CHAPTER 10

Motion

1. NCERT INTEXT QUESTIONS

1. An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example.

Ans :

Yes, an object can have zero displacement provided that final position of the object coincides with its initial position.

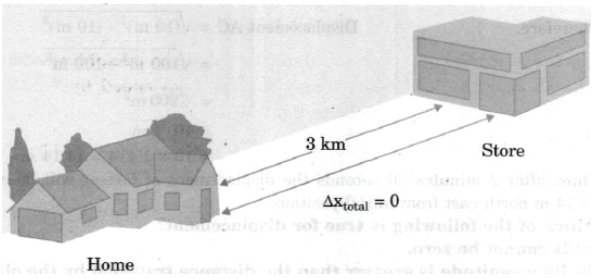


Figure: Showing distance and displacement covered by person

For example : If a person moves from home to store and stands on place from where he started then here displacement will be zero.

2. A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position?

Ans : :

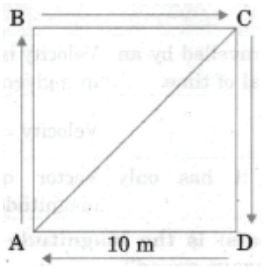


Figure: Boundary of a square field of side 10 m

Given,

Side of the square field = 10 m

So, perimeter = 10 m × 4 = 40 m

Farmer moves along the boundary in 40 s.

Displacement after 2 m 20 s = 2 × 60 s + 20 s

= 140 s = ?

Since in 40 s farmer moves 40 m.

Therefore, in 1 s distance covered by farmer

$$= \frac{40}{40}\text{ m} = 1\text{ m}$$

Therefore, in 140 s distance covered by farmer

$$= 1 \times 140\text{ m} = 140\text{ m}$$

Now, number of rotation to cover 140 along the boundary

$$= \frac{\text{Total distance}}{\text{Perimeter}}$$

$$= \frac{140\text{ m}}{40\text{ m}} = 3.5 \text{ round}$$

Thus, after 3.5 round farmer will at point C of the field.

Therefore,

$$\text{Displacement AC} = \sqrt{(10\text{ m})^2 + (10\text{ m})^2}$$
$$= \sqrt{100\text{ m}^2 + 100\text{ m}^2}$$
$$= \sqrt{200\text{ m}^2}$$
$$= 10\sqrt{2}\text{ m}$$
$$= 10 \times 1.414 = 14.14\text{ m}$$

Thus, after 2 minutes 20 seconds the displacement of farmer will be equal to 14.14 m north east from initial position.

3. Which of the following is true for displacement?

(a) It cannot be zero.

(b) Its magnitude is greater than the distance travelled by the object.

Ans :

None of the statement is true for displacement. First statement is false because displacement can be zero. Second statement is false as displacement is less than or equal to the distance travelled by the object.

4. Distinguish between speed and velocity.

Ans :

Speed	Velocity
Speed is the distance travelled by an object in a given interval of time.	Velocity is the displacement of an object in a given interval of time.
Speed $= \frac{\text{distance}}{\text{time}}$	Velocity $= \frac{\text{displacement}}{\text{time}}$
Scalar quantity, i.e. it has only magnitude.	Vector quantity, i.e. it has both magnitude as well as direction.

5. Under what condition(s) is the magnitude of average

velocity of an object equal to its average speed?

Ans :

The magnitude of average velocity of an object is equal to its average speed when an object is moving in a straight line in a given direction only.

6. What does the odometer of an automobile measure?

Ans :

The odometer of an automobile measures the distance covered by an automobile in given time.

7. What does the path of an object look like when it is in uniform motion?

Ans :

When an object having uniform motion, it moves along a straight line path.

8. During an experiment, a signal from a spaceship reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is, 3×10^8 ms^{-1}.

Ans :

$$\text{Speed} = 3 \times 10^8 \text{ ms}^{-1}$$
$$\text{Time} = 5 \text{ min} = 5 \times 60 = 300 \text{ seconds}$$
$$\text{Distance} = \text{Speed} \times \text{Time}$$
$$\text{Distance} = 3 \times 10^8 \text{ ms}^{-1} \times 300 \text{ seconds}$$
$$= 9 \times 10^{10} \text{ m}$$

9. When will you say a body is in (i) uniform acceleration? (ii) non-uniform acceleration?

Ans :

(i) A body is said to be in uniform acceleration if it travels in a straight line and its velocity increases or decreases by equal amounts in equal intervals of time.

(ii) A body is said to be in non-uniform acceleration if the rate of change of its velocity is not constant.

10. A bus decreases its speed from 80 km h^{-1} to 60 km h^{-1}. in 5 s. Find the acceleration of the bus.

Ans :

Initial speed of the bus,

$$u = 80 \text{ km/h} = 80 \times \frac{5}{18} = 22.2 \text{ m/s}$$
$$= 60 \times \frac{5}{18} = 16.6 \text{ m/s}$$

Final speed of the bus,

$$v = 60 \text{ km/h}$$

Time taken to decrease the speed, $t = 5$ s

Acceleration,

$$a = \frac{v - u}{t} = \frac{16.66 - 22.22}{5} = -1.112 \text{ m/s}^2$$

11. A train starting from a railway station and moving with uniform acceleration attains a speed 40 km h-1 in 10 minutes. Find its acceleration.

Ans :

Initial velocity of the train, $u = 0$

Final velocity of the train,

$$v = 40 \text{ km/h} = 40 \times \frac{5}{18} = 11.11 \text{ m/s}$$

Time taken,

$$t = 10 \text{ min} = 10 \times 60 = 600 \text{ s}$$

Acceleration,

$$a = \frac{v - u}{t} = \frac{11.11 - 0}{600} = 0.0185 \text{ m/s}^2$$

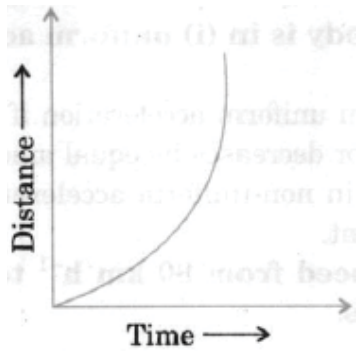
Hence, the acceleration of the train is 0.0185 m/s^2.

12. What is the nature of the distance-time graphs for uniform and non-uniform motion of an object?

Ans :

When the motion is uniform, the distance-time graph is a straight line having a definite slope. The slope tells us the value of constant velocity of the object.

