(*i*) If a car covers a distance of 195 km in 3 hours, its speed is $\frac{195\,\text{km}}{3\,\text{hour}}$ *i.e.* 65 km per hour. It is written as 65 km/hr.

(*ii*) If an aeroplane covers an aerial distance of 1750 km in $2\frac{1}{2}$ hours,

its speed = $\frac{1750}{\frac{5}{2}}$ km/hr = $\left(1750 \times \frac{2}{5}\right)$ km/hr = 700 km/hr.

(*iii*) If an athelete covers a distance of 750 metres in 1 minute 40 seconds *i.e.* in 100 seconds, then his

speed = $\frac{750}{100}$ metres per second = 7·5 m/sec.

Thus, $\boxed{\textbf{\textit{speed}} = \frac{\textbf{\textit{distance}}}{\textbf{\textit{time}}}}$

From this formula, we get

$$\textbf{\textit{distance}} = \textbf{\textit{speed}} \times \textbf{\textit{time}}$$
$$\textbf{\textit{time}} = \frac{\textbf{\textit{distance}}}{\textbf{\textit{speed}}}$$

Speed is usually given in km/hr (kilometres per hour) or m/sec (metres per second). Note that unit of measuring must be mentioned.

CONVERSION OF UNITS OF SPEED

To convert km/hr to m/sec, note that

$$1\ \text{km/hr} = \frac{1\ \text{km}}{1\ \text{hour}} = \frac{1000\ \text{metres}}{(60 \times 60)\ \text{seconds}} = \frac{5}{18}\ \text{m/sec.}$$

Hence, to convert km/hr into m/sec, multiply by $\frac{5}{18}$.

To convert m/sec to km/hr, note that

$$1\ \text{m/sec} = \frac{1\ \text{m}}{1\ \text{sec}} = \frac{\frac{1}{1000}\ \text{km}}{\frac{1}{60 \times 60}\ \text{hour}} = \frac{3600}{1000}\ \text{km/hr} = \frac{18}{5}\ \text{km/hr.}$$

Hence, to convert m/sec into km/hr, multiply by $\frac{18}{5}$.

Uniform speed, variable speed

If an object covers equal distances in equal intervals of time, its speed is said to be ***uniform*** *(or* ***constant****); otherwise, its speed is said to be* ***variable****.*

The above formulae connecting speed, distance and time are based on the assumption that the speed is uniform.

Average speed

Most of the time, a vehicle does not cover the entire distance at a uniform speed. It picks up speed, then covers some distance and then reduces speed to come to halt. In such a case, we calculate the total distance travelled and divide it by the total time taken to get average speed.

$$\textbf{\textit{Average speed}} = \frac{\textit{total distance travelled}}{\textit{total time taken}}$$

!! Remark

- To pass a fixed object (post, pole or man etc.), a train has to cover a distance = length of the train.
- To pass a bridge (tunnel or platform), a train has to cover a distance = length of the train + length of bridge (tunnel or platform).
- If one train passes another train (in the same direction or in the opposite direction), the distance covered = sum of lengths of both the trains.

Example 1. A cyclist covers 600 metres in 5 minutes.

(*i*) Calculate his speed in m/sec as well as in km/hr.

(*ii*) How much distance will he travel in $1\frac{1}{2}$ hours?

(*iii*) How much time will he require to cover 1·8 km?

Solution. (*i*) Distance covered = 600 metres,

time taken = 5 minutes = (5 × 60) seconds = 300 seconds

$$\therefore \quad \text{speed} = \frac{\text{distance}}{\text{speed}} = \frac{600 \text{ m}}{300 \text{ sec}} = 2 \text{ m/sec}$$

$$\text{In km/hr, speed} = \left(2 \times \frac{18}{5}\right) \text{ km/hr} = 7{\cdot}2 \text{ km/hr.}$$

(*ii*) Distance covered in $1\frac{1}{2}$ hours = speed × time

= (7·2 km/hr) × 1·5 hours = 10·8 km.

(*iii*) Time required to cover 1·8 km

$$= \frac{\text{distance}}{\text{speed}} = \frac{1{\cdot}8 \text{ km}}{7{\cdot}2 \text{ km/hr}} = \frac{18}{72} \text{ hr} = \frac{1}{4} \text{hr} = 15 \text{ minutes.}$$

Example 2. A car completes a journey of 360 km in $5\frac{3}{4}$ hours. If it covers the first three-fourth of the journey at 60 km/hr, find the speed of the car for the rest of the journey.

