Board – CBSE | Class –9th | Topic – Motion

1. An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?

Ans. Diameter of a circular track, d = 200 m

The radius of the track, r = $\frac{d}{2}$ = $100m$

Circumference = 2πr = 2π (100) = 200π m

In 40 s, the given athlete covers a distance of 200π m.

In 1 s, the given athlete covers a distance = $\frac{200\pi}{40}$ m

The athlete runs for 2 minutes 20 s = 140 s

∴Total distance covered in 140 s = $\frac{200\times22}{40\times7}$

The athlete covers one round of the circular track in 40 s. This means that after every 40 s, the athlete comes back to his original position. Hence, in 140 s, he had completed 3 rounds of the circular track and is taking the fourth round.

He takes 3 rounds in 40 × 3 = 120 s. Thus, after 120 s, his displacement is zero.

Then, the net displacement of the athlete is in 20 s only. In this interval of time, he moves at the opposite end of the initial position. Since displacement is equal to the shortest distance between the initial and final position of the athlete, displacement of the athlete will be equal to the diameter of the circular track.

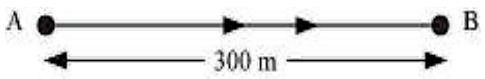
∴ Displacement of the athlete = 200 m

Distance covered by the athlete in 2 min 20 s is 2200 m, and his displacement is 200 m.

2. Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 30 seconds and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in jogging (a) from A to B and (b) from A to C?

Ans. (a) 2 m/s, 2 m/s (b) 1.90 m/s, 0.95 m/s

(a) From end A to end B



Distance covered by Joseph while jogging from A to B = 300 m

Time taken to cover that distance = 2 min 30 seconds = 150 s

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

Total distance covered = 300 m

Total time taken = 150 s

Average speed = $\frac{300}{150}$ = 2 m/s

Average speed = $\frac{Displacement}{Time\ interval}$

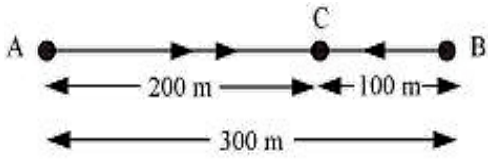
Displacement = shortest distance between A and B = 300 m

Time interval = 150 s

Average speed = $\frac{300}{150}$ = 2 m/s

Joseph's average speed and average velocity from A to B are the same and equal to 2 m/s.

(b) From end A to end C



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

Total distance covered = Distance from A to B + Distance from B to C = 300 + 100 = 400 m

Total time taken= Time taken to travel from A to B + Time taken to travel from B to C = 150 + 60 = 210 s

Average speed = $\frac{400}{210}$ = 1.90 m/s

Average velocity = $\frac{Displacement}{Time\ interval}$

Displacement from A to C = AC = AB − BC = 300 − 100 = 200 m

Time interval = time taken to travel from A to B + time taken to travel from B to C = 150 + 60 = 210 s

Average velocity = $\frac{200}{210}$ = 0.95 m/s

The average speed of Joseph from A to C is 1.90 m/s, and his average velocity is 0.95 m/s.

3. Abdul, while driving to school, computes the average speed for his trip to be 20 km h^{-1}. On his return trip along the same route, there is less traffic, and the average speed is 30 km h^{-1}. What is the average speed for Abdul's trip?

Ans. **Case I.** While driving to school

The average speed of Abdul's trip = 20 km/h

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

Total distance = Distance travelled to reach school = d

Let the total time taken = t_1

$$\therefore 20 = \frac{d}{t_1}$$

$$t_1 = \frac{d}{20} \text{ ...(i)}$$

Case II. While returning from school

Total distance = Distance travelled while returning from school = d

Now, total time taken = t_2

$$30 = \frac{d}{t_2}$$

$$t_2 = d/30 \text{ ..... (ii)}$$

$$Average\ speed\ for\ Abdul's\ trip = \frac{Total\ distance\ covered\ in\ the\ trip}{Total\ time\ taken}$$

Where,

Total distance covered in the trip = d + d = 2d

Total time taken, t = Time taken to go to school + time taken to return to school= $t_1 + t_2$

$$\therefore Average\ speed = \frac{2d}{t_1+t_2}$$

From equations (i) and (ii),

$$\text{Average Speed} = \frac{2d}{\frac{d}{20}+\frac{d}{30}} = \frac{2}{\frac{3+2}{60}}$$

$$\text{Average Speed} = \frac{120}{5} = 24 \text{ m/s}$$

Hence, the average speed for Abdul's trip is 24 m/s.

4. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m s^{-2} for 8.0 s. How far does the boat travel during this time?

Ans. Initial velocity, u = 0 (since the motorboat is initially at rest)

Acceleration of the motorboat, a = 3 m/s^2

Time taken, t = 8 s

According to the second equation of motion.

$$s = ut + \frac{1}{2}at^2$$

Distance covered by the motorboat, s

$$s = 0 + \frac{1}{2}3\times(8)^2 = 96m$$

Hence, the boat travels a distance of 96 m.