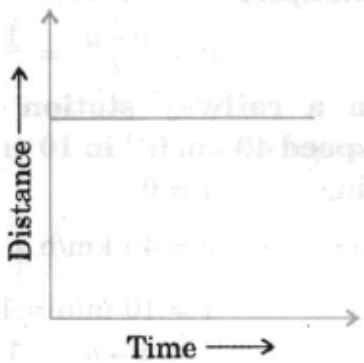
When the motion is non-uniform, the distance time graph is a curve whose slope varies from point to point.



13. What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis?

Ans :

If distance-time graph is a straight line parallel to the time axis, the body is at rest and the distance of the object does not change with time.



14. What can you say about the motion of an object if its speed-time graph is a straight line parallel to the time axis?

Ans :

If speed-time graph is a straight line parallel to the time axis, the object is moving uniformly.

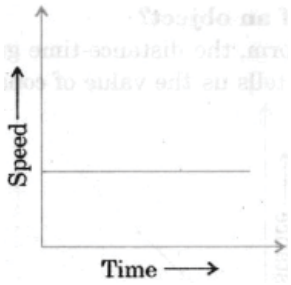


Figure:

15. What is the quantity which is measured by the area occupied below the velocity-time graph?

Ans :

Area occupied below the velocity-time graph of an object gives the magnitude of displacement or the distance covered during the given time interval.

16. A bus starting from rest moves with a uniform acceleration of 0.1 ms^{-2} for 2 minutes. Find (a) the speed acquired, (b) the distance travelled.

Ans :

Initial speed of the bus, $u = 0$

Acceleration, $a = 0.1\ m/s^2$

Time taken, $t = 2$ minutes $= 120$ s

(a) $v = u + at$

$v = 0 + 0.1 \times 120$

$v = 12\ ms^{-1}$

(b) According to the third equation of motion :

$$v^2 - u^2 = 2\ as$$

Where, s is the distance covered by the bus

$$(12)^2 - (0)^2 = 2(0.1)\ s$$

$$s = 720\ m$$

Speed acquired by the bus is 12 m/s.
Distance travelled by the bus is 720 m.

17. A train is travelling at a speed of 90 km h^{-1}. Brakes are applied so as to produce a uniform acceleration of – 0.5 m s^{-2}. Find how far the train will go before it is brought to rest.

Ans :

Initial speed of the train,

$$u = 90\ km/h = 25\ m/s$$

Final speed of the train,

$$v = 0 \text{ (finally the train comes to rest)}$$

Acceleration = – 0.5 m
According to third equation of motion :

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

$$(0)^2 = (25)^2 + 2\ (-0.5)\ s$$

Where, s is the distance covered by the train

$$s = \frac{25^2}{2(0.5)} = 625\ m$$

The train will cover a distance of 625 m before it comes to rest.

18. A trolley, while going down an inclined plane, has an acceleration of 2 cm s^{-2}. What will be its velocity 3 s after the start?

Ans :

Initial velocity of trolley, $u = 0\ cm\ s^{-1}$

Acceleration, $a = 2\ cm\ s^{-2}$

Time, $t = 3\ s$

We know that final velocity,

$$v = u + at$$

$$= 0 + 2 \times 3\ cm\ s^{-1}$$

Therefore, the velocity of train after 3 seconds = 6 cm s^{-1}

19. A racing car has a uniform acceleration of 4 ms^{-2}. What distance will it cover in 10 s after start?

Ans :

Initial velocity of the car, $u = 0\ ms^{-1}$

Acceleration, $a = 4\ m\ s^{-2}$

Time, $t = 10\ s$

We know, distance, $s = ut + (1/2)at^2$

Therefore, distance covered by car in 10 seconds

$$= 0 \times 10 + (1/2) \times 4 \times 102$$

$$= 0 + (1/2) \times 4 \times 10 \times 10\ m$$

$$= (1/2) \times 400\ m = 200\ m$$

20. A stone is thrown in a vertically upward direction with a velocity of 5 m s^{-1}. If the acceleration of the stone during its motion is 10 m s^{-2} in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?

Ans :

Given initial velocity of stone, u= 5 m s^{-1}
Downward of negative acceleration, a = –10 m s^{-2}
(acceleration is taken negative because it is in downward direction, i.e. the direction of acceleration is opposite to that of velocity.

We know that $2\ as = v^2 - u^2$
Therefore, height attained by the stone,

$$s = \frac{0^2}{5^2} \times (-10)\,m = \frac{-25}{-20}\,m = 1.25\ m$$

Also we know that final velocity,

$$v = u + at$$

or, $$\text{Time, } t = \frac{v-u}{a}$$

Therefore, time, t taken by stone to attain the height,

$$s = \frac{0-5}{-10\,s} = 0.5\ s$$

2. NCERT EXERCISE QUESTIONS

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 circular track, D = 200 m

Radius of circular track, $r = \frac{200}{2} = 100$ m

Time taken by the athlete for one round (t) = 40 s
Distance covered by athlete in one round

$$s = 2\pi r = 2 \times \frac{22}{7} \times 100$$

Speed of the athlete

$$v = \frac{\text{Distance}}{\text{Time}} = \frac{2 \times 2200}{7 \times 40} = \frac{4400}{7 \times 40}$$

Therefore, distance covered in 140 s

$$= \text{Speed (s)} \times \text{Time (t)}$$

$$= \frac{4400}{7 \times 40} \times (2 \times 60 + 20)$$

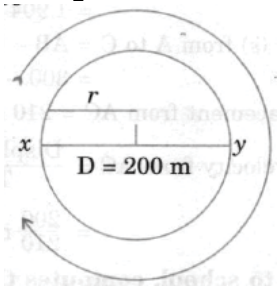
$$= \frac{4400}{7 \times 40} \times 140$$

$$= \frac{4400 \times 140}{7 \times 40} = 2200\,\text{m}$$

Number of round in 40 s = 1 round

Number of round in 140 s $= \frac{140}{40} = 3\frac{1}{2}$

After taking start from position X, the athlete will be at position Y after $3\frac{1}{2}$ rounds as shown in figure



Hence, displacement of the athlete with respect to initial position at x = xy

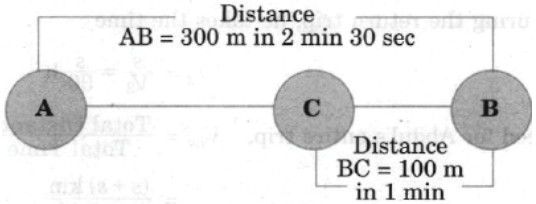
$$= \text{Diameter of circular track}$$

$$= 200\ \text{m}$$

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 : :

