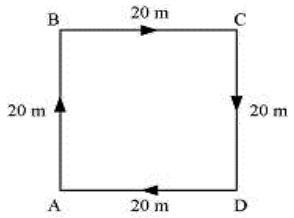
Board – CBSE | Class –9th | Topic – Motion

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 that has moved through a distance can have zero displacement. Displacement is the shortest measurable distance between the initial and the final position of an object. An object which has covered a distance can have zero displacement if it comes back to its starting point, i.e., the initial position.

Consider the following situation. A man walks in a square park of 20 m (as shown in the following figure). He starts walking from point A, and after moving along all the corners of the park (point B, C, D), he returns to the same point, i.e., A.



In this case, the total distance covered by the man is 20 m + 20 m + 20 m + 20 m = 80 m. However, his displacement is zero because the shortest distance between his initial and final position is 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?

Ans. The farmer takes 40 s to cover $4 \times 10 = 40$ m.

In 2 min and 20 s (140 s), he will cover a distance $= \frac{40}{40} \times 140 = 140\ m$

Therefore, the farmer completes $\frac{140}{40} = 3.5$ rounds (3 complete rounds and a half round) of the field in 2 min and 20 s.

That means, after 2 min 20 s, the farmer will be at the opposite end of the starting point.

Now, there can be two extreme cases.

Case I. The starting point is a corner point of the field.

In this case, the farmer will be at the diagonally opposite corner of the field after 2 min 20 s.

Therefore, the displacement will be equal to the diagonal of the field.

Hence, the displacement will be $\sqrt{10^2 + 10^2} = 14.1\ m$

Case II. The starting point is the middle point of any side of the field.

In this case, the farmer will be at the middle point of the opposite side of the field after 2 min 20 s.

Therefore, the displacement will be equal to the side of the field, i.e., 10 m.

For any other starting point, the displacement will be between 14.1 m and 10 m.

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. (a) Not true

Displacement can become zero when the initial and final position of the object is the same.

(b) Not true

Displacement is the shortest measurable distance between the initial and final positions of an object. It cannot be greater than the magnitude of the distance travelled by an object. However, sometimes, it may be equal to the distance travelled by the object.

4. 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. The radius of the circular orbit, r= 42250 km

Time taken to revolve around the earth, t= 24 h

Speed of a circular moving object, $v = \frac{2\pi r}{t}$

$= \frac{2\times3.14\times42250}{24} = 1.105\times10^{4} km/h = 3.069 km/s$

Hence, the speed of the artificial satellite is 3.069 km/s.

5. Distinguish between speed and velocity.

Speed	**Velocity**
Speed is the distance travelled by an object in a given interval of time. It does not have any direction.	Velocity is the displacement of an object in a given interval of time. It has a unique direction.
Speed is given by the relation. $Speed = \frac{Distance\ travelled}{Time\ taken}$	Velocity is given by the relation. $Velocity = \frac{Displacement}{Time\ interval}$

The speed of an object can never be negative. At the most, it can become zero. This is because the distance travelled can never be negative.	The velocity of an object can be negative, positive, or equal to zero. This is because displacement can take any of these three values.

Ans.

6. Under what condition(s) is the magnitude of the average velocity of an object equal to its average speed?

Ans. $Average\ Speed = \frac{Total\ distance\ covered}{Total\ time\ taken}$

$Average\ Speed = \frac{Displacement}{Total\ time\ taken}$

If the total distance covered by an object is the same as its displacement, its average speed would equal its average velocity.

7. What does the odometer of an automobile measure?

Ans. The odometer of an automobile measures the distance covered by an automobile.

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

Ans. An object having uniform motion has a straight-line path.

9. 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 m s^{-1}.

Ans. Time taken by the signal to reach the ground station from the spaceship

$= 5$ min $= 5 \times 60 = 300$ s

Speed of the signal $= 3 \times 10^8$ m/s

$Speed = \frac{Distance\ travelled}{Time\ taken}$

$\therefore$ Distance travelled = Speed $\times$Time taken $= 3 \times 10^8 \times 300 = 9 \times 10^{10}$ m

Hence, the distance of the spaceship from the ground station is 9×10^{10} m.

10. When will you say a body is in (i) Uniform acceleration? (ii) Non-uniform acceleration?

Ans. (i) A body is said to have uniform acceleration if it travels in a straight path in such a way that its velocity changes at a uniform rate, i.e., the velocity of a body increases or decreases by equal amounts in an equal interval of time.

(ii) A body is said to have non-uniform acceleration if it travels in a straight path in such a way that its velocity changes at a non-uniform rate, i.e., the velocity of a body increases or decreases in unequal amounts in an equal interval of time.

11. 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. The initial speed of the bus, u = 80 km/h $= 80 \times \frac{5}{18} = 22.22\ m/s$

The final speed of the bus, v = 60 km/h $= 60 \times \frac{5}{18} = 16.66\ m/s$

Time take to decrease the speed, t = 5 s

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

Here, the negative sign of acceleration indicates that the velocity of the car is decreasing.

