CLASS IX: SCIENCE
Chapter 7: Motion

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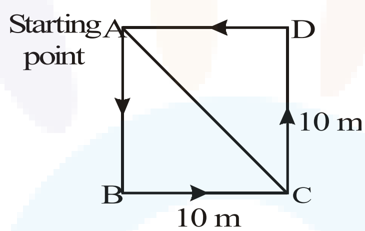
Q1. An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example.

Ans. Yes, an object which has moved through a distance can have zero displacement.
Example : When a person, walking along a circular path, returns back to the starting point, after completing a circle, his displacement is zero. But he covers a distance $2\pi r$, where 'r' is the radius of circular path.

Q2. 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 perimeter of square field
ABCD = 4 × 10 m = 40 m.
Time for moving around the 10 m square field once = 40 s.
Time for journey of farmer = 2 min and 20 s = 140 s.
Number of times the farmer moves around the square field = $\frac{140}{40} = 3\frac{1}{2}$ times .
For going once around the square field, the displacement = 0
For going thrice around the square field, the displacement = 0
For going $\frac{1}{2}$ around the square field, the distance covered = 40 m× $\frac{1}{2}$=20 m.
It is obvious from the figure, that if the farmer starts from point A, then he will cover 10 m along AB and then 10 m along BC.
Therefore, displacement of farmer from the point A to point C is

$$AC = \sqrt{(AB)^2 + (BC)^2} = \sqrt{(10)^2 + (10)^2} = \sqrt{200}$$
$$= 10\sqrt{2} = 14.14 \text{ m}$$

Q3. 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 statements (a) or (b) is true for displacement.

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Q1. Distinguish between speed and velocity.

Ans. Speed is rate of change of distance, while velocity is the rate of change of displacement. Speed is a scalar quantity, while velocity is a vector quantity. Speed is always positive, while velocity is positive, negative or zero.

Q2. Under what condition is the magnitude of average velocity of an object equal to its average speed ?

Ans. When an object moves along a straight path without change in its direction, the average velocity of an object is equal to its average speed.

Q3. What does the odometer of an automobile measure?

Ans. Odometer measures the distance travelled by the automobile.

Q4. What does the path of an object look like when it is in uniform motion ?

Ans. In uniform motion, the object moves along a straight path i.e. the path of object is a straight line.

Q5. During an experiment a signal from a spaceship reached the ground station in five minutes. What was the distance of the space ship from the ground station ? The signal travels at the speed of light that is, 3×10^8 m/s.

Ans. Let the distance between the spaceship and the ground station be 's'.

Then, $s = v \times t$

where, v = speed of signal = 3×10^8 m/s

t = time taken = 5 min = 5×60 s = 300 s

$\therefore\ s = 3 \times 10^8 \times 300 = 9 \times 10^{10}$ m

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Q1. When will you say a body is in

(i) Uniform acceleration ?

(ii) Non uniform acceleration ?

Ans. (i) A body is in uniform acceleration when it moves in a straight line and equal changes of velocity take place in equal intervals of time.

(ii) A body is said to be possessing non-uniform acceleration when unequal changes in velocity take place in equal intervals of time.

Q2. 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. Given t = 5 s

Initial speed of bus

$u = 80 \text{ km h}^{-1} = 80 \times \frac{5}{18} = 22.2 \text{ ms}^{-1}$

Final speed of the bus

$v = 60 \text{ km h}^{-1} = 60 \times \frac{5}{18} = 16.6 \text{ ms}^{-1}$

Now acceleration is given by the relation

$$a = \frac{v-u}{t} = \frac{16.6 - 22.2}{5} = -1.1 \text{ ms}^{-2}$$

Q3. A train starting from a railway station and moving with uniform acceleration attains a speed of 40 kmh^{-1} in 10 minutes. Find its acceleration.

Ans. Given t = 10 min = 10 × 60 = 600 s

Initial speed of train, $u = 0 \text{ ms}^{-1}$

Final speed of train

$v = 40 \text{ km h}^{-1} = 40 \times \frac{5}{18} = 11.1 \text{ ms}^{-1}$

Now acceleration is given by the relation

$$a = \frac{v-u}{t} = \frac{11.1 - 0}{600} = 0.0185 \text{ ms}^{-2}$$

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Q1. What is the nature of the distance time graphs for uniform and non-uniform motion of an object?

Ans. The distance-time graph for uniform motion is a straight line, not parallel to the time axis. The distance-time graph for non-uniform motion is not a straight line, it can be a curve or a zigzag line.

Q2. What can you say about the motion of an object whose distance time-graph is a straight line parallel to the time axis ?

Ans. The object is stationary.

Q3. 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 may be in uniform motion.

Q4. What is the quantity which is measured by the area occupied below the velocity-time graph ?

Ans. Distance is the quantity which is measured by the area under velocity time graph.