Total distance covered from AB = 300 m
Total time taken = 2 × 60 + 30 s = 150 s



Therefore, average speed from AB

$$= \frac{\text{Total Distance}}{\text{Total Time}} = \frac{300}{150}\ \text{ms}^{-1}$$

$$= 2\ \text{m s}^{-1}$$

Therefore, velocity from AB

$$= \frac{\text{Displacement AB}}{\text{Time}}$$

$$= \frac{300}{150}\ \text{ms}^{-1}$$

$$= 2\ \text{m s}^{-1}$$

Total distance covered from AC

$$= \text{AB} + \text{BC}$$

$$= 300 + 200\ \text{m}$$

Total time taken from A to C

= Time taken for AB + Time taken for BC

$$= (2 \times 60 + 30) + 60\ \text{s} = 210\ \text{s}$$

Therefore, average speed from AC

$$= \frac{\text{Total Distance}}{\text{Total Time}}$$

$$= \frac{400}{210}\ \text{m s}^{-1}$$

$$= 1.904\ \text{m s}^{-1}$$

Displacement (s) from A to C

$$= \text{AB} - \text{BC}$$

$$= 300 - 100\ \text{m} = 200\ \text{m}$$

Time (t) taken for displacement from AC = 210 s
Therefore, velocity from AC

$$= \frac{\text{Displacement (s)}}{\text{Time (t)}} = \frac{200}{210}\ \text{m s}^{-1} = 0.952\ \text{m s}^{-1}$$

3. Q. a. 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 :

Let the distance of Abdul's school from his residence be s km.
As during his trip from his residence to school, his average speed,

$$V_1 = 20\ \text{km h}^{-1}$$

Hence, in covering a distance s km, he takes the time

$$t_1 = \frac{s}{V_1} = \frac{s}{20} h$$

Similarly, during the return trip, he takes the time

$$t_2 = \frac{s}{V_2} = \frac{s}{30} h$$

Average speed for Abdul's entire trip,

$$V_{av} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{(s+s)\,\text{km}}{(t_1+t_2)\,\text{h}}$$

$$V_{av} = \frac{(s+s)\,\text{km}}{\left(\frac{s}{20}+\frac{s}{30}\right)\text{h}} = \frac{2s\,\text{km}}{\left(\frac{s}{12}\right)\text{h}} = 2 \times 12\ \text{km h}^{-1}$$

$$= 24\ \text{km h}^{-1}$$

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 :

Given initial velocity of motorboat, u = 0
Acceleration of motorboat, a = 3.0 m s^{-2}
Time under consideration, t = 8.0 s
We know that distance, $s = ut + (1/2)at^2$
Therefore, the distance travel by motorboat

$$= 0 \times 8 + (1/2)3.0 \times 8^2$$
$$= (1/2) \times 3 \times 8 \times 8 \text{ m} = 96 \text{ m}$$

5. A driver of a car 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 :

PR and SQ are the speed-time graph for given two cars with initial speeds 52 km h^{-1} and 3 km h^{-1} respectively (given in figure).

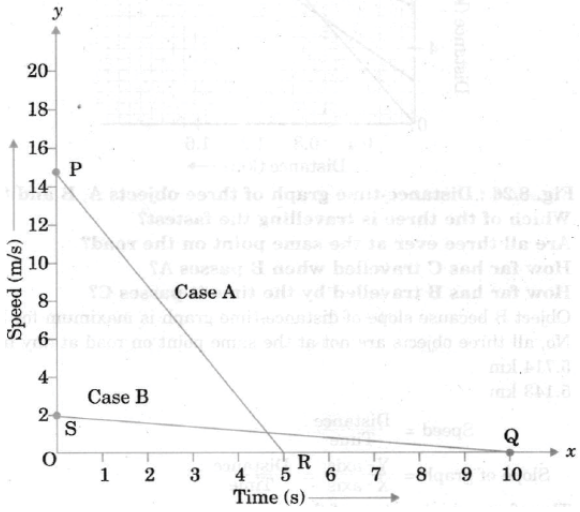


Figure: Speed-time graph for given two cars

Distance travelled by first car before coming to rest = Area of AOPR

$$= (1/2) \times \text{OR} \times \text{OP} = (1/2) \times 5\text{s} \times 52 \text{ kmh}^{-1}$$
$$= \left(\frac{1}{2}\right) \times 5 \times \left[\frac{(52 \times 1000)}{3600}\right] \text{m}$$
$$= \left(\frac{1}{2}\right) \times 5 \times \left(\frac{130}{9}\right) \text{m}$$
$$= \frac{325}{9} \text{ m} = 36.11 \text{ m}$$

Distance travelled by second car before coming to rest = Area of ΔOSQ

$$= \left(\frac{1}{2}\right) \times \text{OQ} \times \text{OS} = \left(\frac{1}{2}\right) \times 10 \text{ s} \times 3 \text{ kmh}^{-1}$$
$$= \left(\frac{1}{2}\right) \times 10 \times \left[\frac{(3 \times 1000)}{3600}\right] \text{m}$$
$$= \left(\frac{1}{2}\right) \times 10 \times \left(\frac{5}{6}\right) \text{m}$$
$$= 5 \times \left(\frac{5}{6}\right) \text{m} = \frac{25}{6} \text{ m} = 4.16 \text{ m}$$

6. Figure shows the distance-time graph of three objects A, B and C. Study the graph and answer the following questions :

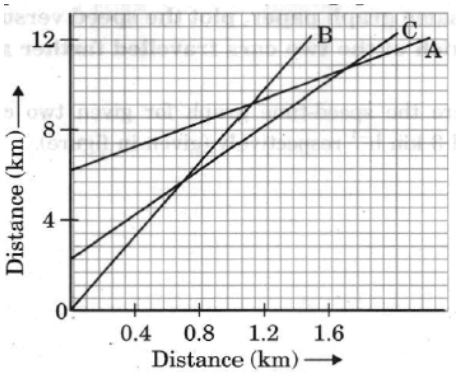


Figure: Distance-time graph of three objects A, B and C

(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 :

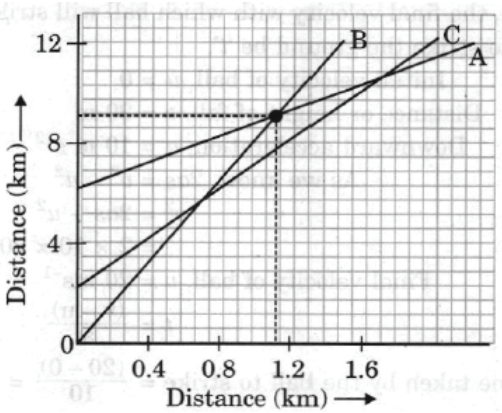
(a) $$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Slope of graph} = \frac{\text{Y–axis}}{\text{X–axis}} = \frac{\text{Distance}}{\text{Time}}$$

Therefore, speed = slope of the graph
Since 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 road.