Solution. Total distance of the journey = 360 km

Distance of three-fourth of the journey = $\left(\frac{3}{4} \times 360\right)$ km = 270 km

Time taken to cover this part of journey = $\frac{\text{distance}}{\text{speed}} = \frac{270 \text{ km}}{60 \text{ km/hr}}$

$= \frac{9}{2}$ hours $= 4\frac{1}{2}$ hours

Remaining distance of the journey = (360 – 270) km = 90 km

Remaining time = $\left(5\frac{3}{4} - 4\frac{1}{2}\right)$ hours = $\left(\frac{23}{4} - \frac{9}{2}\right)$ hours

$= \frac{23-18}{4}$ hours $= \frac{5}{4}$ hours

$\therefore$ Speed during the rest of journey

$= \frac{\text{distance}}{\text{speed}} = \frac{90 \text{ km}}{\frac{5}{4} \text{ hours}} = \left(90 \times \frac{4}{5}\right)$ km/hr

= 72 km/hr.

Example 3. A car covers a certain distance in 4 hours if it is travelling at a speed of 60 km/hr. How much time would it have taken if it were travelling 20 km/hr faster?

Solution. Travelling 20 km/hr faster means travelling at a speed of 60 + 20 *i.e.* 80 km/hr.

First we find the distance.

As the car covers the distance in 4 hours at a speed of 60 km/hr,

$\therefore$ distance = speed × time = (60 km/hr) × 4 hours = 240 km

If the speed is 80 km/hr, then

time taken = $\frac{\text{distance}}{\text{speed}} = \frac{240 \text{ km}}{80 \text{ km/hr}}$ = 3 hours.

Alternatively, using multiplying ratio method

As the speed increases, the time to cover the same distance decreases. So, we have inverse variation.

Since the speed increases in the ratio 60 km/hr : 80 km/hr

i.e. in the ratio 3 : 4, the time decreases in the ratio 4 : 3

Therefore, multiplying 4 hours by the ratio $\frac{3}{4}$,

the required time = $\frac{3}{4}$ of 4 hours = $\left(\frac{3}{4} \times 4\right)$ hours = 3 hours.

Example 4. A bus covers first 100 km in $2\frac{1}{2}$ hours and then travels at a speed of 60 km/hr for $1\frac{1}{2}$ hours. Find the average speed of the bus for the whole journey.

Solution. First 100 km is covered in $2\frac{1}{2}$ hours.

Then the bus travels for $1\frac{1}{2}$ hours at 60 km/hr

Distance covered during these $1\frac{1}{2}$ hours = speed × time

= (60 km/hr) × $\frac{3}{2}$ hours = 90 km

$\therefore$ Total distance travelled = 100 km + 90 km = 190 km

Total time taken = $2\frac{1}{2}$ hours + $1\frac{1}{2}$ hours = 4 hours

$\therefore$ Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}} = \frac{190 \text{ km}}{4 \text{ hours}}$ = 47·5 km/hr.

Example 5. A man covers first 112 km of his journey at 56 km/hr, next 105 km at 70 km/hr and the last 68 km in one hour. Find

(*i*) the total time taken to complete the journey.

(*ii*) his average speed during the whole journey.

Solution. (*i*) Time taken to cover first 112 km = $\frac{\text{distance}}{\text{speed}} = \frac{112 \text{ km}}{56 \text{ km/hr}}$ = 2 hours

Time taken to cover next 105 km = $\frac{\text{distance}}{\text{speed}} = \frac{105 \text{ km}}{70 \text{ km/hr}} = \frac{3}{2}$ hours

Time taken to cover last 68 km = 1 hour

$\therefore$ Total time taken for the whole journey

= 2 hours + $\frac{3}{2}$ hours + 1 hour = $4\frac{1}{2}$ hours.

(*ii*) Total distance travelled = 112 km + 105 km + 68 km = 285 km

$\therefore$ Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}} = \frac{285 \text{ km}}{\frac{9}{2} \text{ hours}}$

$= \left(285 \times \frac{2}{9}\right)$ km/hr = $\frac{190}{3}$ km/hr = $63\frac{1}{3}$ km/hr.

Example 6. If Arvind cycles at 10 km/hr, he reaches the school late by 4 minutes; if he cycles at 12 km/hr, he reaches the school early by 2 minutes. Find the distance of the school from his home.

