TIME SPEED AND DISTANCE

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Time required to cover a distance is inversely proportional to the speed with which it travels. Whereas time–distance and speed–distance are directly proportional quantities.

Basic formulae

1. Distance = Speed × Time

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

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

4. x km/h $= x \times \dfrac{5}{18}$ m/s

5. x m/s $= x \times \dfrac{18}{5}$ km/h

When two persons A and B are running around a circular track of length L metre with speeds a m/s and b m/s in same direction, they meet each other in $\dfrac{L}{a-b}$ seconds.

When two persons A and B are running around a circular track of length L m with speeds a m/s and b m/s in opposite direction, they meet each other in $\dfrac{L}{a+b}$ seconds.

Train Problems

Train problems broadly centre around the following three types.

1. Time taken by a train to cross a stationary point.

2. Time taken by a train to cross a stationary length.

3. Time taken by a train to cross a moving length.

"A train takes 20 seconds to cross or go past a man" implies that to start with, the man was in line with the front of the train and after 20 seconds he was in line with rear of the train. Thus, the distance travelled by a train to cross a man or a tree or a lamp post or for that matter any stationary point is its length itself and hence, the time taken can be obtained once the train's speed is known.

Time taken by a train to cross a stationary point = train length/train speed

If the train has to cross a platform, it has to cover an additional distance equal to the platform length. The same logic applies to a tunnel or a bridge or any stationary length.

Time taken by a train to cross = (train length + stationary a stationary length   length)/train speed

If the train is to cross another train which is stationary, the distance to be covered is the sum of the length of the two trains and the speed would be governed by the speed of the moving train. But if the other train is also moving, the distance to be covered remains the same, but the speed would be governed by the relative speed since both trains are moving.

Time taken by a train to cross another train moving in the same direction	=	(sum of the lengths of the two trains)/difference in their speeds
Time taken by a train to cross another train moving towards it	=	(sum of the lengths of the two trains)/sum of their speeds

Application 1

A bus runs at a speed of 80 km/h. If it started at 10.00 a.m. and reached a nearby city by 12.30 p.m., find the distance travelled by the bus.

Solution

Time taken = 2 h 30 min

Speed = 80 km/h

Distance travelled = Speed × Time = $80 \times \dfrac{5}{2}$ = 200 km

Application 2

If A travels at 30 km/h speed, he arrives at a place at 2 p.m. If he travels at 40 km/h speed then he arrives the same place at 1 p.m. At what speed must he go to reach there at noon?

Solution

By travelling at 40 km/h speed, time spent is reduced by 1 hour.

So, $\dfrac{d}{30} - \dfrac{d}{40} = 1$ (d is the distance travelled)

$\Rightarrow d = \dfrac{1200}{10} = 120$ km

Let x km/h be the speed with which he should travel to reach at noon.

Then $\dfrac{120}{30} - \dfrac{120}{x} = 2$ or $2 = \dfrac{120}{x}$

So, x = 60 km/h

> **Remember!**
> If a train moving in 'd' m/s speed, takes 's' seconds to cross completely a lamp post then its length is 'ds' metres.

Application 3

A train travelling at a uniform speed clears a platform 1400 m long in 40 seconds and passes a lamp post in 20 seconds. Find the length of the train and its speed.

Solution

Let 'x' be the length of the train and 's' m/s be the speed of the train.

As the train takes 40 seconds to cross the station,

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$\dfrac{1400 + x}{s} = 40$

or 40s – x = 1400   ... (1)

As it takes 20 seconds to cross a lamp post,

$\dfrac{x}{s} = 20$ or x = 20s   ... (2)

Solving (1) and (2), s = $\dfrac{1400}{20} = 70$ m/s and x = 1400 m

So, length of the train = 1400 m and its speed = 70 m/s

> **Remember!**
> When two persons A and B are running around a circular track of length L metre with speeds a m/s and b m/s, they meet for first time at the starting point at LCM of $\left(\dfrac{L}{a}, \dfrac{L}{b}\right)$ seconds.

