
Speed

Speed

Suppose there are two trains A and B. If train A covers 5 km in 3 hours and train B covers 4 km in 2 hours, then consider the following question.

1) **Which train is faster?**
2) **What will be distance covered by train A in 5 hours?**
3) **If the train B starts at 11 am at what time train B will cover 6 km?**

How to answer?

Speed

Only way is to measure how fast is the train. But how to measure it? We can measure this with the help of SPEED.

Speed is defined as distance covered per unit time.

Hence

$$\text{Speed} = \frac{\text{Distance covered}}{\text{Time taken}}$$

Here per unit time can be either one second or one minute or one hour.

Example

1) Suppose the distance between station A and station B is 20 miles. A train starts at 8 am from station A and reaches station B at 12 am. Find the speed of the train. Suppose station C is 12 miles away from station B, then how much time is required for the train to reach station C from station B, if the train is moving at the same speed?

Solution:

First let us find the speed of the train.

$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{20 \text{ miles}}{(12 - 8)} = \frac{20}{4} = 5 \text{ miles per hr.}$$

Hence speed of the train is 5 miles per hr. In other words, in one hour the train covers 5 miles.

Now distance between station B and station C is 12 miles. Hence the time required for train to cover the distance is

$$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{12}{5} = 2.5 \text{ hours}$$

Required time is 2½ hours or 2 hours 30 minutes.

Example

2) A car moves at the speed of 8 miles/hr for ½ hour and for next one hour the car moves at the speed of 10 miles per hr. Find the total distance covered by the car.

Solution: We have to find the distance.

Hence use the formula
Distance = Speed X Time.

Total time taken for the car is (½ + 1) = 1½ hrs

For ½ hr, the car moves at the speed of 8 miles/hr.
Distance covered by the car is Speed X Time = 8 X ½ = 4 miles.

For next one hr, the car moves at the speed of 10 miles/hr.
Distance covered by the car is Speed X Time =10 X 1 = 10 miles.

Hence the total distance covered by the car is (4 + 10) = 14 miles

Exercise

a) Suppose there are two trains X and Y. Each train starts at station A and reach station C passing through station B. Train X starts from station A moves at the speed of 150 miles/hr for 4 hrs and reach station B. The train X spends next 4 hours in the station and reach station C at the same speed. Train Y starts from station A moves at the speed of 100 miles/hr to station B. It spends 1 hour in the station and moves to station C at the same speed and reach station C in 4 hours.

Then find the following:

i) Distance between station A and station B
ii) Distance between station B and station C.
iii) Find the total distance covered by each train.
iv) If both the train starts from the station A at the same time then which train will reach the station C first.

b) A car covers a third of the total distance at the speed of 50 km/hr and remaining distance at the speed of 35 km/hr. Suppose the distance covered by the car is 60 km, then find the time taken by the car to cover the total distance.

Average Speed

In real life we often use the term average speed, which is rate of total distance (or length) and time interval. For example, if you go 60 miles in 2 hours, your average speed during that time is 60/2 = 30 miles/hr.

Exercise

c) A car covers 80 miles in 2 hrs and 105 miles in 3 hrs. Find the average speed of the car.

Hint: Find the total distance and the total time taken.

Points to remember

Conversions:

Distance:

1 km	= 1000 meter(m)	1 m	= 100 centimeter(cm)
1 m	= 1000 millimeter (mm)	1 cm	= 10 mm
1 in(inch)	= 2.54 cm	1 ft(foot)	= 12 in
1 mile	= 1.6 km	1 mile	= 5280 ft
1 yard	= 3 feet		

Time:

1 day	=	24 hours				
1 hour	=	60 minutes				
½ hour	=	0.5 hr	=	0.5 X 60	=	30 minutes
¼ hour	=	0.25 hr	=	0.25 X 60	=	15 minutes
¾ hour	=	0.75hr	=	0.75 X 60	=	45 minutes
0.6 hr	=	0.6 X 60	=	36 minutes		
4.3 hr	=	4 hr + 0.3 hr				
	=	4 hr + 0.3 X 60 minutes				
	=	4 hr + 18 minutes				

Points to remember

Speed:

1 km/hr = $\frac{1000 \text{ meters}}{60 \times 60 \text{ seconds}} = \frac{5}{18}$ meter/sec (m/s)

1 mile/hr = 1.6 km/hr

1 mile/hr = 22/15 ft/sec

Remember : While solving the problems make sure that unit of the distance, time and the speed are the same.