Solution. Let the distance of the school from his home be x km.

At the speed of 10 km/hr,

the time taken to reach the school = $\frac{x}{10}$ hours

At the speed of 12 km/hr,

the time taken to reach the school = $\frac{x}{12}$ hours

Difference in time taken = $\left(\frac{x}{10} - \frac{x}{12}\right)$ hours = $\left(\frac{1}{10} - \frac{1}{12}\right) x$ hours

$= \frac{6-5}{60} x$ hours = $\frac{x}{60}$ hours

Given, difference in time taken = (4 + 2) minutes

= 6 minutes = $\frac{1}{10}$ hours

$\therefore \quad \frac{x}{60} = \frac{1}{10} \quad \Rightarrow \quad x = 6$

Hence, the distance of the school from his home = 6 km.

Example 7. A horse can walk at a speed of 9 km/hr and can trot at a speed of 15 km/hr. It covered a distance of 11 km in an hour, partly by walking and partly by trotting. Find for how much time it walked and to how much distance.

Solution. Total distance covered in one hour is 11 km.

Suppose the horse walked for x km, then it trotted for $(11 - x)$ km

As the walking speed is 9 km/hr, the time taken to cover x km

$$= \frac{\text{distance}}{\text{speed}} = \frac{x \text{ km}}{9 \text{ km/hr}} = \frac{x}{9} \text{ hours}$$

As the trotting speed is 15 km/hr, the time taken to cover $(11 - x)$ km

$$= \frac{\text{distance}}{\text{speed}} = \frac{(11 - x) \text{ km}}{15 \text{ km/hr}} = \frac{11 - x}{15} \text{ hours}$$

$$\therefore \quad \text{Total time taken} = \left(\frac{x}{9} + \frac{11 - x}{15}\right) \text{ hours}$$

As the total time taken is 1 hour,

$$\therefore \quad \frac{x}{9} + \frac{11 - x}{15} = 1 \qquad \text{(Multiply by 45, L.C.M. of 9 and 15)}$$

$$\Rightarrow \quad 5x + 3(11 - x) = 45 \quad \Rightarrow \quad 5x + 33 - 3x = 45$$

$$\Rightarrow \quad 2x = 45 - 33 \Rightarrow 2x = 12 \quad \Rightarrow \quad x = 6$$

Thus, the horse walked for 6 km and trotted for 5 km.

$$\text{Time taken for walking 6 km} = \frac{\text{distance}}{\text{speed}} = \frac{6 \text{ km}}{9 \text{ km/hr}}$$

$$= \frac{2}{3} \text{ hours} = \left(\frac{2}{3} \times 60\right) \text{ minutes}$$

$$= 40 \text{ minutes}$$

Hence, the horse covered 6 km by walking in 40 minutes.

Example 8. A train 300 m long is running at a steady speed of 72 km/hr. Find

(*i*) the time taken by it to cross a signal.

(*ii*) the time taken by it to cross a bridge 450 m long.

Solution. Speed of the train = 72 km/hr $= \left(72 \times \frac{5}{18}\right)$ m/sec = 20 m/sec

(*i*) Time taken by the train to cross a signal

$$= \text{time taken by it to cover 300 m} = \frac{300 \text{ m}}{20 \text{ m/sec}} = 15 \text{ sec.}$$

(*ii*) Distance covered by the train in crossing the bridge

= length of train + length of bridge

= 300 m + 450 m = 750 m

$\therefore$ Time taken by the train to cross the bridge

$$= \frac{750 \text{ m}}{20 \text{ m/sec}} = 37{\cdot}5 \text{ sec.}$$

Example 9. A train 320 m long is travelling at a uniform speed of 66 km/hr. If it passes a platform in 42 seconds, find the length of the platform.

Solution. Speed of the train = 66 km/hr $= \left(66 \times \frac{5}{18}\right)$ m/sec $= \frac{55}{3}$ m/sec

Distance covered by the train in 42 seconds $= \left(\frac{55}{3} \text{ m/sec}\right) \times 42 \text{ sec} = 770 \text{ m}$

$\therefore$ Length of the train + length of platform = 770 m

$\Rightarrow$ length of platform = 770 m – 320 m = 450 m.

Example 10. A train travelling at 60 km/hr passes through a tunnel 850 m long. Find how long a passenger travelling by the train remains inside the tunnel.