Application 4

In a circular race of 3600 m length, P and Q start with speeds 18 km/h and 27 km/h starting at the same time from the same point. When will they meet for the first time when running in the same direction and opposite direction?

Solution

Speed of P = 18 km/h = 5 m/s

Speed of Q = 27 km/h = 7.5 m/s

Time taken to meet,

(i) when they run in same direction

$= \dfrac{3600}{7.5 - 5} = \dfrac{3600}{2.5} = 1440$ sec or 24 min

(ii) when they run in opposite direction

$= \dfrac{3600}{7.5 + 5} = \dfrac{3600}{12.5} = 288$ sec or 4.8 min

Application 5

A and B run with speeds 25 m/s and 40 m/s around a circular track of length 400 m. They participate in a 2000 m race. What is the distance between them when one of them reaches the final distance?

Solution

Time required for B to cover 2000 m = $\dfrac{2000}{40} = 50$ sec

Distance covered by A in 50 seconds = 25 × 50 = 1250 m

So, distance between A and B = 2000 – 1250 = 750 m

Application 6

A train starts from A to reach B at 2 p.m. with the speed of 80 km/h. Another train starts from B to reach A at the same time with the speed of 70 km/h. If B is 300 km away from A, where and when will both the train meet?

Solution

Relative speed of the trains = 150 km/h

So, the time required for the trains to meet = $\dfrac{300}{150} = 2$ hours

The point of meet = 2 × 80 = 160 km from A

> **Remember!**
> If a train of length x metres and another train of length y metres crossed each other completely means both the trains has covered the distance of (x + y) metres.

Application 7

Two trains A and B each 500 m long run parallel to each other in the same direction. A is running at the speed of 50 km/h and B at the speed of 40 km/h. B is 20 km ahead of A when A starts. Find in what time A will completely pass B.

Solution

Relative speed of the trains = 50 – 40 = 10 km/h

Distance to be covered by A to completely pass B

= 20 km + 1000 m = 21 km

Time required for A to cover 21 km = $\dfrac{21}{10} = 2.1$ hours

❧ BOATS AND STREAMS

If the speed of the boat is x km/h and if the speed of the stream is y km/h then,

- In the upstream direction, the effective speed of the boat is (x – y) km/h.

- In the downstream direction, the effective speed of the boat is (x + y) km/h.

Application 8

A man rows 12 km down the stream in 4 hours and up the stream in 6 hours. Find the velocity of the man.

Solution

Let x km/h be the speed of man and y km/h be the speed of the stream.

Relative speed of man in downstream direction = x + y km/h

Relative speed of man in upstream direction = x – y km/h

Then, $\dfrac{12}{x + y} = 4$ or x + y = 3   ... (1)

And $\dfrac{12}{x - y} = 6$ or x – y = 2   ... (2)

Solving (1) and (2), x = 2.5 km/h

So, the velocity of the man = 2.5 km/h

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1. When distance is constant, speed and time are in inverse proportion.

2. When time is kept constant, speed and distance are in direct proportion.

3. Let the speed of two vehicles be x km/h and y km/h respectively,
   (i) If they travel in the same direction, then their relative speed is $(x - y)$ km/h.
   (ii) If they travel in the opposite directions, then their relative speed is $(x + y)$ km/h.

GUARD AGAINST POPULAR ERRORS

1. If distance in metres and speed in m/s are divided, we get time in seconds.

2. Speed in km/h should be multiplied by time in hours to get distance in km.

3. Distance in metres should be divided by time in seconds to get speed in m/s.

CLASS WORK

1. If a man cycles at 10 km/h, then he arrives at a certain place at 1 p.m. If he cycles at 15 km/h, he will arrive at the same place at 11 a.m. At what speed must he cycle to get there at noon?
   (a) 11 km/h   (b) 12 km/h
   (c) 13 km/h   (d) 14 km/h

