13 SPEED, DISTANCE, AND TIME

- Speed, Distance, and Time
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Speed, Distance, and Time

Let us recall the formulae used to calculate speed, distance, and time.

1. $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$

   If distance is constant, speed is inversely proportional to time, or if the distance to be covered is the same, the time taken will be inversely proportional to the speed. The more the speed, the less will be the time taken.

2. Distance = Speed × Time

   If speed is constant, distance covered is directly proportional to the time taken, or if the same speed is maintained, the distance covered will be directly proportional to the time period. The more the time, the more will be the distance covered.

   If time is constant, distance covered is directly proportional to the speed, or in the same time period, the distance covered will be directly proportional to the speed. The more the speed, the more will be the distance covered.

3. $\text{Time} = \dfrac{\text{Distance}}{\text{Speed}}$

   If speed is constant, time is directly proportional to distance. The more the distance covered, the more will be the time taken. If distance is constant, time is inversely proportional to speed.

Example 1: Express 9.9 km/h in m/s and 6.3 m/s in km/h.

$$1 \text{ km} = 1000 \text{ m}$$

or $$1000 \text{ m} = 1 \text{ km} \Rightarrow 1 \text{ m} = \frac{1}{1000} \text{ km}$$

$$1 \text{ h} = 60 \text{ minutes} = 60 \times 60 \text{ seconds} = 3600 \text{ seconds}$$

or $$3600 \text{ s} = 1 \text{ h}$$

$$1 \text{ s} = \frac{1}{3600} \text{ h}$$

$$1 \text{ km/h} = \frac{1000 \text{ m}}{3600 \text{ s}} = \frac{5}{18} \text{ m/s}$$

Conversely, $1 \text{ m/s} = \dfrac{18}{5}$ km/h

$$9.9 \text{ km/h} = 9.9 \times \frac{5}{18} = 2.75 \text{ m/s}$$

$$6.3 \text{ m/s} = 6.3 \times \frac{18}{5} \text{ km/h}$$

$$= 22.68 \text{ km/h}$$

- To convert from km/h to m/s, multiply by $\dfrac{1000}{3600}$ or $\dfrac{5}{18}$.
- To convert from m/s to km/h, multiply by $\dfrac{3600}{1000}$ or $\dfrac{18}{5}$.

Example 2: A night bus needs to cover 408 km in 8 h. If it covers the first quarter of the journey at 45 km/h and the second quarter of the journey

at 55 km/h, what should be its speed for the rest of the journey?

Distance covered in the first quarter

$= 45 \text{ km/h} \times 2 \text{ h} = 90 \text{ km}$

Distance covered in the second quarter

$= 55 \text{ km/h} \times 2 \text{ h} = 110 \text{ km}$

Distance to be covered in 4 h

$= 408 - (90 + 110) = 208 \text{ km}$

Speed for the remaining journey

$$= \frac{\text{Distance remaining}}{\text{Time remaining}} = \frac{208 \text{ km}}{4 \text{ h}} = 52 \text{ km/h}$$

Example 3: The Coalfield Express, 150 m long, was waiting at Durgapur station when the New Delhi-bound Rajdhani Express, 130 m long, thundered past it in only 8 seconds. At what speed was the Rajdhani Express travelling?

In order to go past the Coalfield Express the engine of Rajdhani Express has to go past its entire length and then go another 130 m till its own last compartment clears the Coalfield Express.

Thus distance travelled = 150 m + 130 m

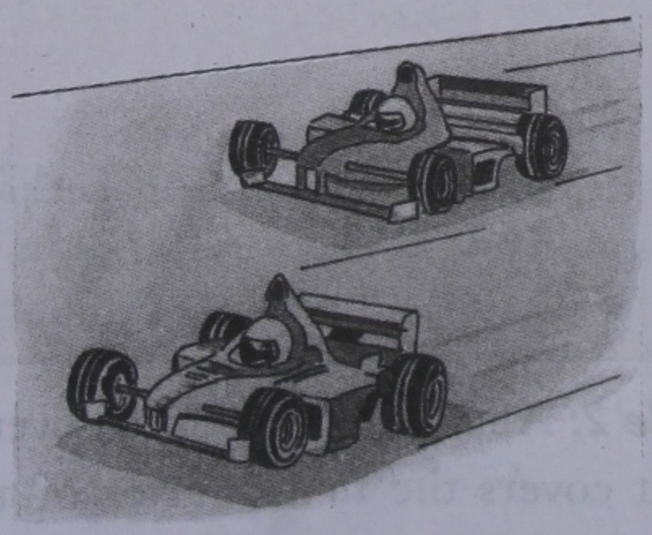
= 280 m

Time taken = 8 seconds

$$\text{Speed} = \frac{280}{8} = 35 \text{ m/s} = 35 \times \frac{18}{5} = 126 \text{ km/h}$$

Thus, the Rajdhani Express thundered past the Coalfield Express at 126 km/h.