Solution. Speed of the train = 60 km/hr = $\left(60 \times \frac{5}{18}\right)$ m/sec = $\frac{50}{3}$ m/sec

The passenger remains inside the tunnel till the train covers the distance equal to the length of the tunnel *i.e.* 850 m.

$\therefore$ The time for which the passenger remains inside the tunnel

$$= \frac{850 \text{ m}}{\frac{50}{3} \text{ m/sec}} = \left(850 \times \frac{3}{50}\right) \text{ sec} = 51 \text{ sec.}$$

Example 11. A train passes a platform 330 m long in 40 seconds and a man standing on the platform in 18 seconds. Find

(*i*) the speed of the train in km/hr.

(*ii*) the length of the train.

Solution. (*i*) In 40 seconds, distance covered by train = length of train + 330 m

In 18 seconds, distance covered by train = length of train

$\therefore$ In 22 seconds, distance covered by train = 330 m

$\therefore$ The speed of the train = $\frac{330 \text{ m}}{22 \text{ sec}}$ = 15 m/sec

$$= \left(15 \times \frac{18}{5}\right) \text{ km/hr} = 54 \text{ km/hr.}$$

(*ii*) Length of the train = distance covered by it in 18 seconds

= (15 m/sec) × 18 sec = 270 m.

Example 12. A train running at a uniform speed passes a station 450 m long in 27 seconds and another station 330 m long in 21 seconds. Find

(*i*) the speed of the train in km/hr.

(*ii*) the length of the train.

Solution. (*i*) In 27 seconds, distance covered by the train = length of train + 450 m

In 21 seconds, distance covered by the train = length of train + 330 m

$\therefore$ In 6 seconds, distance covered by the train = 120 m

$\therefore$ The speed of the train = $\frac{120 \text{ m}}{6 \text{ sec}}$ = 20 m/sec

$$= \left(20 \times \frac{18}{5}\right) \text{ km/hr} = 72 \text{ km/hr.}$$

(*ii*) Distance covered by the train in 21 seconds

= (20 m/sec) × 21 sec = 420 m

$\therefore$ length of train + 330 m = 420 m

$\Rightarrow$ length of train = 420 m − 330 m = 90 m.

Exercise 6.1

1. A car is travelling at a speed of 36 km/hr. How much distance will it travel in 45 minutes?
2. A bullock cart is moving at a speed of 6 km/hr. How much time will it take to cover a distance of 20 kilometres?
3. A cat runs at a speed of 100 metres in a minute. Find its speed in km/hr.
4. Convert the following speeds to m/sec :
   (*i*) 45 km/hr (*ii*) 540 km/hr (*iii*) 4·5 km/hr
   (*iv*) 2·4 km/minute (*v*) 450 m/hr (*vi*) 75 m/minute
5. Convert the following speeds to km/hr :
   (*i*) 20 m/sec (*ii*) 1·5 m/sec (*iii*) 15 m/minute
6. A man leaves home at 7·45 a.m. and cycles to work $6\frac{1}{4}$ km away. He arrives at work at 8·10 a.m. What is his average speed?
7. A train covers first 200 km in $3\frac{1}{2}$ hours and next 100 km in $1\frac{1}{2}$ hours. Find its average speed.
8. A cyclist travels at 10 km/hr for 2 hours and at 13 km/hr for 1 hour. Find his average speed.
9. A bus covers 160 km at a speed of 40 km/hr and the next 120 km at a speed of 60 km/hr. Find its average speed.
10. A car travels 5 kilometres up a hill at 10 km/hr and back down at 20 km/hr. What is the average speed for the entire trip?
11. A car completes a journey of 270 km in 3 hours 45 minutes. The first one-third of the journey was completed at 60 km/hr. Calculate the speed for the rest of the journey.
12. A man walking at the rate of 5 km/hr covers a certain distance in $2\frac{1}{4}$ hours. How much time will he take to cover the same distance if he cycles at 15 km/hr?
13. A car completes a certain journey in 6 hours at a speed of 50 km/hr. By how much the speed of the car must be increased to cover the same distance in $4\frac{1}{2}$ hours?
14. A rabbit can run at 5 m/sec and a monkey can run at 5 km/hr. If they start a race, who will be ahead after half an hour and by how much distance?
15. I walked at 4 km/hr and missed the bus by 3 minutes. However, if I walk at 5 km/hr, I reach the bus stand 3 minutes early. How far is the bus stand from my home?
16. A cyclist covered a certain distance in $3\frac{1}{2}$ hours. If the speed for the first half of the distance was 20 km/hr and for the second half was 15 km/hr, find the total distance covered by him.