5. A car driver travelling at 52 km h^{-1} applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 3 km h^{-1} in another car applies his brakes slowly and stops in 10 s. On the same graph paper, plot the speed versus time graphs for the two cars. Which of the two cars travelled farther after the brakes were applied?

Ans. Case A.

Initial speed of the car, $u_1 = 52$ km/h $= 14.4$ m/s

Time taken to stop the car, $t_1 = 5$ s

The final speed of the car becomes zero after 5 s of application of brakes.

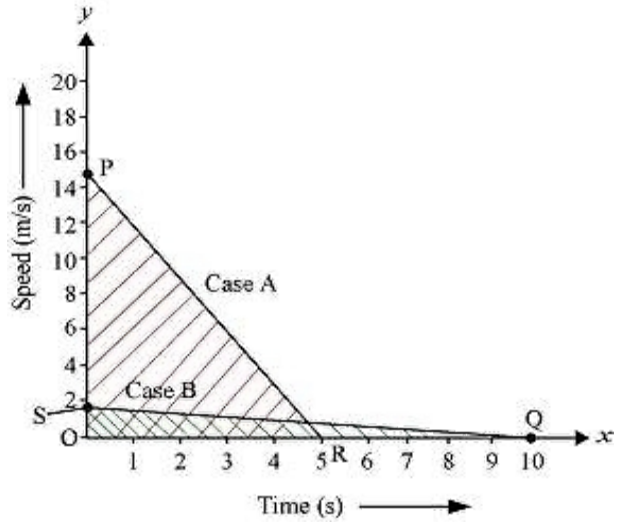
Case B.

Initial speed of the car, $u_2 = 3$ km/h $= 0.833$ m/s $\cong 0.83$ m/s

Time taken to stop the car, $t_2 = 10$ s

The final speed of the car becomes zero after 10 s of application of brakes.

The plot of the two cars on a speed−time graph is shown in the following figure.



The distance covered by each car is equal to the area under the speed−time graph.

Distance covered in case A,

$s_1 = \frac{1}{2} \times OP \times OR = \frac{1}{2} \times 1.44 \times 5 = 36m$

Distance covered in case B,

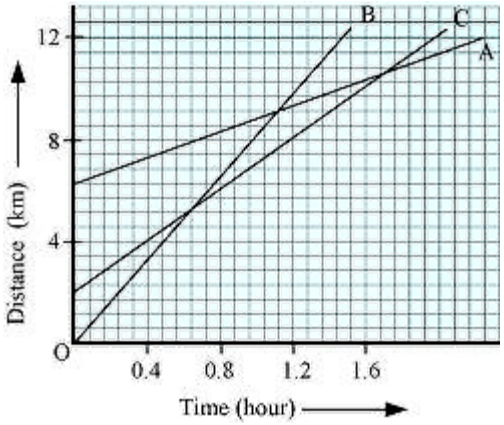
$s_2 = \frac{1}{2} \times OS \times OQ = \frac{1}{2} \times 0.83 \times 10 = 4.15m$

Area of ΔOPR > Area of ΔOSQ

Thus, the distance covered in case A is greater than the distance covered in case B.

Hence, the car travelling with a speed of 52 km/h travels farther after brakes are applied.

6. Fig 8.11 shows the distance-time graph of three objects, A, B and C. Study the graph and answer the following Question.



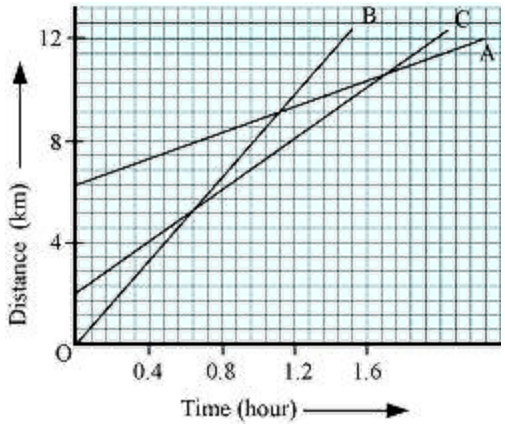
(a) Which of the three is travelling the fastest?

(b) Are all three ever at the same point on the road?

(c) How far has C travelled when B passes A?

(d)How far has B travelled by the time it passes C?

Ans. (a) Object B (b) No (c) 5.714 km (d) 5.143 km



(a) $Speed = \frac{Distance}{Time}$

$Slope\ of\ graph = \frac{y-axis}{x-axis} = \frac{Distance}{Time}$

∴Speed = slope of the graph

Since the slope of object B is greater than objects A and C, it is travelling the fastest.

(b) All three objects A, B, and C, never meet at a single point. Thus, they were never at the same point on the road.

(c) On the distance axis.