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

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

Final velocity of the train, v = 40 km/h $= 40 \times \frac{5}{18} = 11.11\ m/s$

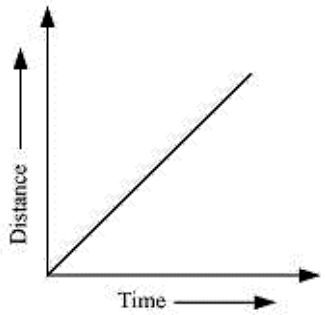
Time taken, t = 10 min $= 10 \times 60 = 600$ s

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

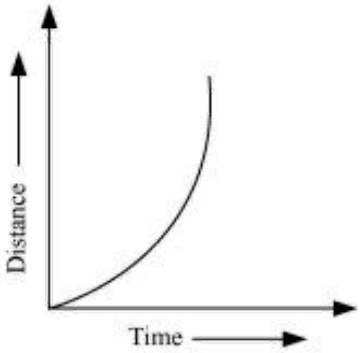
Hence, the acceleration of the train is 0.0185 m/s^2.

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

Ans. The distance–time graph for the uniform motion of an object is a straight line (as shown in the following figure).

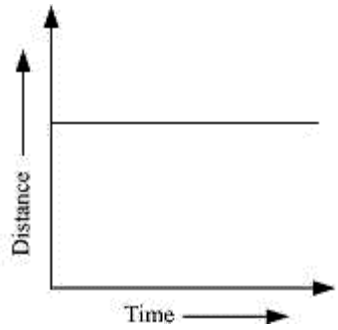


The distance–time graph for the non-uniform motion of an object is a curved line (as shown in the given figure).



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

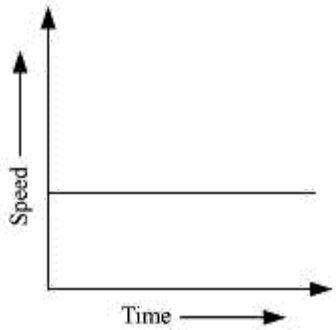
Ans. When an object is at rest, its distance–time graph is a straight line parallel to the time axis.



A straight line parallels the x-axis in the distance-time graph, indicating no change in the object's position with a change in time. Thus, the object is at rest.

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

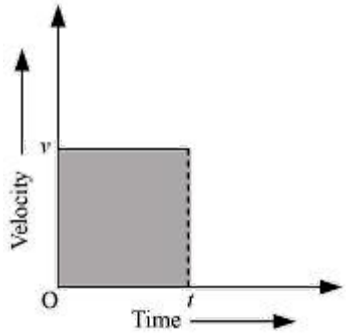
Ans. The object is moving uniformly.



A straight line parallel to the time axis in a speed–time graph indicates no change in the object's speed with a change in time. This indicates the uniform motion of the object.

16. What is the quantity which is measured by the area occupied below the velocity–time graph?

Ans. Distance



The graph shows the velocity–time graph of a uniformly moving body.

Let the velocity of the body at a time (t) be v.

Area of the shaded region = length × breath

Where,

Length = t, Breath = v, Area = vt = velocity × time ...(i)

We know,

$$Velocity = \frac{Displacement}{Time}$$

∴ Displacement = Velocity × Time...(ii)

From equations (i) and (ii),

Area = Displacement

Hence, the area occupied below the velocity–time graph measures the displacement covered by the body.

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

Ans. (a) 12 m/s (b) 720 m

(a) Initial speed of the bus, u = 0 (since the bus is initially at rest)

Acceleration, a = 0.1 m/s^2

Time taken, t = 2 minutes = 120 s

Let v be the final speed acquired by the bus.

$\therefore a = \frac{v-u}{t}\ 0.1 = \frac{v-0}{120}$

$\therefore$v = 12 m/s

(b) According to the third equation of motion.

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

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.

The distance travelled by bus is 720 m.

18. A train is travelling at a speed of 90 km h^{-1}. Brakes are applied 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

The final speed of the train, v = 0 (finally the train comes to rest)

Acceleration = -0.5 m s^{-2}

According to the 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.

19. 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. The initial velocity of the trolley, u = 0 (since the trolley was initially at rest)

Acceleration, a = 2 cm s^{-2} = 0.02 m/s^2

Time, t = 3 s

According to the first equation of motion.

v = u + at

Where, v is the velocity of the trolley after 3 s from start

$v = 0 + 0.02 \times 3 = 0.06$ m/s

Hence, the velocity of the trolley after 3 s from the start is 0.06 m/s.

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

Ans. The initial velocity of the racing car, u = 0 (since the racing car is initially at rest)

Acceleration, a = 4 m/s^2

Time taken, t = 10 s

According to the second equation of motion.

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

Where s is the distance covered by the racing car

$$s = 0 + \frac{1}{2} \times 4 \times (10)^2 = \frac{400}{2} = 200m$$

Hence, the distance covered by the racing car after 10 s from the start is 200 m.

21. 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. Initially, the velocity of the stone,u = 5 m/s

Final velocity, v = 0 (since the stone comes to rest when it reaches its maximum height)

Acceleration of the stone, a = acceleration due to gravity, g = 10 m/s^2

(in a downward direction)

There will be a change in the sign of acceleration because the stone is being thrown upwards.

Acceleration, a = -10 m/s^2

Let s be the maximum height attained by the stone in time t.

According to the first equation of motion.

$v = u + at$

$0 = 5 + (-10)\, t$

$\therefore t = \frac{-5}{-10} = 0.5s$

According to the third equation of motion.

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

$(0)^2 = (5)^2 + 2(-10)s$

$S = \frac{5^2}{20} = 1.25\, m$

Hence, the stone attains a height of 1.25 m in 0.5 s.