   [Hint. Let the total distance covered be $2d$ km. Then $\frac{d}{20} + \frac{d}{15} = \frac{7}{2}$.]
17. A thief walks at a speed of 4 km/hr and can run at a speed of 5 m/sec. He walked for some time before he saw a policeman and ran way. If he covered a total distance of 2·5 km in 20 minutes, find out how much distance had he walked and in how much time before he saw the policeman.
18. A train 200 m long is travelling at 72 km/hr. How long will it take
   (*i*) to go past a man standing on the platform?
   (*ii*) to go past the platform 400 m long?

19. A train 240 m long passes an electric pole in 16 seconds. Find

(*i*) the speed of the train in km/hr.

(*ii*) the time taken by it to cross a platform 180 m long.

20. A train passes through a tunnel 750 m long. The guard finds that he remains in the tunnel for 67·5 seconds. Calculate the speed of the train in km/hr.

21. With a speed of 48 km/hr, a train crosses a signal in 21 seconds. Find the length of the train.

22. A train 360 m long is travelling at 54 km/hr. If it crosses a bridge in one minute, find the length of the bridge.

23. A train passes a station 270 m long in 32 seconds and a man standing on the station in 14 seconds. Find

(*i*) the speed of the train in km/hr. (*ii*) the length of the train.

24. A train running at uniform speed passes a bridge 300 m long in 15 seconds and another bridge 450 m in 21 seconds. Find

(*i*) the speed of the train in km/hr. (*ii*) the length of the train.

Module 2

RELATIVE SPEED

where & how to use?

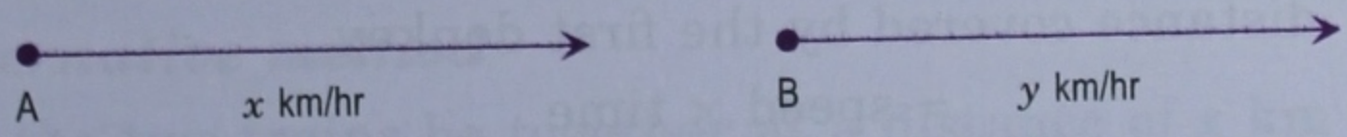
You have already solved some problems on relative speed. Surprised?

If a rabbit runs at 18 km/hr and a monkey at 5 km/hr, you calculated that after half an hour, the rabbit will be ahead by 6·5 km. Probably you found that the distance travelled by rabbit in half an hour is 9 km and the distance travelled by monkey in half an hour is 2·5 km, so rabbit is ahead by 6·5 km. An easier method to solve this problem is to use the idea of relative speed. Lagwale introduce the idea of relative speed?

Relative speed *means the speed of one object with respect to another.*

(i) If two objects are moving in the same direction, then relative speed = difference of speeds.

If two objects A and B are moving in the same direction with speeds x km/hr and y km/hr respectively ($x > y$), then



(objects moving in the same direction)

relative speed = $(x - y)$ km/hr.

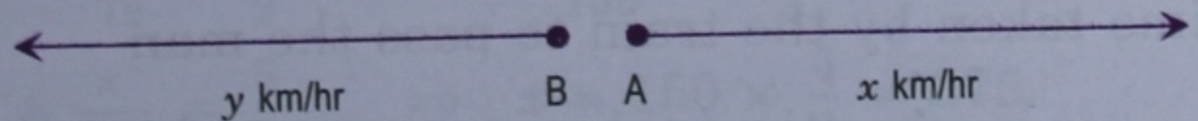
For example, in the above question,

relative speed = 18 km/hr – 5 km/hr = 13 km/hr

So after half an hour, rabbit will be (13 km/hr) $\times \frac{1}{2}$ hour *i.e.* 6·5 km ahead.