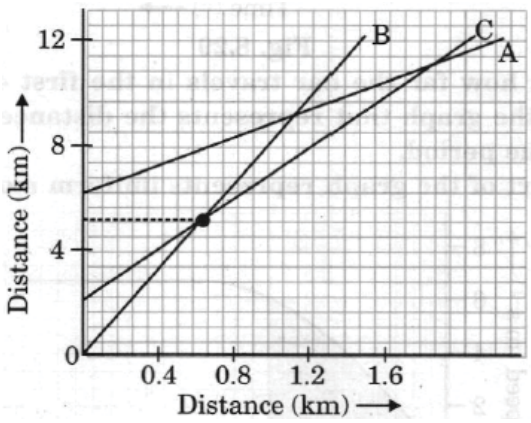
(c)



7 square box = 4 km
1 square box = $\frac{4}{7}$ km
C is 4 blocks away from origin, therefore, initial distance of C from origin = $\frac{16}{7}$ km
Distance of C from origin when B passes A = 8 km
Thus, distance travelled by C when B passes A

$$= 8 - \frac{16}{7} = \frac{(56 - 16)}{7} = \frac{40}{7} = 5.714 \text{ km}$$

(d)



Distance travelled by B by the time it passes C = 9 square boxes

$$9 \times \frac{4}{7} = \frac{36}{7} = 5.143 \text{ km}$$

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 :

Let us assume, the final velocity with which ball will strike the ground be and time it takes to strike the ground be t.
Initial velocity of ball, u = 0
Distance or height of fall, s = 20 m
Downward acceleration, a = 10 m s^{-2}

As we know, $2as = v^2 - u^2$

$$v^2 = 2as + u^2$$
$$= 2 \times 10 \times 20 + 0 = 400$$

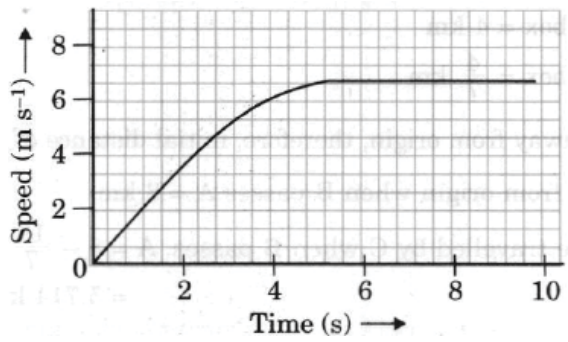
Final velocity of ball,

$$v = 20 \text{ ms}^{-1}$$
$$t = \frac{(v-u)}{a}$$

Time taken by the ball to strike

$$= \frac{(20-0)}{10} = \frac{20}{10} = 2 \text{ seconds}$$

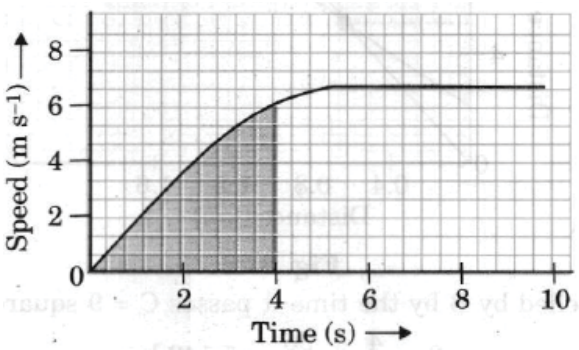
8. The speed-time graph for a car is shown in figure.



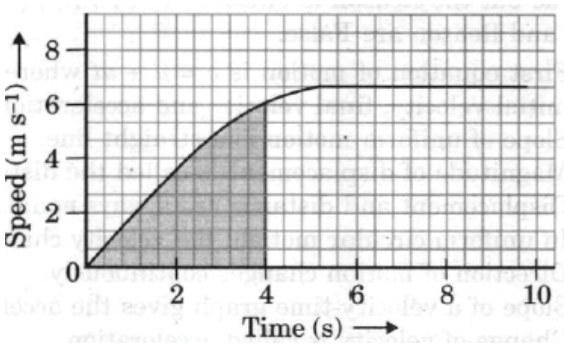
(a) Find out how far the car travels in the first 4 seconds. Shade the area on the graph that represents the distance travelled by the car during the period.
(b) Which part of the graph represents uniform motion of the car?

Ans :

(a)



The shaded area which is equal to $\frac{1}{2} \times 4 \times 6$ = 12 m represents the distance travelled by the car in the first 4 s.
(b)



The part of the graph between time 6 s to 10 s represents 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 a ball has zero velocity when a ball is thrown up at maximum height. It will have constant acceleration due to gravity, which is equal to 9.8 m/s^2.
(b) Possible a car's acceleration is perpendicular to its direction when a car is moving in a circular track.

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 :

Radius of the circular orbit, r = 42250 km
Time taken to revolve around the Earth, t = 24 h
Speed of a circular moving object,

$$v = \frac{(2\pi r)}{t}$$
$$= \frac{\left[2 \times \left(\frac{22}{7}\right) \times 42250 \times 1000\right]}{(24 \times 60 \times 60)}$$
$$= \frac{(2 \times 22 \times 42250 \times 1000)}{(7 \times 24 \times 60 \times 60)} \text{ ms}^{-1}$$
$$= 3073.74 \text{ ms}^{-1}$$

3. NCERT EXEMPLAR

Objective Type Questions

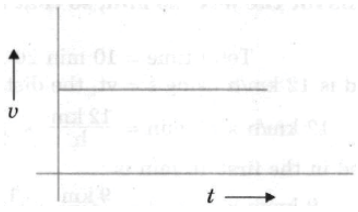
1. A particle is moving in a circular path of radius r. The displacement after half a circle would be :
(a) Zero (b) πr
(c) 2r (d) $2\pi r$
Ans : (c) 2r

2. A body is thrown vertically upward with velocity u, the greatest height h to which it will rise is :
(a) u/g (b) $u^2/2g$
(c) u^2/g (d) u/2g
Ans : (b) $u^2/2g$

3. The numerical ratio of displacement to distance for a moving object is :
(a) Always less than 1 (b) Always equal to 1
(c) Always more than 1 (d) Equal or less than 1
Ans : (d) Equal or less than 1