2. A car crosses a man walking at 6 km/h. The man can see the things up to 450 m only in one direction due to fog. He sees the car which was going in the same direction for 4.5 minutes. What is the speed of the car?
   (a) 9 km/h   (b) 12.5 km/h
   (c) 12 km/h   (d) 15 km/h

3. The wheel of an engine of 300 cm in circumference makes 10 revolutions in 6 seconds. What is the speed of the wheel (in km/h)?
   (a) 18   (b) 20   (c) 27   (d) 36

4. A boat moves downstream 1 km in 5 minutes and upstream 1 km in 12 minutes. What is the speed of the current?
   (a) 4.5 km/h   (b) 3.5 km/h
   (c) 2 km/h   (d) 2.5 km/h

5. On 20 km tunnel connecting two cities A and B, there are three gutters. The distance between gutters G_1 and G_2 is half the distance between gutters G_2 and G_3. The distance from city A to its nearesst gutter, is equal to the distance of city B from gutter 3. On a particular day, the hospital in city A receives information that an accident has happened at the third gutter. The victim can be saved only if an operation is started within 40 min. An ambulance started from city A at 30 km/h and crossed the first gutter after 5 min. If the driver had doubled the speed after that, what is the maximum amount of time the doctor would get to attend the patient at the hospital? Assume 1 min is elapsed for taking the patient into and out of the ambulance.
   (a) 4 mins
   (b) 2.5 mins
   (c) 1.5 mins
   (d) Patient died before reaching the hospital

Directions for Q6 to Q12: Answer the questions based on the following information.

Two places P and Q are 800 km apart from each other. Two persons start from P towards Q at an interval of 2 hours with A leaving P for Q before B. The speeds of A and B are 40 km/h and 60 km/h respectively. B overtakes (or catches or meets) A at M, which is on the way from P to Q.

6. How long will B take to overtake?
   (a) 1 h 20 min   (b) 6 h
   (c) 4 h   (d) 5 h

7. What is the distance from P, where B overtakes A (i.e., PM)?
   (a) 150 km   (b) 220 km   (c) 240 km   (d) 280 km

8. What is the ratio of time taken by A and B to meet at M?
   (a) 2:3   (b) 3:2   (c) 2:1   (d) 1:2

9. What is the extra time required by A to reach at Q?
   (a) 2 h 20 min   (b) 2 h 40 min
   (c) 6 h   (d) 6 h 40 min

10. How many hours later A will reach at Q than B?
    (a) 4 h 40 min late   (b) 4 h 10 min late
    (c) 5 h 20 min late   (d) 3 h 50 min late

11. After how many hours A and B will be separated by 50 km before M, when both are moving?
    (a) 2 h   (b) 1 h 30 min
    (c) 2 h 15 min   (d) 2 h 30 min

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12. How many hours does B require to advance himself by 100 km in comparison to A?
    (a) 7 h   (b) 8 h   (c) 9 h   (d) 9.5 h

13. Two trains coming from the opposite sides cross each other in 10 seconds. If the length of first and second train be 125 m and 175 m respectively, also the speed of 1st train be 36 km/h, find the speed of 2nd train.
    (a) 54 km/h   (b) 72 km/h
    (c) 144 km/h   (d) 90 km/h

14. A man rows downstream 60 km and upstream 36 km, taking 4 hours each way. The speed of the man is
    (a) 15 km/h   (b) 16 km/h
    (c) 8 km/h   (d) 12 km/h

15. If Ram travels in 40 km/h speed, he arrives at a place at 11 p.m. If he travels at 60 km/h speed, he arrives at 9 p.m. At what speed must he go to reach there at 8 p.m.?
    (a) 60 km/h   (b) 50 km/h
    (c) 40 km/h   (d) 80 km/h

16. The difference between downstream speed and upstream speed is 3 km/h and the total time taken during upstream and downstream is 3 hours. What is the downstream speed, if the downstream and upstream distance are 3 km each?
    (a) 2.5 km/h   (b) 4.3 km/h
    (c) 4 km/h   (d) 3.3 km/h