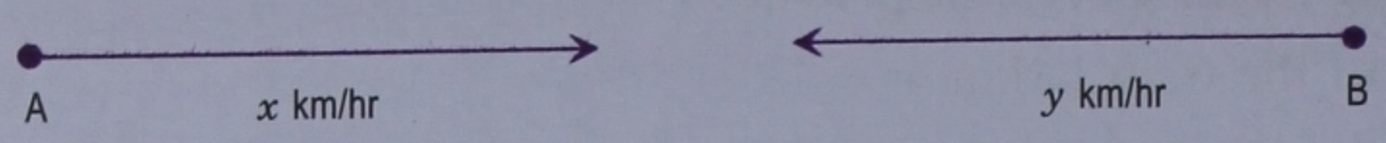
(ii) If two objects are moving in the opposite directions, then relative speed = sum of speeds.

If two objects A and B are moving in the opposite direction with speeds x km/hr and y km/hr respectively, then



(objects moving away from each other)

Or



(objects moving towards each other)

relative speed = $(x + y)$ km/hr.

If the speed of a boat in still water is x km/hr and the speed of the stream is y km/hr, then

speed of the boat downstream = $(x + y)$ km/hr and

speed of the boat upstream = $(x - y)$ km/hr.

Example 1. Two donkeys are standing 400 metres apart. First donkey can run at a speed of 3 m/sec and second can run at 2 m/sec.

(*i*) If first donkey starts running towards second, but at the same time the second donkey starts to run away, after how much time will the first donkey catch up with the second?

(*ii*) If the two donkeys run towards each other, after how much time will they bump into each other? Also find the distance covered by the first donkey when they bump into each other.

Solution. (*i*) In this case, both donkeys are running in the same direction.

Relative speed = 3 m/sec – 2 m/sec = 1 m/sec

$\therefore$ Time taken to cover 400 metres $= \frac{400 \text{ m}}{1 \text{ m/sec}} = 400$ sec

= 6 minutes 40 seconds

Hence, the first donkey will catch up with second donkey in 6 minutes 40 seconds.

(*ii*) The two donkeys are running in the opposite directions.

Relative speed = 3 m/sec + 2 m/sec = 5 m/sec

$\therefore$ Time taken to cover 400 metres $= \frac{400 \text{ m}}{5 \text{ m/sec}} = 80$ seconds

= 1 minute 20 seconds

Hence, the two donkeys will bump into each other in 1 minute 20 seconds.

As the two donkeys bump into each other after 80 seconds, the distance covered by the first donkey

= speed × time

= (3 m/see) × 80 sec = (3 × 80) m = 240 m.

Example 2. A train 210 m long is running at a speed of 54 km/hr and a man on the ground is running at a speed of 9 km/hr. How long will the train take to pass the man if they are running

(*i*) in the same direction

(*ii*) in the opposite directions?

Solution. (*i*) When the train and the man are running in the same direction,

relative speed = (54 – 9) km/hr $= \left(45 \times \frac{5}{18}\right)$ m/sec $= \frac{25}{2}$ m/sec.

Time taken by the train to pass the man

= time taken to cover 210 m at the speed of $\frac{25}{2}$ m/sec

$$= \frac{210}{\frac{25}{2}} \text{ sec} = \left(210 \times \frac{2}{25}\right) \text{ sec}$$

$$= \frac{84}{5} \text{ sec} = 16{\cdot}8 \text{ sec.}$$

(*ii*) When the train and the man are running in opposite directions,

relative speed = (54 + 9) km/hr = $\left(63 \times \frac{5}{18}\right)$ m/sec = $\frac{35}{2}$ m/sec.

Time taken by the train to pass the man

= time taken to cover 210 m at the speed of $\frac{35}{2}$ m/sec

$$= \frac{210}{\frac{35}{2}} \text{ sec} = \left(210 \times \frac{2}{35}\right) \text{ sec} = 12 \text{ sec.}$$

Example 3. A train travelling at the speed of 50 km/hr leaves Lucknow at 9 a.m. and another train travelling at the speed of 75 km/hr leaves Lucknow at 11·30 a.m. in the same direction. Find the distance from Lucknow when the two trains are together.

Solution. Difference between the times of start of the two trains

= 11·30 a.m. – 9 a.m. = 2 hours 30 minutes = $\frac{5}{2}$ hours

Distance covered by the first train just before the start of the second train

= (50 km/hr) × $\frac{5}{2}$ hours = 125 km.

The distance gained by the second train over the first train (75 – 50) km per hour

= 25 km per hour.

∴ The second train will gain 125 km over the first train in $\frac{125}{25}$ hours

= 5 hours

∴ The required distance from Lucknow = (75 km/hr) × 5 hours

= 375 km.

