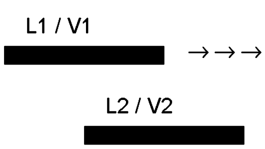
TRAIN

We know that when the direction of the movement of a boat and a river is the same, the relative speed is obtained by adding the speeds of both, the boat and the river. But if two trains are moving in the same direction, then what is the relative speed?

Let us see some cases:

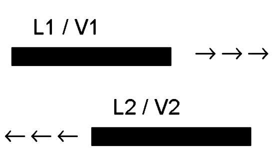
1. When two trains of length L_1 and L_2 and speed V_1 m/s and V_2 m/s respectively are crossing each other:

i. The direction of the movement of both the trains are the same:



Relative speed = $|V_1 - V_2|$
Total distance covered = $L_1 + L_2$

ii. The direction of the movement of both the trains are opposite:



Relative speed = $|V_1 + V_2|$
Total distance covered = $L_1 + L_2$

2. When a train is crossing a stationary object:

i. When the train is crossing a pole or a stationary human being:

(Fig. 1)

(Fig. 2)

Let us assume that A is a pole. In figure 1, the front of the train is about to cross the pole and in figure 2, the tail of the train has just crossed the pole. It is understood here that the train has crossed its whole length with respect to the pole. So, when the train is crossing any stationary object of negligible width, total distance covered is its own length.

Relative speed = $V_1 + V_2$, since $V_2 = 0$, then, the relative speed = V_2

Total distance covered = $L_1 + L_2$, since L_2 (width of the pole) is negligible with respect to L_2 (Length of the train), so we do not consider it while calculating the quantities. Thus, distance = L_1

However, it should be remembered that this is mathematically not correct and all the solutions are on the assumption that the width of the pole is zero, which is obviously not true.

ii. When the train is crossing a platform or a standing train:

Relative speed = $V_1 + V_2$,

Where V_1 is the speed of the moving train and V_2 is the speed of the standing train or the platform.

Since $V_2 = 0$, so the relative speed = V_1

Total distance covered = $L_1 + L_2$

Where L_1 is the length of the moving train and L_2 is the length of the standing train or the platform.

Example A train takes 10 s to cross a pole and 20 s to cross a platform of length 200 m. What is the length of train?

Solution The train takes 10 s to cross its own length and 20 s to cross its own length and length of the platform. So, it is infered that the train takes 10 s to cross the platform and 10 s to cross its own length.

Since the time taken to cross the platform = time taken to cross its own length

So, length of the platform=length of the train=200 m

Example Speed of a train is 36 km/h. It takes 25 s to cross a pole. What is the length of this train?

Solution Speed of train = 10 m/s ($36 \times 5/18$)

Distance covered = $10 \times 25 = 250$ m

So, length of train = 250 m

Some Special Cases

Case 1 Two trains are moving in an opposite direction with a speed of V_1 and V_2. Their lengths are L_1 and L_2. Now, see the whole situation from the point of view of a person sitting on the window seat of the 1st train.

Relative speed = $V_1 + V_2$ (This person can be assumed to be running with a speed of V_2.)

Relative distance = L_2

Case 2 A train is running with a speed V_1 and a person X is running inside the train with a speed of V_2 in the direction of the movement of train. Now if a person Y is watching this from the outside of the train, then the relative speed of Y with respect to $X = V_1 + V_2$.

Speed of person X with respect of another person Z who is sitting in the train $= V_2$

There is also a person P who is outside the train and is moving with a speed of V_3 in the opposite direction of train.

Relative speed of P with respect to person

$X = V_1 + V_2 + V_3$

Had this person P been running in the same direction as that of the train, then the relative speed of P with respect to person $X = |V_1 + V_2 - V_3|$