Relative Speed

Consider the following situation:
1) Suppose Tom is standing 300 feet away from the school and Bob is 240 feet away from the school. Walking speed of Tom and Bob is 15 feet per minute and 10 feet per minute respectively. Both had started walking at the same time .

Guess: Who will reach first?

More Examples

3) Imagine a burglar is standing 100 feet away from a policeman. The speed of the policeman is 25 feet per minute and the speed of the burglar is 20 feet per minute. The burglar starts to run away from the police and the later starts chasing him. If both started at the same time, then find the distance to be covered by the policeman in order to catch the burglar and also time required for the same.

Let us find it out.

Suppose policeman has to cover D feet to catch the burglar, then definitely the burglar must have covered (D – 100) feet.
Now the time taken by the policeman to cover D feet = D/25 minutes
and the time taken by the burglar to cover (D -100) feet = (D - 100)/20 minutes

But the time taken by the policeman to cover D feet must be equal to the time taken by the burglar to cover (D -100) feet.
Hence D/25 = (D – 100)/20
D = 500 feet. (Check the answer)
Hence the policeman has to cover 500 feet to catch the burglar.
Time required by the policeman to catch the burglar will be
T = D/25 = 500/25 = 20 minutes.

Relative Speed

Suppose you are burglar and you are running with the speed of 20 ft per min. According to you what will be the speed of the policeman? As we know speed is nothing but distance per unit time. Here the unit time is one minute. In one minute you have covered 20 feet and the policeman had covered 25 feet. Hence according to you speed of the policeman is 5 feet per minute.

But according to the policeman, you will be moving in the opposite direction.

Now let us define RELATIVE SPEED.

Suppose A and B are moving in same direction with speed S_A and S_B then the relative speed of A and B is given by $|S_A - S_B|$

Hence in this case, the relative speed between you and the policeman is 5 feet per minute

More Examples

4) The two cars are at the distance of 150 km away from each other. The cars started to move towards each other at the same time. Speed of car A is 100 Km/hr and speed of car B is 20 km/hr. How much time is required for the car A to reach car B. In other words how much time is required for both the car to meet each other.

Solution: Let d be the distance covered by the car A to reach car B. Then the distance covered by car B will be (150 – d).
Time required by car A to cover d km will be d/ 100 hrs
Time required by car B to cover (150-d) km will be (150-d)/ 20 hrs

Time taken by car A to cover d km is equal to time taken by car B to cover (150-d) km
d / 100 = (150-d) / 20

After calculating we get d =125 km
Now how much time is required for car A to cover 125 km
time required will be 125/100 = 1.25 hours or 125/100 X 60 = 75 minutes

Relative Speed

Relative Speed: If A and B moves towards each other with the speed of S_A and S_B respectively then the relative speed of A and B is given by $S_A + S_B$

Note that in 1.25 hr the two cars have finished driving 150 km.

What will be the speed if 150 km is covered in 1.25 hrs ? What is the relative speed of car A and car B

Speed = 150 / 1.25

$$= \frac{\text{(distance covered by car A) + (distance covered by car B)}}{1.25}$$