Example 4: Two racing cars are flagged off together. Car A travels at 124.2 km/h, while car B travels at 120 km/h to finish the race 7 seconds after car A. What was the distance covered in the race?



Method I: Using Direct Proportion

$$124.2 \text{ km/h} = 124.2 \times \frac{5}{18} = 34\frac{1}{2} \text{ m/s}$$

$$120 \text{ km/h} = 120 \times \frac{5}{18} = 33\frac{1}{3} \text{ m/s}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \Rightarrow \text{Time } \frac{\text{Distance}}{\text{Speed}}$$

At $34\frac{1}{2}$ m/s, covering 1000 m would take

$$1000 \div 34\frac{1}{2} = \frac{2000}{69} \text{ seconds}$$

At $33\frac{1}{3}$ m/s, covering 1000 m would take

$$1000 \div 33\frac{1}{3} = 30 \text{ seconds}$$

Thus, difference in time taken to cover 1000 m

$$= 30 - \frac{2000}{69} = \frac{70}{69} \text{ seconds}$$

Actual difference in time taken to cover

x m = 7 seconds

Direct proportion = Time difference for

1000 m : Time difference for x m : : 1000 m : x m

$$\frac{70}{69} : 7 : : 1000 : x$$

$$\Rightarrow \quad \frac{70x}{69} = 7 \times 1000$$

$$\Rightarrow \quad x = \frac{7000 \times 69}{70} = 6900 \text{ m} = 6.9 \text{ km}$$

Method II: Using Formula

Let the distance covered in the race be represented by x.

Covering x m at $34\frac{1}{2}$ m/s $= x \div \frac{69}{2} = \frac{2x}{69}$ seconds

Covering x m at $33\frac{1}{3}$ m/s $= x \div \frac{100}{3} = \frac{2x}{100}$ seconds

Time difference $= \frac{3x}{100} - \frac{2x}{69} = \frac{7x}{6900}$ seconds

Given that $\frac{7x}{6900} = 7$ seconds

$$\Rightarrow x = \frac{7 \times 6900}{7} = 6900 \text{ m} = 6.9 \text{ km}$$

Try this!

1. A scooterist covers a certain distance at 36 kmph. How many metres does he cover in 2 minutes?

Average Speed

Most moving bodies that we see around us rarely run at a fixed speed. Sometimes they slow down and at other times they travel faster. In such instances we need to find the average speed.

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

Example 5: Arijit started off eagerly and ran the first 350 m of the race at 25.2 km/h. Then settling into a steady 18 km/h, he ran the next 1000 m. He made a dash for it towards the finishing line, running the last 150 m at 27 km/h. How much time did he take to finish the race and what was his average speed?

$25.2 \text{ km/h} = 25.2 \times \frac{5}{18} = 7 \text{ m/s}$

First 350 m at 25.2 km/h or 7 m/s took

$\frac{350}{7} = 50$ seconds

Next 1000 m at 18 km/h or 5 m/s took

$\frac{1000}{5} = 200$ seconds

Last 150 m at 27 km/h or 7.5 m/s took

$\frac{150}{7.5} = 20$ seconds

Thus covering 1500 m took the runner

$= 270$ seconds

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

$$= \frac{1500 \text{ m}}{270 \text{ s}} = 5\frac{5}{9} \text{ m/s}$$

$$= \frac{50}{9} \text{ m/s} = \frac{50}{9} \times \frac{18}{5} = 20 \text{ km/h}$$

Relative Speed

1. If you float on water in a swimming pool, you will stay in the same place because the water in the swimming pool is not going anywhere.
2. But if you **float on water in a river**, you will be carried downstream at the speed of the river's current. Although your speed will be 0, your speed in relation to the river bank, or your **relative speed, will be the speed of the river's current**.
3. If you **swim downstream**, your speed in relation to the river bank will be more than the speed at which you are swimming, as your **relative speed will be your speed plus the speed of the river's current**.
4. If you swim upstream against the river's current at a speed equal to that of the river's current, your position in relation to the river bank will not change as your relative speed will be 0. This is because the water's opposite speed will cancel out your effort.
5. If you **swim upstream** against the river's current at a speed greater than the river's current, you will surely make some headway as your **relative speed will be your speed minus the speed of the river's current**.

Example 6: A bird is flying at 57.6 km/h against a strong wind blowing at 7.2 km/h. How long would it take to fly from one tree top to another 630 m away?

$$\text{Speed of bird} = 57.6 \times \frac{5}{18} = 16 \text{ m/s}$$

$$\text{Opposite speed of wind} = 7.2 \times \frac{5}{18} = 2 \text{ m/s}$$

Relative speed of bird = 16 m/s – 2 m/s
= 14 m/s

$$\text{Time taken} = \frac{\text{Distance to be covered}}{\text{Relative speed}} = \frac{630}{14} = 45 \text{ s}$$

Example 7: The engine driver of a 130 m long Rajdhani Express, travelling at 144 km/h, sees the rear of a slow-moving goods train ahead of him on another track. If the Rajdhani Express takes 19 seconds to overtake the goods train which was travelling at 75.6 km/h, how long was the goods train?