7 small boxes = 4 km

∴1 small box $\frac{4}{7}\ km$

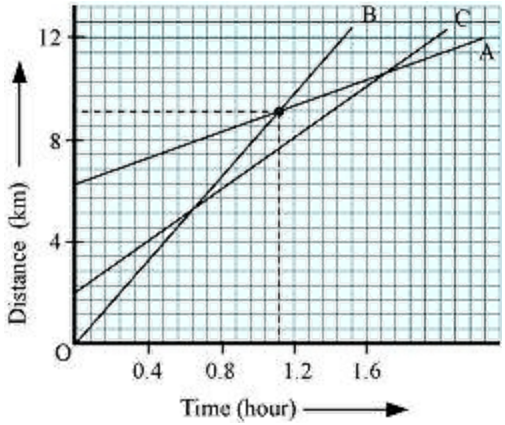
Initially, object C is 4 blocks away from the origin.

∴Initial distance of object C from origin= $\frac{16}{7}km$

Distance of object C from the origin when B passes A = 8 km

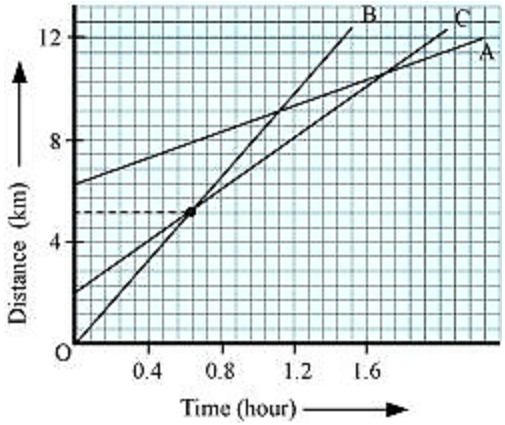
Distance covered by C = $8 - \frac{16}{7} = \frac{56-16}{7} = \frac{40}{7} = 5.714km$

Hence, C has travelled a distance of 5.714 km when B passes A.



(d) Distance covered by B at the time it passes C = 9 boxes= $\frac{4}{7}\times 9 = \frac{36}{7} = 5.143km$

Hence, B has travelled a distance of 5.143 km when B passes A.



7. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m s^{-2}, with what velocity will it strike the ground? After what time will it strike the ground?

Ans. Distance covered by the ball, s = 20 m

Acceleration, a = 10 m/s^2

Initially, velocity, u = 0 (since the ball was initially at rest)

The final velocity of the ball with which it strikes the ground, v

According to the third equation of motion.

$v^2 = u^2 + 2as$

$v^2 = 0 + 2\ (10)\ (20)$

v = 20 m/s

According to the first equation of motion.

v = u + at

Where,

Time t taken by the ball to strike the ground is,

20 = 0 + 10 (t)

t = 2 s

Hence, the ball strikes the ground after 2 s with a velocity of 20 m/s.

8. The speed-time graph for a car is shown in Fig. 8.12.

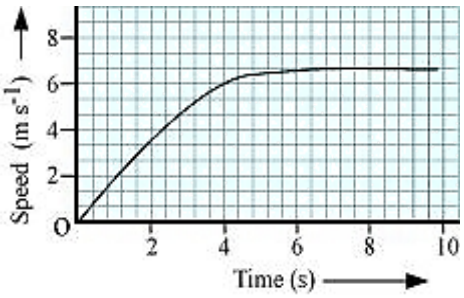
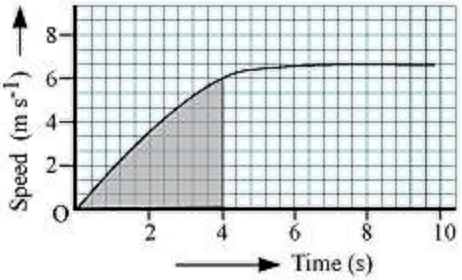


Fig. 8.12

(a) Find out how far the car travels in the first 4 seconds. Shade, the area on the graph that represents the distance travelled by car during the period.

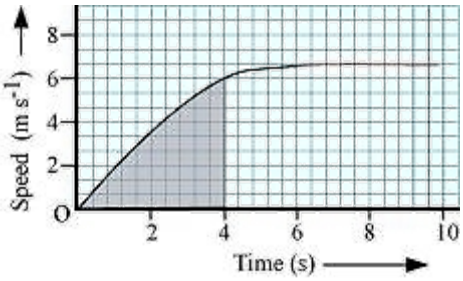
(b) Which part of the graph represents the uniform motion of the car?

Ans. (a)



The shaded area, which is equal to $\frac{1}{2}\times4\times6 = 12$ represents the distance travelled by car in the first 4 s.

(b)



The part of the graph in red colour between time 6 s to 10 s represents the uniform motion of the car.

9. State which of the following situations are possible and give an example for each of these.

(a) An object with a constant acceleration but with zero velocity.

(b) An object moving in a certain direction with an acceleration in the perpendicular direction.

Ans. (a) Possible

When a ball is thrown up at maximum height, it has zero velocity. However, it will have constant acceleration due to gravity, which is equal to 9.8 m/s^2.

(b) Possible

When a car is moving in a circular track, its acceleration is perpendicular to its direction.

10. An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth.

Ans. $Speed = \frac{Distance}{Time}$

$Distancee = 2\pi r = 2\times 3.14\times 42250 = 265330\ km$

$Time = 24h$

$Speed = \frac{265330}{24} = 11055.4 km/h.$