7 Motion

Fastrack Revision

- **Motion:** A body is said to be in a state of motion when its position changes continuously with reference to a point, *e.g.*, vehicles moving on road, flying birds, etc.
- **Rest:** A body is said to be in the state of rest when its position does not change with respect to a reference point, *e.g.*, tree, building, etc.
- **Position:** It is the location of an object with respect to a particular point called reference point or origin.
- **Scalar Quantity:** Physical quantities with which only magnitude can be associated, *e.g.*, mass, time, distance, etc.
- **Vector Quantity:** Physical quantities with which both magnitude and direction can be associated, *e.g.*, displacement, velocity, etc.
- **Distance:** It is the actual path or length travelled by an object during its journey from its initial position to its final position. It is a scalar quantity and its SI unit is metre (m).
- **Displacement:** It is the shortest path measured in the direction from initial position to the final position of the object. It is a vector quantity and its SI unit is metre (m).

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Ratio of displacement and distance is always less than or equal to 1.

- **Uniform Motion:** A body is said to be in uniform motion if it travels equal distances in equal intervals of time irrespective of direction, *e.g.*, a car moving along a straight line path covering equal distances in equal intervals of time.
- **Non-uniform Motion:** A body is said to be in non-uniform motion if it travels unequal distances in equal intervals of time irrespective of direction, *e.g.*, a car moving through a crowded market.
- **Rate of Motion:** It is the ratio of distance travelled by an object and time taken.
- **Speed:** It is the measurement of distance travelled by an object per unit time. It is a scalar quantity and its SI unit is metre per second ($m\ s^{-1}$).

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

Types of Speed

- **Uniform Speed:** An object is said to be moving with uniform speed if it covers equal distances in equal intervals of time.
- **Non-uniform Speed:** An object is said to be moving with non-uniform speed if it covers equal distances in unequal intervals of time or *vice-versa*.
- **Average Speed:** It is the ratio of total distance covered by the body to the total time taken.

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

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For non-uniform motion, average speed will describe one single value of speed throughout the motion of the body.

- **Instantaneous Speed:** It refers to the speed of an object at a particular instant of time or at a particular point of its path.

- **Velocity:** It is the displacement of the body per unit time. It is a vector quantity and its SI unit is metre per second ($m\ s^{-1}$). It can be positive, zero or negative.

$$\text{Velocity } (v) = \frac{\text{Displacement } (d)}{\text{Time } (t)}$$

- **Types of Velocity**
  - **Uniform Velocity:** It is the velocity of a body when it moves along a fixed direction and covers equal distances in equal intervals of time.
  - **Non-uniform Velocity:** It is the velocity of a body when it covers unequal distances in equal intervals of time along a fixed direction.
  - **Average Velocity:** It is the ratio of total displacement of the object to the total time taken.
    For uniformly changing velocity,
    $$\text{Average velocity} = \frac{\text{Initial velocity} + \text{Final velocity}}{2}$$
  - **Instantaneous Velocity:** It refers to the velocity of a body at a particular instant of time or at a particular point of its path.
- **Acceleration:** It is the rate of change of velocity of a moving body with respect to time. It is a vector quantity and its SI unit is metre per second square (ms^{-2}).

$$\text{Acceleration } (a) = \frac{\text{Change in velocity } (\Delta v)}{\text{Time taken } (t)} = \frac{v - u}{t}$$

where, u = Initial velocity and v = Final velocity.

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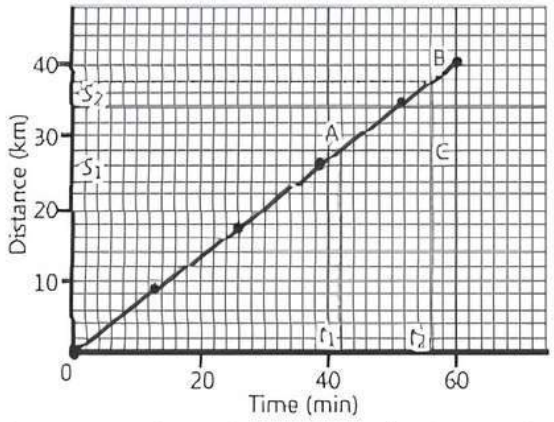
Deceleration is seen in non-uniform motion during decrease in velocity with time. Since $v < u$, a = negative.

- **Types of Acceleration**
  - **Uniform Acceleration:** Acceleration in which velocity of an object increases or decreases by equal amounts in equal intervals of time.
  - **Non-uniform Acceleration:** Acceleration in which velocity of an object increases or decreases by unequal amounts in equal intervals of time.