Speed of overtaking = Relative speed = Speed of Rajdhani Express – Speed of goods train

= 144 km/h – 75.6 km/h = 68.4 km/h

$$= 68.4 \times \frac{5}{18} = 19 \text{ m/s}$$

Distance covered = Speed × Time
= 19 m/s × 19 s = 361 m

Length of goods train
= 361 m – Length of Rajdhani Express
= 361 m – 130 m = 231 m

Exercise 13.1

1. How much distance will be covered by a cheetah, running at 56.16 km/h, in 45 s?
2. How much time will a snail take to crawl past a 30 cm long brick, if it moves at 5 mm/s?
3. What speed must a bus driver maintain if he has to reach his destination 164 km away in 3 hours?
4. Meera jogged around a park 400 m long and 300 m wide 3 times in 14 minutes. At what speed did Meera run?
5. Tarun lights a rocket which goes high into the dark sky. Tarun sees a flash as it bursts in sparkling colours and hears a bang 2.5 s later. If sound travels at 1206 km/h, how high was the rocket when it burst?

6. Jatin's father starts off to drop Jatin at his school 9.2 km away driving at 30 km/h. After 4 minutes Jatin tells his father he has to reach school in another 10 minutes. At what speed must Jatin's father drive to reach the school on time?
7. A bus, 9 m long, goes past a lamp-post in 1.2 seconds. At what speed was the bus travelling?
8. A bus, 9 m long, goes past a 5 m long bus-stop in 2.1 seconds. At what speed was the bus travelling?
9. An engine driver wants the guard to show him the green flag as soon as the 100 m long train clears the 200 m long railway platform. Moving at 12 km/h, if the engine driver enters the platform, after how many seconds will the guard show the green flag if the train maintains the same speed going past the platform?
10. A train leaves station A at 0800 hours to reach station B at 0930 hours, travelling at 90 km/h. At 1000 hours it leaves station B and travels at 110 km/h to reach station C at 12 noon. What was the average speed of the train in travelling from station A to station C?
11. An express train covers the first half of its journey in 1 h 20 min, travelling at 90 km/h.

Due to heavy fog, the next 12 km of its journey could be covered at 40 km/h. If it covers the rest of the journey in 52 minutes, find the total time taken and the average speed of the train for the entire journey.

12. Leaving home at the same time, if Pratibha walks to school at 3 km/h, she reaches 10 min late. If she cycles to school at 6 km/h, she reaches 15 min early. How far is the school from her home?
13. Two brothers left home for a cinema hall. One brother rode a bicycle at 25.2 km/h to reach the cinema hall 5 min 50 s after the other brother who took a taxi that drove at 37.8 km/h. How far was the cinema hall from their home?
14. Little Johny is caught with his hand in the cookie jar by his mother standing 12 m away. Johny runs as fast as he can but he is caught 5 seconds later by his mother who is much faster at 7 m/s. How fast did little Johny run?
15. An office-goer sees a tram trundling past at 10 km/h and makes a run for it at 14 km/h. If he manages to board the tram after 9 seconds, how far was the tram's entrance when the office-goer started running?
16. The engine driver of a 130 m long Rajdhani Express, travelling at 150 km/h, sees the rear of a 220 m long goods train, travelling at 80 km/h ahead of him on another track at 8:05:00 a.m. If the Rajdhani Express overtakes the goods train at 8:06:30 a.m., how far ahead was the goods train when the driver saw its rear at 8:05 a.m.?
17. A team of 8 rowers are rowing a boat at 18 km/h with a favourable water current of 5.4 km/h helping them go even faster. How long will they take to finish a 3.25 km race?

18. On a day when the Hooghly river's current was very strong, Mihir took 1 minute to swim 540 m with the current but 3 minutes to swim the same distance against the current. If Mihir swam in a swimming pool how many metres would he cover in a second?
19. Two bulls are 65 m away when they charge at each other. If one bull runs in at 36 km/h and the other at 42 km/h, how long will the bulls take to lock horns?

Revision Exercise

1. Express 13.5 km/h in m/s and 15.8 m/s in km/h.
2. How much distance will be covered by a tiger, running at 64.75 km/h in 55 s?
3. What speed must a bus driver maintain, if he has to reach his destination 747 km away, in 9 hours?
4. A 11 m long bus goes past a 7 m long bus stop in 3.2 seconds. At what speed was the bus travelling?
5. A bus is travelling at an average speed of 65 km/h. How much distance will it travel in 20 minutes?