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Q1. 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. Given
Initial speed of bus, $u = 0\ ms^{-1}$
Final speed of bus, $v = ?$
$a = 0.1\ ms^{-2}$, $t = 2\ min = 120\ s$
$s = ?$
(i) We know, $v = u + at$
or $v = 0 + 0.1 \times 120 = 12\ ms^{-1}$

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

$$s = 0 \times 120 + \frac{1}{2} \times 0.1 \times (120)^2 = 720\ m$$

Therefore, final speed acquired = 12 ms^{-1}
Distance travelled = 720 m

Q2. A train is travelling at a speed of 90 kmh^{-1}. Brakes are applied so as to produce a uniform acceleration of – 0.5 ms^{-2}. Find how far the train will go before it is brought to rest.

Ans. Given, initial speed of train,
$u = 90\ km\ h^{-1} = 90 \times \frac{5}{18} = 25\ ms^{-1}$
Final speed, $v = 0\ ms^{-1}$,
Acceleration, $a = -0.5\ ms^{-2}$,
Distance covered, $s = ?$
Using the relation $v^2 - u^2 = 2as$, we have

$$s = \frac{v^2 - u^2}{2a} = \frac{0 - (25)^2}{2 \times (-0.5)} = 625\ m$$

Q3. A trolley, while going down an inclined plane, has an acceleration of 2 cms^{-2}. What will be its velocity 3 s after the start ?

Ans. Given, initial velocity, u = 0 ; final velocity, v = ?
Time, t = 3 s
Acceleration, a = 2 cms^{-2}
We know that, v = u + at
or v = 0 + 2 × 3 = 6 cms^{-1}
Therefore, final velocity = 6 cms^{-1}.

Q4. A racing car has uniform acceleration of 4 ms^{-2}. What distance will it cover in 10 s after start ?

Ans. Given
Initial velocity, u = 0
Acceleration, a = 4 ms^{-2}
Time, t = 10 s
Distance covered, s = ?
We know, $s = ut + \frac{1}{2}at^2$
$s = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2$
= 0 + 200 = 200 m
Therefore, distance covered = 200 m.

Q5. A stone is thrown in vertically upward direction with a velocity of 5 ms^{-1}. If the acceleration of the stone during its motion is 10 ms^{-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, u = 5 ms^{-1}
Final velocity, v= 0
Since, u is upward & a is downward, it is a retarded motion. ∴ a = –10 ms^{-2}
Height attained by stone, s = ?
Time taken to attain height, t = ?
(i) Using the relation, v = u + at
0 = 5 + (– 10) t or
t = 5/10 = 0.5 s
(ii) Using the relation, $v^2 - u^2 = 2as$, we have

$$s = \frac{v^2 - u^2}{2a} = \frac{(0)^2 - (5)^2}{2 \times (-10)} = 1.25 \text{ m}$$

EXERCISES

Q1. 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. Given

Diameter of circular track, 2r =200 m

Circumference of circular track = 2 π r

$s = \pi(2r) = \frac{22}{7} \times 200 = \frac{4400}{7}$ m

Time for completing one round = 40 s.

Time for which the athlete ran = 2 min and 20 s = 140 s

Now distance covered by the athlete in 40 s is

$s = \frac{4400}{7}$ m $\therefore$ Distance covered in 1s = $\frac{4400}{7 \times 40}$ m

(i) Therefore, distance covered by athlete in 140 s

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

(ii) As the athlete returns to the initial point in 40 s, his displacement = 0

Now,

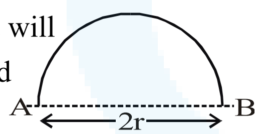
Number of rounds in 40 seconds = 1

Hence number of rounds in 140 s is $= \frac{140}{40} = 3\frac{1}{2}$.

For each complete round the displacement is zero.

Therefore for 3 complete rounds, the displacement will be zero.

The final displacement will be due to half the round (i.e. semicircle).

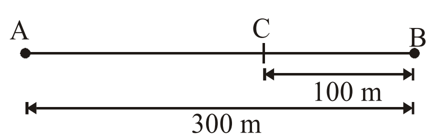


Thus, his displacement = diameter of circular track = 200 m

$\therefore$ Displacement after 140 s = 200 m

Q2. Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 50 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. The required figure is as shown



(a) Distance covered = 300 m

Time taken = 2 min and 50 s = 170 s

Now average speed from A to B is given by

$$V_{av} = \frac{\text{distance covered}}{\text{time}} = \frac{300}{170} = 1.76\ \text{ms}^{-1}$$

Now average velocity from A to B is given by

$$V_{av} = \frac{\text{displacement}}{\text{time}} = \frac{300}{170} = 1.76\ \text{ms}^{-1}$$

(b) When Joseph turns around from B to C towards west, then

Distance covered = 300 + 100 = 400 m

Time taken = 170 + 60 = 230 s

Therefore, average speed from A to C is

$$V_{av} = \frac{\text{distance covered}}{\text{time}} = \frac{400}{230} = 1.74\ \text{ms}^{-1}$$

Now displacement from A to C = 200 m

Therefore, average velocity from A to C is

$$V_{av} = \frac{\text{displacement}}{\text{time}} = \frac{200}{230} = 0.869\ \text{ms}^{-1}$$

Q3. 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 40 km h^{-1}. What is the average speed for Abdul's trip ?