17. Arun and Varun run with speeds of 30 m/s and 20 m/s around a circular track of 600 m. They participate in a 3000 m race. What is the distance between Arun and Varun when Arun completes his fourth round?
    (a) 400 m   (b) 800 m   (c) 850 m   (d) 600 m

18. A car travelled first 36 km at 6 km/h faster than the usual speed, but it returned the same distance at 6 km/h slower than the usual speed. If the total time taken by car is 8 hours, for how many hours does it travel at the faster speed?
    (a) 4   (b) 3   (c) 2   (d) 1

19. Anjali fires two bullets from the same place at an interval of 6 minutes but Bhagawat sitting in a car approaching the place of firing hears the second of fire 5 minutes 32 seconds after the first firing. What is the speed of car, if the speed of the sound is 332 m/s?
    (a) 56 m/s   (b) 102 m/s   (c) 28 m/s   (d) 32 m/s

20. A train covers a distance in 50 min, if it runs at a speed of 48 kmph on an average. Find the speed at which the train must run to reduce the time of journey to 40 min.
    (a) 50 km/hr   (b) 60 km/hr
    (c) 65 km/hr   (d) 70 km/hr

21. Two buses travel to a place at 45 km/h and 60 km/h respectively. If the second bus takes $5\frac{1}{2}$ hours less than the first for the journey, the length (all in km) of the journey is
    (a) 900   (b) 945   (c) 990   (d) 1350

22. City B is located between the cities A and C, dividing the distance in the ratio 2:3. Raju travels from A to B at 20 km/h and B to C at 30 km/h. When he comes back from C, he reaches B at an average speed of 20 km/h and then A at 30 km/h. Then the average speed of his journey is (all in km/h)
    (a) 24   (b) 25   (c) 27   (d) 22.5

23. A train travelling at 42 km/h passes a runner in 9 seconds running in same direction and took 5 seconds in the opposite direction. Find the length of the train.
    (a) 75 m   (b) 100 m   (c) 84 m   (d) 90 m

24. The distance between two stations is 425 km. Two trains start simultaneously from the stations on parallel tracks to cross each other. The speed of one of them is greater than that of the other by 5 km/h. If the distance between the two trains after 3 hours of their start is 20 km, find the speed of each train (all in km/h).
    (a) 80, 85   (b) 70, 75   (c) 60, 65   (d) 65, 70

25. A man standing on a railway platform notices that a train going in one direction takes 10 seconds to pass him and other train of the same length takes 15 seconds to pass him. Find the time taken by the two trains to cross each other when they are running in the opposite directions (all in seconds).
    (a) 12   (b) 14   (c) 13.5   (d) 15

26. Starting from the same point at the same time on a circular track of 624 m, x moves in clockwise direction whereas y and z move in anticlockwise direction. x meets y every 39 seconds while x meets z every 48 seconds. After how much time does y meet z (all in seconds)?
    (a) 208   (b) 200   (c) 108   (d) 172

27. A can beat B by 20 yards in a race of 200 yards. B can beat C by 10 yards in a race of 250 yards. By how many yards can A beat C in a race of 100 yards?
    (a) 13.6   (b) 13   (c) 14   (d) None of these

28. In a stream running at 2 km/h, a motor boat goes 10 km upstream and returns to the starting point in 55 minutes. Find the speed (all in km/h) of the motor boat in still water.
    (a) 2   (b) 11   (c) 22   (d) None of these

29. On a river, B is between A and C and is equidistant from A and C. A boat goes from A to B and back in 5 hours 15 minutes and from A to C in 7 hours. How long will it take to go from C to A, if the river flows from C to A (all in hours)?
    (a) 2   (b) $2\frac{1}{4}$ (c) $3\frac{1}{4}$ (d) $3\frac{1}{2}$

30. In a kilometre race, A can give B a start of 100 m or 15 seconds. How long does A take to complete the race (all in seconds)?
    (a) 120   (b) 135   (c) 155   (d) 150