Alternative method

Let the two trains be together at a distance of x km from Lucknow.

Time taken by the first train to cover x km = $\frac{x}{50}$ hours.

Time taken by the second train to cover x km = $\frac{x}{75}$ hours.

Difference between the times of start of the two trains

= 11·30 a.m. – 9 a.m. = 2 hours 30 minutes = $\frac{5}{2}$ hours.

$\Rightarrow$ the difference between the times of the two trains to cover x km = $\frac{5}{2}$ hours

$\Rightarrow \frac{x}{50} - \frac{x}{75} = \frac{5}{2} \quad \Rightarrow \frac{3x-2x}{150} = \frac{5}{2}$

$\Rightarrow \frac{x}{150} = \frac{5}{2} \quad \Rightarrow x = 150 \times \frac{5}{2} = 375.$

Hence, the required distance from Lucknow = 375 km.

Example 4. Two trains of lengths 280 m and 210 m are travelling at the speeds of 72 km/hr and 54 km/hr respectively on parallel tracks. How long will it take to pass each other if they travel in

(*i*) the same direction (*ii*) the opposite directions?

Solution. To pass each other, distance covered = sum of lengths of both trains

$= (280 + 210)$ m $= 490$ m

(*i*) When the trains are travelling in the same direction,

relative speed $= (72 - 54)$ km/hr $= 18$ km/hr

$= \left(18 \times \frac{5}{18}\right)$ m/sec $= 5$ m/sec

Time taken by the trains to pass each other

= time taken to cover 490 m at the speed of 5 m/sec

$= \frac{490}{5}$ sec $= 98$ sec $= 1$ minute 38 seconds.

(*ii*) When the trains are travelling in the opposite directions,

relative speed $= (72 + 54)$ km/hr $= 126$ km/hr

$= \left(126 \times \frac{5}{18}\right)$ m/sec $= 35$ m/sec

Time taken by the trains to pass each other

= time taken to cover 490 m at the speed of 35 m/sec

$= \frac{490}{35}$ sec $= 14$ sec.

Example 5. The speed of a boat in still water is 7 km/hr and the speed of a stream is 3 km/hr. Find the time taken by the boat to go :

(*i*) 12 km upstream (*ii*) 35 km downstream.

Solution. (*i*) The speed of the boat upstream $= (7 - 3)$ km/hr $= 4$ km/hr

$\therefore$ Time taken by the boat to go 12 km upstream

$= \frac{12}{4}$ hr $= 3$ hours.

(*ii*) The speed of the boat downstream $= (7 + 3)$ km/hr $= 10$ km/hr

$\therefore$ Time taken by the boat to go 35 km downstream

$= \frac{35}{10}$ hours $= \frac{7}{2}$ hours $= 3$ hours 30 minutes.

Example 6. The speed of a boat in still water is 8 km/hr. If the boat covers a distance of 16·5 km upstream in 3 hours, find the speed of the current.

Solution. Speed of boat upstream $= \frac{\text{distance}}{\text{speed}} = \frac{16{\cdot}5 \text{ km}}{3 \text{ hours}} = 5{\cdot}5$ km/hr

But speed of boat upstream

= speed of boat in still water – speed of the current

$\therefore$ speed of the current

= speed of boat in still water – speed of boat upstream

= 8 km/hr – 5·5 km/hr = 2·5 km/hr.

Exercise 6.2

1. Liza and Tanya leave the same camp and run in opposite directions. Liza runs at 2 m/sec and Tanya at 3 m/sec. How far apart are they after one hour?
2. Two cars are 635 km apart. They start at the same time and drive towards each other. One travels at 70 km/hr and the other travels at 57 km/hr. In how many hours do they meet?
3. A train travelling at 45 km/hr leaves Kolkata at 7 p.m. and another train travelling at the speed of 60 km/hr leaves Kolkata at 9 p.m. in the same direction. Find the distance from Kolkata when the two trains are together.
4. In how much time will a train 180 m long, running at 67 km/hr pass a cyclist, cycling at 13 km/hr in the direction of the train?
5. In how much time will a train 210 m long, travelling at 64 km/hr pass a man, running at 8 km/hr in the direction opposite to that of the train?
6. One train is 200 m long and is travelling at a speed of 40 km/hr. Another train is 300 m long and is travelling at a speed of 60 km/hr. How much time will they take to go past each other completely if
   (*i*) they are running in opposite directions (on parallel tracks)?
   (*ii*) they are running in same direction (on parallel tracks)?
7. A man can swim at 6 km/ hr in still water. The speed of a stream is 2 km/hr. How much time will the man take to swim 400 m if
   (*i*) he is swimming with the stream?
   (*ii*) he is swimming against the stream?
8. A boat can be rowed with the stream at 15 km/hr and against the stream at 12 km/hr. What is the speed of the stream?
9. The speed of a boat in still water is 6 km/hr. If the boat covers a distance of 22·5 km downstream in 3 hours, find the speed of the current.
10. A stream is flowing at 2 km/hr. If a boat covers 21 km upstream in 2 hours, find the speed of the boat in still water.
11. A stream is flowing at 3 km/hr. A boat with a speed of 9 km/hr is rowed downstream for $3\frac{1}{2}$ hours. Find the distance covered. How long will it take to return to the starting point?