$$= \frac{125 + 25}{1.25}$$

$$= \frac{125}{1.25} + \frac{26}{1.25}$$

= 100 km/hr + 20 km/hr

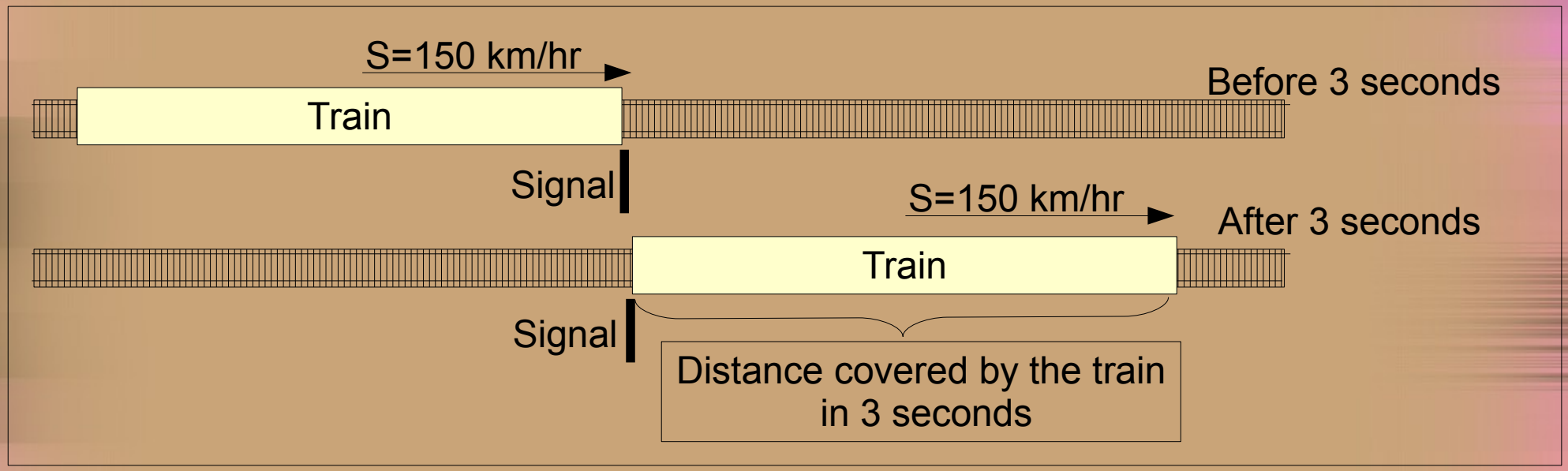
= Speed of car A + speed of car B

Here the relative speed between car A and car B = 120 km/hr

More Examples

5) A train is moving with a speed of 150 km/hr. If the train cross one signal in 3 second then find the length of the train. (See the figure given below).

Solution: First convert the speed into meter per second.
Speed = 150 km/hr = 125/3 m/s.



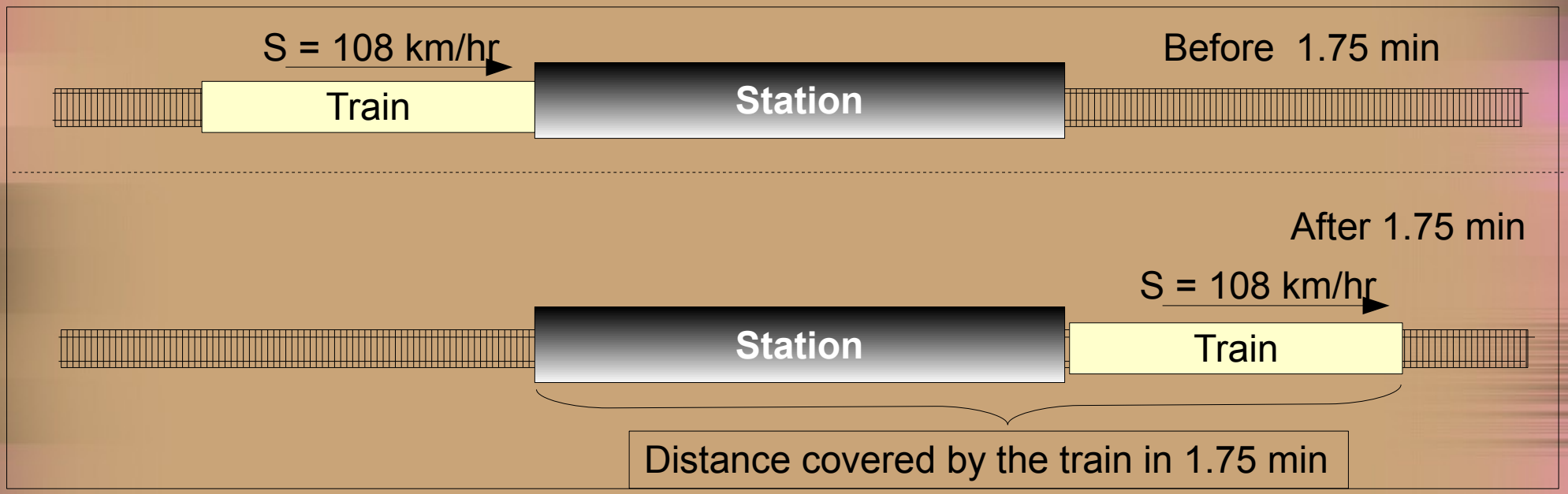
Hence distance covered by the train in 3 second is equal to the length of the train.