4. If the displacement of an object is proportional to square of time, then the object moves with :
(a) Uniform velocity
(b) Uniform acceleration
(c) Increasing acceleration
(d) Decreasing acceleration
Ans : (b) Uniform acceleration

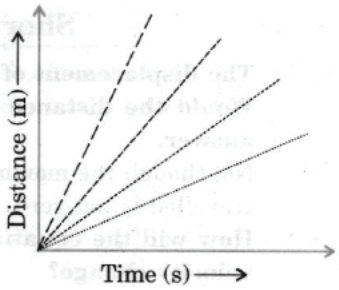
5. From the given v - t graph figure, it can be inferred that the object is :



(a) In uniform motion
(b) At rest
(c) In non-uniform motion
(d) Moving with uniform acceleration
Ans : (a) In uniform motion

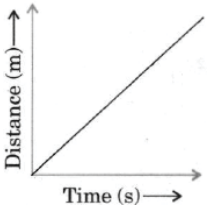
6. Suppose a boy is enjoying a ride on a merry-go-round which is moving with a constant speed of 10 m s^{-1}. It implies that the boy is :
(a) At rest
(b) Moving with no acceleration
(c) In accelerated motion
(d) Moving with uniform velocity
Ans : (c) In accelerated motion

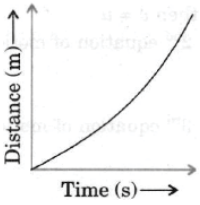
7. Four cars A, B, C and D are moving on a levelled road. Their distance versus time graphs are shown in figure.

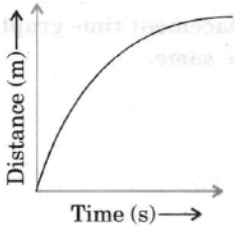


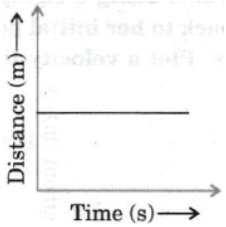
Choose the correct statement :
(a) Car A is faster than car D.
(b) Car B is the slowest.
(c) Car D is faster than car C.
(d) Car C is the slowest.
Ans : (b) Car B is the slowest.

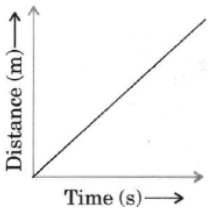
8. Which of the following figure represents uniform motion of a moving object correctly?

(a)


(b)


(c)


(d)


Ans : (a)


9. Area under a v - t graph represents a physical quantity which has the unit:
(a) m^2 (b) m
(c) m^3 (d) m s^{-1}
Ans : (b) m

10. Slope of a velocity-time graph gives :
(a) The distance (b) The displacement
(c) The acceleration (d) The speed
Ans : (c) The acceleration

11. In which of the following cases of motions, the distance moved and the magnitude of displacement are equal?
(a) If the car is moving on straight road.
(b) If the car is moving in circular path.
(c) The pendulum is moving to and fro.
(d) The Earth is revolving around the Sun.

Ans : (a) If the car is moving on straight road.

Short Answer Questions

12. The displacement of a moving object in a given interval of time is zero. Would the distance travelled by the object also be zero? Justify your answer.

Ans :

No, though the moving object comes back to its initial position the distance travelled is not zero.

13. How will the equations of motion for an object moving with a uniform velocity change?

Ans :

In uniform motion, if acceleration (a) = 0
So, 18t equation of motion becomes,

$$v = u + at$$

If a = 0 then v = u
If a = 0, 2nd equation of motion becomes,

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

$$s = ut$$

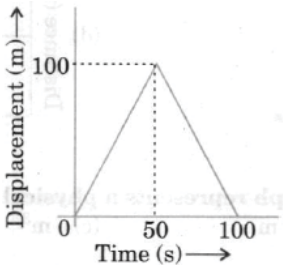
If a = 0, 3rd equation of motion becomes,

$$v^2 - u^2 = 2as$$

$$v^2 - u^2 = 0$$

14. A girl walks along a straight path to drop a letter in the letterbox and comes back to her initial position. Her displacement-time graph is shown in figure. Plot a velocity-time graph for the same.

Ans :



From the graph, we get
Initial velocity (u) = 0 (As time and displacement are zero.)

Velocity after 50 s, $v = \dfrac{\text{Displacement}}{\text{Time}}$

By substituting the values, we get

$$v = \frac{100}{50} = 2 \text{ ms}^{-1}$$

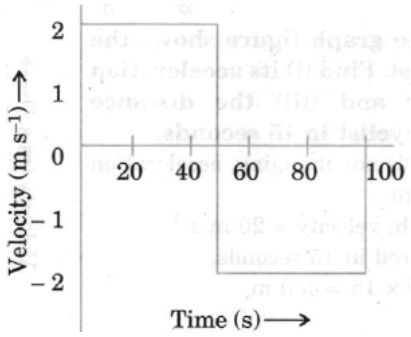
Velocity after 100 s, $v = \dfrac{\text{Displacement}}{\text{Time}}$

Displacement = 0; Time = 100 s
Therefore,
By substituting the values, we get

$$v = \frac{0}{100} = 0$$

V	0	2	0
t	0	50	100

Velocity-time graph for above data :



15. A car starts from rest and moves along the x-axis with constant acceleration 5 ms^{-2} for 8 seconds. If it then continues with constant velocity, what distances will the car cover in 12 seconds since it started from the rest?

Ans :

As the car moves from rest, therefore, u = 0, a = 5 ms 2, t = 8 sec, distance (s) = ?

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

$$= 0 + \tfrac{1}{2} \times 5 \times (8)^2$$

$$= 0 + \frac{320}{2}$$

$$= 160 \text{ m}$$

To calculate the velocity after 8 sec,

$$v = u + at$$

$$= 0 + 5 \times 8 = 40 \text{ m/s}$$

So, the distance travelled with this velocity for remaining 4 sec (12 s – 8 s = 4 s)

$$s'' = 40 \times 4 = 160 \text{ m}$$

Therefore, total distance travelled by the car

$$= s' + s''$$

$$= 160 + 160 = 320 \text{ m}$$

16. A motorcyclist drives from A to B with a uniform speed of 30 km h-1 and returns back with a speed of 20 km h^{-1}. Find its average speed.