Ans. Let one way distance for his trip be S.

Let t_1 be the time for his trip from home to school and t_2 be the time for his return trip.

Then $t_1 = \frac{S}{v_1} = \frac{S}{20}$ h, and $t_2 = \frac{S}{v_2} = \frac{S}{40}$ h

Therefore, total time of trip is

$$T = t_1 + t_2 = \frac{S}{20} + \frac{S}{40} = \frac{3S}{40}\ \text{h}$$

Total distance covered = 2S

Therefore, average speed of Abdul

$$V_{av} = \frac{\text{total distance}}{\text{total time}} = \frac{2S \times 40}{3S} = 26.6\ \text{kmh}^{-1}$$

Q4. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 ms^{-2} for 8.0 s. How far does the boat travel during this time ?

Ans. Given, initial velocity of boat, u = 0

Acceleration, a = 3.0 m s^{-2}

Time, t = 8 s

Distance covered, s = ?

Using the relation $s = ut + \frac{1}{2}at^2$ we have,

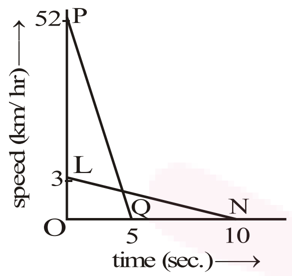
$s = 0 \times 8 + \frac{1}{2} \times 3 \times 8^2 = 96$ m.

Q5. The 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 kmh^{-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. The speed time graph of both the cars are shown below.
(i) Distance covered by car moving at 52 kmh^{-1}

(or $52 \times \frac{5}{18} = 14.4\ ms^{-1}$)

$= \text{area of } \Delta POQ = \frac{1}{2} \times PO \times OQ = \frac{1}{2} \times 14.4 \times 5 = 36$ m



(ii) Distance covered by car moving at 3 kmh^{-1}

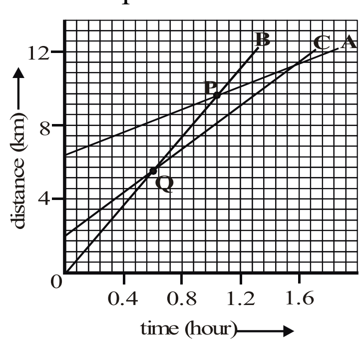
(or $3 \times \frac{5}{18} = 0.83\ ms^{-1}$)

$= \text{area of } \Delta OLN = \frac{1}{2} \times LO \times ON = \frac{1}{2} \times 0.83 \times 10$
$= 4.15$ m

$\therefore$ The car moving at 52 km h^{-1} travels more distance on the application of brakes.

Q6. Figure below shows the distance-time graph of three objects A, B and C. Study the graph and answer the following questions :

(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 ?



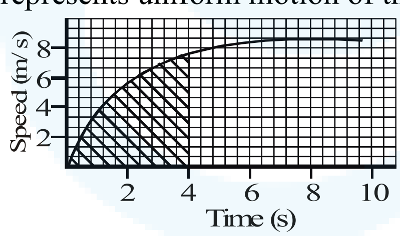
Ans. (a) Car B is travelling the fastest, because its slope is largest among the three.
(b) No, they are never at the same point because all the graphs of A, B and C do not intersect at one point.
(c) When car B passes car A at point P, the distance covered by car C = 8 – 2 = 6 km. (approx.)
(d) Car B and C pass each other at point Q. The distance travelled by B at that point is nearly 5.7 km.

Q7. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 ms^{-2}, with what velocity will it strike the ground? After what time will it strike the ground ?

Ans. Given, initial velocity of ball, u = 0
Final velocity of ball, v = ?
Distance through which the ball falls, s = 20 m
Acceleration a = 10 ms^{-2}
Time of fall, t = ?
We know
$v^2 - u^2 = 2as$
or $v^2 - 0 = 2 \times 10 \times 20 = 400$ or $v = 20\ ms^{-1}$
Now using v = u + at we have
$20 = 0 + 10 \times t$ or $t = 2s$

Q8. The speed-time graph for a car is shown in figure below.

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



Ans. (a) During first 4 seconds, car is moving with non-uniform acceleration. The car will travel 12 m in the first four seconds. Area of shaded portion represents distance travelled.
(b) The straight line portion of the graph represents uniform motion of the car.

Q9. 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 acceleration in the perpendicular direction.

Ans. (a) A body with a constant acceleration but with zero velocity is possible. For example, when a body is just released, its initial velocity u = 0, but acceleration g = 10 ms^{-2}.
(b) It is possible when a stone, tied to a string, is whirled in a circular path, the acceleration acting on it is always at right angle to the direction of motion of stone.

Q10. 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. Distance covered by the satellite in 24 hours.

$S = 2\pi r$

$= 2 \times \frac{22}{7} \times 42250$

$= 265571.43$ km

Therefore speed of satellite

$$v = \frac{\text{distance travelled}}{\text{time taken}} = \frac{265571.43}{24 \times 60 \times 60} = 3.07 \text{ kms}^{-1}$$