Length of the train = speed X time = 125/3 X 3 = 3 meters

More Examples

6) Instead of the signal if train crosses the station of 3 km in 1.75 minutes at the speed of 108 km/hr then what is the length of the train?

Note that 1.75 min = 1min + 0.75 X 60 sec = 1 min 45 sec = 105 sec

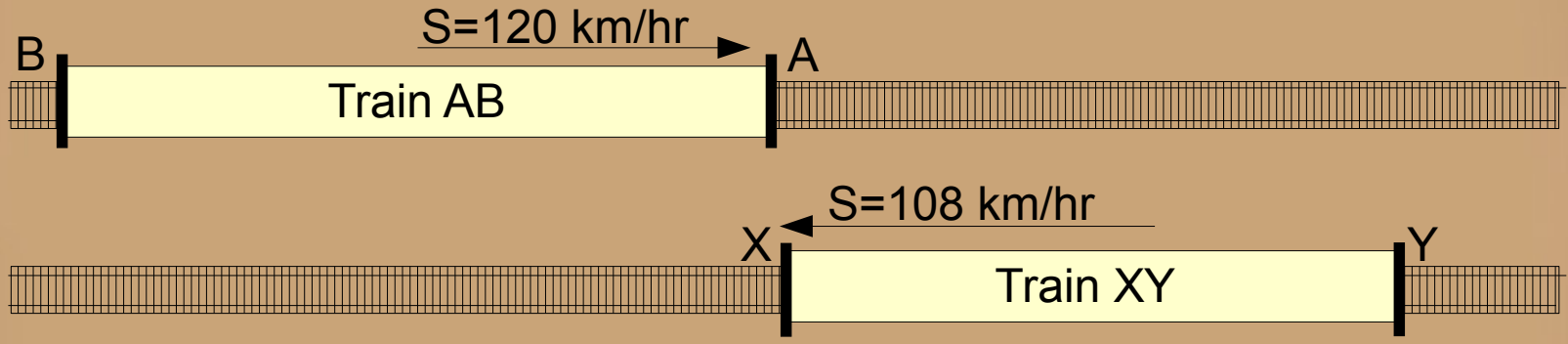


Distance covered by the train = speed X time = 108 km/ hr X 1.75 min
= 3150 meters

But distance covered by the train = length of station + length of train.
Length of the station = 3 X 1000 meters = 3000 meters
Hence length of the train = 3150 – 3000 = 150 meters

More Examples

7) Suppose speed of train AB is 120 km/hr and speed of train XY is 108 km/hr. The length of train AB is 180 meters and the length of train XY is 150 meters. These trains are moving towards each other. How much time is required for the trains to cross each other, if the two trains have just meet each other (See the figure below).



How to solve this?
If you see the question carefully then you will find that this question is equivalent to the example 4. That is if you place first car at position B and the second car at position Y then distance the distance between two car will be (length of train AB + length of train XY = 180 + 150 = 330 meters) . Thus the above problem can be written as

"Speed of first car is 120 km/hr and the second car is 108 km/hr . The distance between two cars is 330 meters. The cars started to move towards each other at the same time. How much time is required for the cars to meet each other."