Ans :

Let the distance (AB) = x, therefore, total distance = x + x = 2x (as it returns back)

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

Therefore, $t_1 = \dfrac{x}{30}$;

t_2 (return trip) $= \dfrac{x}{20}$

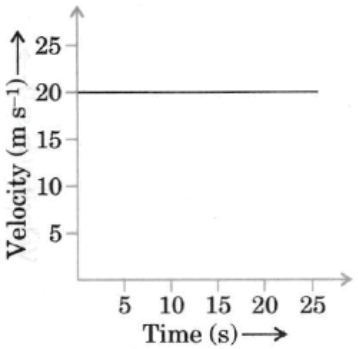
Total time taken $= t_1 + t_2$

Total time taken $= \dfrac{x}{30} + \dfrac{x}{20} = \dfrac{5x}{60}$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time taken}} = \frac{2x}{\frac{5x}{60}}$$

$$= 2x \times \frac{60}{5x} = \frac{120}{5} = 24 \text{ km/hr}$$

17. The velocity-time graph figure shows the motion of a cyclist. Find (i) its acceleration (ii) its velocity and (iii) the distance covered by the cyclist in 15 seconds.



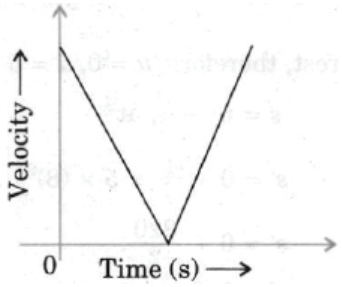
Ans :

(i) Since velocity is not changing, acceleration is equal to zero.
(ii) Through graph, velocity = 20 m s^{-1}
(iii) Distance covered in 15' seconds,

$$s = u \times t = 20 \text{ x } 15 = 300 \text{ m}$$

18. Draw a velocity versus time graph of a stone thrown vertically upwards and then coming downwards after attaining the maximum height.

Ans :



Long Answer Questions

19. An object is dropped from rest at a height of 150 m and simultaneously another object is dropped from rest at a height of 100 m. What is the difference in their heights after 2 s if both the objects drop with same accelerations? How does the difference in heights vary with time?

Ans :

Initial difference in height

$$h = (150 - 100) \text{ m} = 50 \text{ m}$$

Both the objects are dropped simultaneously from rest (zero velocity),
Distance travelled by first body in 2 s

$$d_1 = ut + \tfrac{1}{2}at^2$$

Initial speed = 0 (as the object was at rest), t = 2s
Therefore, by substituting the values we get

$$= 0 + \tfrac{1}{2}g\,(2)^2 = 2 \text{ g}$$
$$= 2 \times 9.8 = 19.6 \text{ m}$$

Where, g = 9.8
Distance travelled by another body in

$$2s = d_2 = 0 + \tfrac{1}{2}\text{ g } (2)^2$$
$$= 2g = 19.6 \text{ m}$$

After 2s, height at which the first body will be

$$h_1 = 150 - 19.6$$

After 2s, height at which the second body will be

$$h_2 = 100 - 19.6$$

Thus, after 2s, difference in height

$$= h_1 - h_2$$
$$= 150 - 19.6 - (100 - 19.6)$$
$$= 50 \text{ m}$$

After 2s, the difference in height will be 50 m = Initial difference in height (h)
Thus, difference in height does not vary with time.

20. An object starting from rest travels 20 m in first 2 s and 160 m in next 4 s. What will be the velocity after 7 s from the start?

Ans :

Let's acceleration of the body be 'a'.
Therefore, in order to find the acceleration of the body, we use

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

Where, u = 0, t = 2s and s = 20 m, a = ?
Therefore, by substituting the values we get,

$$20 = 0 + \tfrac{1}{2} \times a \times (2)^2$$
$$20 = \tfrac{1}{2} \times 4a$$
$$a = 20 \times \tfrac{2}{4} = 10 \text{ m/s}$$

To find final velocity (v), we use

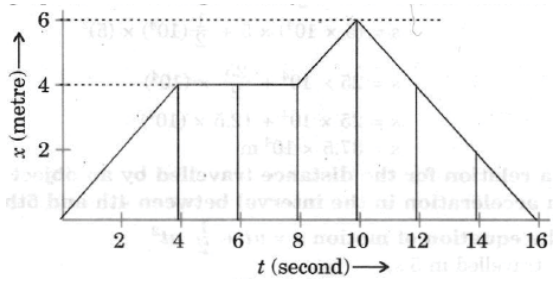
$$v = u + at$$
$$v = 0 + 10 \times 7$$
$$v = 70 \text{ m/s}$$

21. Using following data, draw time-displacement graph for a moving object-

Time (s)	0	2	4	6	8	10	12	14	16
Displacement (m)	0	2	3	4	4	6	4	2	0

Ans :

Use this graph to find average velocity for first 4 s, for next 4 s and for last 6 s.



Average velocity for first 4 s :

$$\text{Average velocity} = \frac{\text{Change in displacement}}{\text{Total time taken}}$$

$$v = \frac{4-0}{4-0} = \frac{4}{4} = 1 \text{ ms}^{-1}$$

For next 4 s, $v = \dfrac{4-4}{8-4}$

$$v = \frac{0}{4} = 0 \text{ ms}^{-1}$$

As x (metre) remains the same from 4 to 8 seconds, velocity is zero (refer the graph)

For last 6 s, $v = \frac{0-6}{16-10} = -1 \text{ ms}^{-1}$

22. An electron moving with a velocity of 5×10^4 m s^{-1} enters into a uniform electric field and acquires a uniform acceleration of 10^4 m s^{-2} in the direction of its initial motion.
(i) Calculate the time in which the electron would acquire a velocity double of its initial velocity.
(ii) How much distance the electron would cover in this time?