Summary

- Speed of an object is the distance covered by it in a unit time.
- Speed = $\frac{\text{distance}}{\text{speed}}$, time = $\frac{\text{distance}}{\text{speed}}$ and distance = speed × time.
- Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}}$
- To convert units of speed :
  - 1 km/hr = $\frac{5}{18}$ m/sec
  - 1 m/sec = $\frac{18}{5}$ km/hr
- To solve problems on trains, remember that :
  - To pass a fixed object (post, pole or man etc.), a train has to cover a distance = length of the train.

- ❑ To pass a bridge (tunnel or platform), a train has to cover a distance = length of train + length of bridge (tunnel or platform).
- ❑ If one train passes another train (in the same direction or in the opposite direction), the distance covered = sum of lengths of both the trains.

➥ Relative speed means the speed of one object with respect to another.

➥ If two objects are moving in the same direction, then

relative speed = difference of speeds.

➥ If two objects are moving in the opposite directions, then

relative speed = sum of speeds.

➥ If the speed of a boat (or swimmer) in still water is x km/hr and the speed of the stream is y km/hr, then

speed of the boat downstream $= (x + y)$ km/hr and

speed of the boat upstream $= (x - y)$ km/hr.

Check Your Progress

1. Which is greater : a speed of 25 m/sec or 25 km/hr?
2. A car covered the first half of the journey at a speed of 50 km/hr and then covered the remaining 150 km in 2 hours. Find its average speed.
3. Two cars travel to a place at 60 km/hr and 70 km/hr respectively. If the first car takes $1\frac{1}{2}$ hours more than the second for the same journey, find the length of the journey.
4. A bus completed a journey in $3\frac{1}{2}$ hours. First one-third of the journey was covered at 40 km/hr and the rest at 60 km/hr. Find the length of the journey.
5. The distance between Delhi and Jalandhar is 325 km. One train leaves Delhi for Jalandhar at a speed of 70 km/hr and another train leaves Jalandhar for Delhi at a speed of 60 km/hr (trains are running on parallel tracks). If both trains start simultaneously at 10·30 a.m., find when and where will they meet.

   [Hint. Let the two trains meet after x hours, then $70x + 60x = 325$.**]**
6. At a movie set, a horse gallops away with heroine at a speed of 60 km/hr for some time before the hero jumps on its back from a tree and brings the horse to a comfortable trot of 12 km/hr. If in total 26 minutes, the horse covered a distance of 10 km, calculate for how much distance and time the horse galloped and trotted.
7. A car is travelling at a speed of 81 km/hr. If it crosses a bridge in 18 seconds, find the length of the bridge. (You can ignore the length of the car.)
8. A train travelling at 54 km/hr crosses a signal in 14 seconds. How long will it take to cross a station 330 m long?
9. A train running at 63 km/hr crosses an electric pole in 12 seconds and a bridge in 30 seconds. Find:

   (*i*) the length of the train (*ii*) the length of the bridge.
10. A train 200 m long, travelling at 72 km/hr, overtakes another train travelling at 54 km/hr and passes it completely in 90 seconds. Find the length of the second train.
11. A monkey and an ass went for a race. The monkey ran at a speed of 6 km/hr but the ass started running backwards at a speed of 1 m/sec. Determine the distance between them after 5 minutes.
12. A train 100 m long meets a man going in the opposite direction at the rate of 5 km/hr and passes him in 7·2 seconds. At what rate is the train going?