Formula

Consider two train A and B are moving with speed of V1 and V2 respectively. Length of train A is L1 and length of train B is L2. If D is the distance between the train then,

1) Both the train moves towards each other then the time taken for both the train to meet each other is given by

$$t = \frac{D}{V1 + V2}$$

2) Both the train moves towards each other then the time taken for both the train to cross each other is given by

$$t = \frac{L1 + L2 + D}{V1 + V2}$$

3) Both the trains are moving in same direction. If train B is moving ahead of train A and V1 > V2 then the time at which both the trains meet is given by

$$t = \frac{D}{V1 - V2}$$

4) Both the trains are moving in same direction. If train B is moving ahead of train A and V1 > V2 then the time at which train A will cross train B is given by

$$t = \frac{L1 + L2 + D}{V1 - V2}$$

Note that:

1) Instead of train, a bike or a car or some people are given in the problem then L = 0

2) When A and B moves in the same direction and B is ahead of A, then A can reach A if and only if speed of A is more than speed of B.

Exercise

d) Suppose Dick and Jerry are having running race. They have to cover 400 meters. Dick has covered first 100 meters with the speed of 10m/s and next 240 meters with the speed of 15 m/s. Finally Dick covered 400 meters in 32 seconds. Whereas Jerry has covered first 120 meters in 15 seconds, 180 meters in 10 seconds. Average speed of Jerry was 40/3 m/s. Answer the following.

- **i) By what speed Dick has covered last 60 meters?**
- **ii) What was the speed of Jerry when he covered last 100meters ?**
- **iii) What was the average speed of Dick?**
- **iv) How much time is required for Jerry to cover 400 meters?**
- **v) Who win the race?**

e) If the train of length is 80 meters crosses signal at 2 seconds, then find the speed of the train in meters per second and also in km per hr.

Exercise

f) Suppose the distance between the car and the bike is 3 km and both started to move towards each other in the same road. Speed of car is 10 m/s and the speed of the bike is 18 km/hr. There is a tea shop which is 1 km away from the bike. Answer the following .

i) What is the relative speed of the car and the bike?

ii) Who will reach the tea shop first?

g) Solve example 7.

g) If train A and train B are moving towards each other at the distance of 81 km. The speed of both the trains is 108 km/hr. Length of train A is 150 meters. If the distance covered by train A to cross train B is 40.626 km then find the length of train B

Boats and streams

Now let us deal with the speeds of ships and boats.

When A is moving in the road, the speed A is totally depend on A. But when a boat is sailing on the water then the speed of the boat not only depends on the boat but also on the flow of the water. Hence the direction of the flow of water can effect the speed of the boat.

If the direction of the flow of the water is same as direction of the boat rowing, then it is known as downstream.
If the direction of the flow of the water is opposite to the direction of the boat rowing, then it is known as upstream.

Suppose there is no flow in the water then the water is known as Still water . Hence to find the speed of the boat .

How to calculate the speed of the boat in water?

Boats and streams

Let U be the speed of the boat in the still water and let V speed of the stream or the flow of the water.
If the boat is moving in the upstream, then the speed of the boat in the upstream is given by (U -V) and if the boat is moving in the downstream, then the speed of the boat in the downstream is given by (U+V).
If 't' is the time required to cover the distance D then the distance can be calculated as

D = (U – V) t .....if the boat is moving in the upstream and,
D = (U+V) t .....if the boat is moving in the downstream.

Exercise

1) The speed of a motor boat itself is 20 km/h and the rate of flow of the river is 4 km/h. Moving with the stream the boat went 120 km. What distance will the boat cover during the same time going against the stream?

2) A boat can travel 20 mph in calm water. A downstream trip takes 1 hour, and the return trip takes 3 hours.

- **(a) What is the speed of the river's current?**
- **(b) What is the upstream speed of the boat relative to the river bank?**
- **(c) What is the downstream speed of the boat relative to the river bank?**
- **(d) Find the round trip distance.**