Ans :

Given,

Initial velocity, $u = 5 \times 10^4 \text{ ms}^{-1}$

and acceleration, $a = 10^4 \text{ m s}^{-2}$

(i)Final velocity = $v = 2u$

$v = 2 \times (5 \times 10^4 \text{ ms}^{-1})$

$= 10 \times 10^4 \text{ m s}^{-1}$; $t = ?$

$v = u + at$ or $t = \frac{v-u}{a}$

$= \frac{(10 \times 10^4) - (5 \times 10^4)}{10^4}$

$= \frac{5 \times 10^4}{10^4} = 5 \text{ s}$

(ii) $t = 5$ s; $a = 104$ m s^{-2}; $u = 5 \times 10^4$ m s^{-1}; $s = ?$
Now using the formula,

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

$s = (5 \times 10^4) \times 5 + \frac{1}{2}(10^4) \times (5)^2$

$s = 25 \times 10^4 + \frac{25}{2} \times (10^4)$

$s = 25 \times 10^4 + 12.5 \times (10^4)$

$s = 37.5 \times 10^4 \text{ m}$

23. Obtain a relation for the distance travelled by an object moving with a uniform acceleration in the interval between 4th and 5th seconds. Using the equation of motion $s = ut + \frac{1}{2} at^2$

Ans :

Distance travelled in 5 s,

$s = u \times 5 + \frac{1}{2} \times a \times (5)^2$

$s = 5u + \frac{25}{2} a$ ...(i)

Similarly, distance travelled in 4 s,

$s' = 4u + \frac{16}{2} a$ ...(ii)

Distance travelled in the interval between 4^{th} and 5^{th} seconds

$= (s - s') = \left(u + \frac{9}{2}a\right)$ m

24. Two stones are thrown vertically upwards simultaneously with their initial velocities u_1 and u_2 respectively. Prove that the heights reached by them would be in the ratio of $u_1^2 : u_2^2$ (Assume upward acceleration is – g and downward acceleration to be + g).

Ans :

We know for upward motion,

$v^2 = u^2 - 2gh$

Therefore, $h = \frac{v^2 - u^2}{2g}$

But at highest point $v = 0$

Therefore, $h = \frac{u^2}{2g}$

For first ball, $h_1 = \frac{u_1^2}{2g}$

For second ball, $h_2 = \frac{u_2^2}{2g}$

Thus, $\frac{h_1}{h_2} = \frac{u_1^2/2g}{u_2^2/2g} = \frac{u_1^2}{u_2^2}$ or

or $h_1 : h_2 = u_1^2 : u_2^2$

Thus, proved.

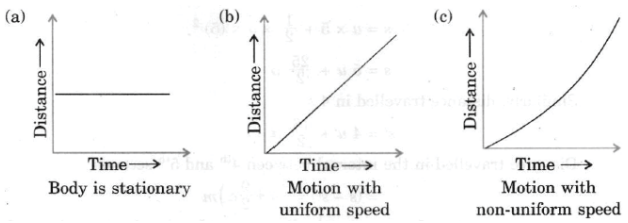
25. Give one example each of type of motion when :
(a) acceleration is positive.
(b) acceleration is negative.
(c) acceleration is zero.

Ans :

(a) When the driver of a car starts motion from rest and increases its velocity, acceleration is positive.
(b) When driver of a running car/train applies brakes so as to stop the car/train, acceleration is negative.
(c) When train is running at constant, velocity along a straight railway track, its acceleration is zero.

26. Draw distance time graph for following situations
(a) When body is stationary.
(b) When body is moving with a uniform speed.
(c) When body is moving with non-uniform speed.

Ans :



27. State two advantages of plotting velocity-time graph.

Ans :

Two advantages of plotting velocity time graph of an object are as follows :
(a) It tells us variation of velocity of object with time.
(b) By finding slope of velocity time graph, we can determine the acceleration of object. Similarly, area under velocity time graph gives the value of distance covered by the object during a given time interval.

28. State three equations of motion. Which of them describes :
(a) Velocity-time relation, and

(b) Position-time relation.

Ans :

Three equations of motion are as follows :

(i) $v = u + at$

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

(iii) $2as = v^2 - u^2$

(a) The first equation $v = u + at$ gives velocity time relation.

(b) The second equation $s = ut + \frac{1}{2}at^2$ gives the position-time relation.

29. A person travelling in bus noted the timing and the corresponding distances as indicated on the kilometre stones on the road :

Time	8:00 am	8:15 am	8:30 am	8:45 am	9:00 am
Distance	10 km	20 km	30 km	40 km	50 km

(a) Name this type of table.

(b) What conclusion do you draw from data?

Ans :

(a) The table is called distance time table.

(b) An analysis of data showed that in every 15 minutes time interval, the bus is covering a distance of 10 km. Thus, the bus is in state of uniform motion having constant speed

$$V = \frac{10\text{ km}}{15\text{ min}} = \frac{10}{\frac{15}{60}\text{h}} = 40\text{ km/h}$$

30. Examine the data given below formation of two different objects A and B carefully and state whether the motion of the object is uniform or non-uniform. Give reasons.

Time	9:30 am	9:45 am	10:00 am	10:15 am	10:30 am	10:45 am	11:00 am
Distance travelled by object A (m)	10	20	30	40	50	60	70
Distance travelled by object B (m)	12	19	23	35	37	41	44

Ans :

Examination of the given data shows that motion of object A is uniform because it covers equal distances of 10 m each in equal intervals of time of 15 minutes. However, motion of object B is non-uniform because it covers unequal distances in equal intervals of time.

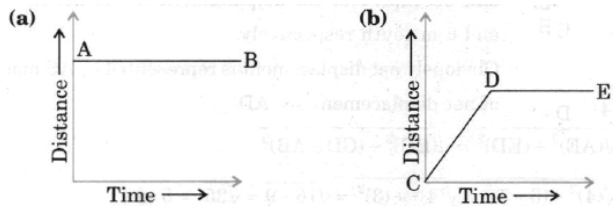
31. Giving one example each, distinguish between uniform acceleration and non-uniform acceleration.

Ans :

Acceleration is said to be uniform if velocity of an object changes equally in equal intervals of time. Motion of a freely falling object is uniformly accelerated one at a rate of about 10 m/s.

Acceleration is said to be non-uniform is velocity of an object changes unequally in equal intervals of time. Motion of a vehicle on a crowded street is having non-uniform acceleration.

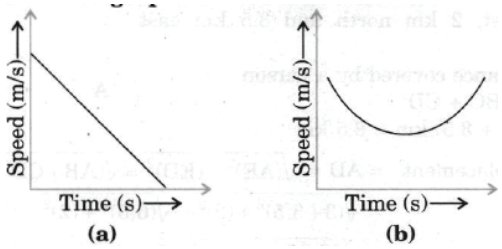
32. What kind of motion of a body is represented by graphs given along side.



Ans :

The graph shown in fig. (a) is a straight line II to time axis and it indicates that the given body is at reset. The graph (b) indicates uniform motion for region CD but thereafter the body comes to rest.

33. What do speed-time graphs shown here indicate?



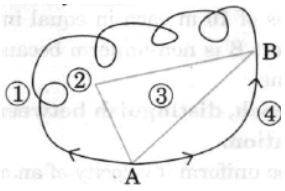
Ans :

Speed-time graph of fig. (a) represents uniformally accelerated motion having negative acceleration. Speed time graph of fig. (b) represent a non-uniform acceleration.

34. "Displacement of an object is independent of path followed by it." Justify.

Ans :

Displacement of an object depends on its initial position and final position and is independent of the path followed by it because it is the shortest distance from initial position to final position. In adjoining figure we have shown for possible paths for motion from A to B. Although path's lengths for these paths are different but displacements are exactly same.



35. A particle moves 3 m north, then 4 m east and finally 6 m south. Calculate the magnitude of displacement.

Ans :

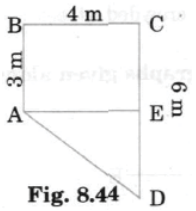


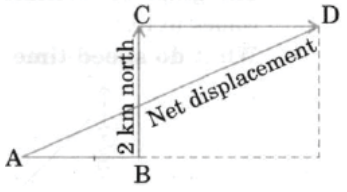
Fig. 8.44

As shown in fig. let us consider east-west direction along x-axis and north-south direction along y-axis. Then AB, BC and CD represent the displacement of 3 m north, 4 m east and 6 m south respectively.
Obviously net displacement is represented by AB magnitude of net displacement

$$\begin{aligned} s &= AD \\ &= \sqrt{(AE)^2 + (ED)^2} \\ &= \sqrt{(BC)^2 + (CD - AB)^2} \\ &= \sqrt{(4)^2 + (6-3)^2} \ = \sqrt{(4)^2 + (3)^2} \\ &= \sqrt{16+9} \ = \sqrt{25} \ = 5 \text{ m} \end{aligned}$$

36. A person moves a distance of 3 km towards east then 2 km towards north and then 3.5 km towards east. Find :
(a) The distance covered by the person, and
(b) the displacement of his motion.

Ans :



As shown AB, BC and CD represent the distance of 3 km east, 2 km north and 3.5 km east respectively.
(a) Net distance covered by a person

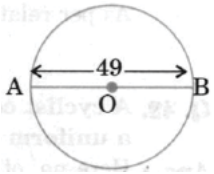
$$\begin{aligned} &= AB + BC + CD \\ &= (3 + 2 + 3.5) \text{ km} = 8.5 \text{ km} \end{aligned}$$

(b) Net displacement

$$\begin{aligned} AD &= \sqrt{(AE)^2 + (ED)^2} \\ &= \sqrt{(AB + CD)^2 + (BC)^2} \\ &= \sqrt{(3+3.5)^2 + (2)^2} \\ &= \sqrt{(6.5)^2 + (2)^2} \\ &= \sqrt{42.25 + 4} \\ &= \sqrt{46.25} \\ &= 6.8 \text{ km} \end{aligned}$$

37. An athlete completes one round of a circular track of diameter 49 m in 20 s. Calculate the distance covered of displacement at end of 30 s.

Ans :



Here, diameter = 49 cm
As an athlete completes one round of a circular track in a period T= 20 s, hence in time t = 30 s, he will complete n $= \frac{30}{20} = 1.5$ rounds. Thus, he will beat point B diagonally opposite to initial position A

$$\text{Displacement} = AB = D = 49 \text{ m}$$

Distance covered

$$\begin{aligned} n(2\pi r) &= n(\pi D) \\ &= 1.5 \times \frac{22}{7} \times 49 \\ &= 231 \text{ m} \end{aligned}$$

38. An electric train is moving with a velocity of 120 km/h. How much distance will it cover in 30 s?

Ans :

Constant velocity of train

$$V = 120 \text{ km/h}$$

$$120 \times \frac{5}{18} = \frac{100}{3} \text{ m/s, time t = 30 s}$$

Distance covered

$$\begin{aligned} s &= vt \\ &= \frac{100}{3} \times 30 = 1000 = 1.0 \text{ km}. \end{aligned}$$

39. On a 120 km track, a train travels the first 30 km at uniform speed of 30 km/h. Calculate the speed with which the train should move rest of the track so as to get the average speed of 60 km/h for entire trip.

Ans :

As the average speed of a train for entire journey s = 120 km is V_{av} = 60 km/h
Hence, total time taken by train to cover the journey

$$t = \frac{s}{V_{av}} = \frac{120 \text{ km}}{60 \text{ km/h}} = 2\text{h}$$

Time taken to travel first 30 km at uniform speed of 30 km/h

$$t_1 = \frac{30 \text{ km}}{30 \text{ km/h}} = 1 \text{ hr}$$

Time for covering remaining distance [120 – 30] = 90 km should be

$$t_2 = t - t_1 = (2 - 1)\text{h} = 1 \text{ h}$$

Constant speed of train for this journey

$$V_2 = \frac{s_2}{t_2} = \frac{90 \text{ km}}{1 \text{ h}} = 90 \text{ km/h}$$

40. A girl while riding a bicycle moves with the speed of 10 km/h for 2 hours and with the speed of 15 km/h in next 2 hours. Find the total distance moved by her and her average speed.

Ans :

Distance moved by girl in time (t_1) = 2h with a speed V_1 = 10 km/h is given as

$$s_1 = V_1 t_1 = 10 \times 2 = 20 \text{ km}$$

and distance moved by girl in subsequent time t_2 =3 h with speed V_2 = 15 km/h
is given as :

$$s_2 = V_2 t_2 = 15 \text{ x } 3 = 45 \text{ km}$$

Total distance moved by girl = 20 + 45 = 65

Her average speed for entire journey V_{av}

$$= \frac{\text{Total distance}}{\text{Total time}} = \frac{s}{t_1 + t_2}$$

$$= \frac{65}{5} = 13 \text{ km/h}$$

41. A marble rolling on the smooth has a initial velocity of 0.4 m/s. If the floor offers a retardation of 0.02 m/s, calculate the time it will take to come to rest.

Ans :

Here initial velocity u = 0.4 m/s, final velocity v = 0, acceleration a = – 0.02 m/s

As per relation v = u + at

$$t = \frac{v - u}{a} = \frac{0 - 0.4}{-0.02} = \frac{-0.4}{-0.02}$$

$$= 20 \text{ s}$$

42. A cyclist completes 8 revolutions of a circular track of radius 98 m with a uniform speed in 40 minutes. Calculate the speed.

Ans :

Here no. of revolutions completed by the cyclist n = 8, radius of circular track r = 98 and time,
t = 40 min = 40 x 60 s = 2400 s
Uniform speed of cyclist

$$v = \frac{\text{Total distance}}{\text{Total time}} = \frac{2\pi rh}{t}$$

$$= \frac{2 \times \frac{22}{7} \times 98 \times 98}{2400} = 0.05 \text{ m/s}$$

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Science IX

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