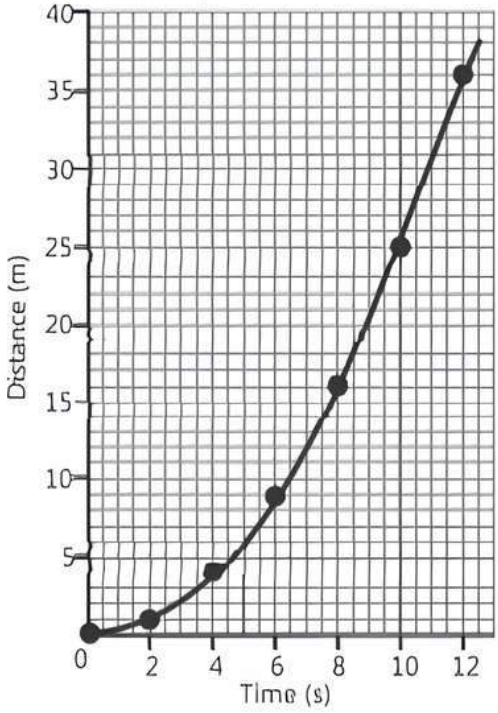
▶ **Graphical Representation of Motion**

➤ **Distance-time Graph:** In this graph, time is an independent variable plotted along *X*-axis and distance is a dependent variable plotted along *Y*-axis. The results obtained are:

- The graph is a straight line parallel to time axis when the object is at rest.
- The nature of graph is a straight line when the object is in the state of uniform motion.



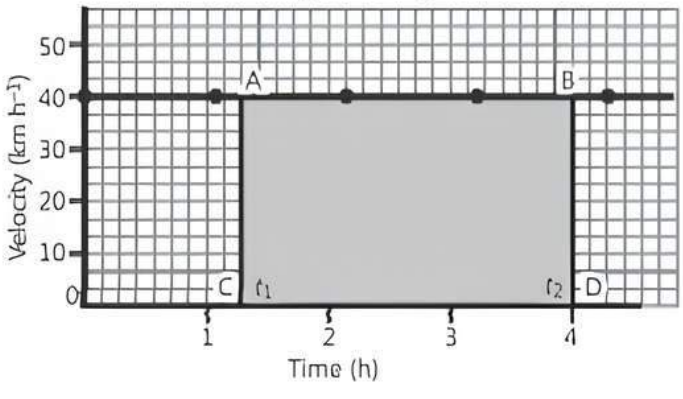
- The nature of graph is a curve having varying slope when the object has non-uniform motion.



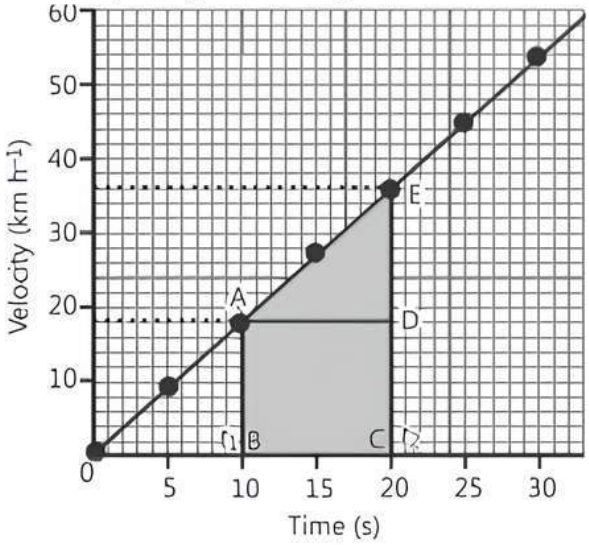
- The slope of graph gives the speed of object.

➤ **Velocity-time Graph:** In this graph, time is plotted along *X*-axis and velocity of the body is plotted along *Y*-axis. The results obtained are:

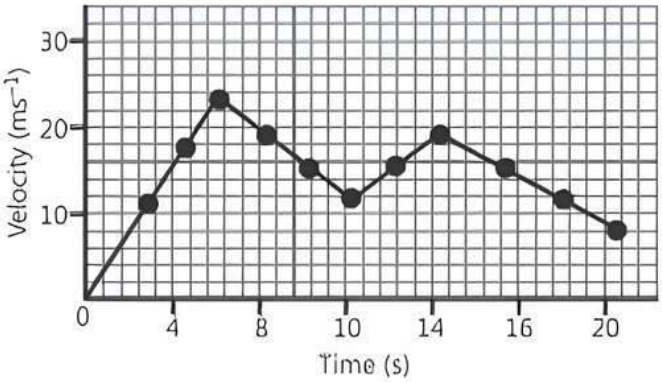
- The graph is a horizontal line parallel to the time axis if the velocity of a body remains constant.



- The graph is a straight line if the velocity of a body changes uniformly at a constant rate.



- The graph is a curve having increasing slope if the velocity of body changes non-uniformly.



- The area enclosed by the graph and the time axis represents the displacement.
- The slope of the graph gives the acceleration.

▶ **Equations of Motion:** When a body is moving along a straight line with uniform acceleration, the relation can be established between velocity of the body, acceleration of the body and the distance travelled by the body in a particular time interval through a set of equations called as equations of motion.

The three equations of motion are:

1. $v = u + at$
2. $s = ut + \frac{1}{2} at^2$
3. $v^2 = u^2 + 2as$

where, u is the initial velocity of the body which moves with uniform acceleration a for time t, v is the final velocity and s is the distance travelled by the body in time t.

▶ **Uniform Circular Motion:** When a body travels along a circular path of constant radius with a constant speed, then its motion is uniform circular motion, *e.g.*, motion of moon and earth, motion of a car on a circular path with constant speed, etc.

The linear velocity of a body moving along a circular path of radius 'r' in time interval 't' is given as,

$$\text{Linear velocity} = \frac{\text{Circumference}}{\text{Time}} = \frac{2\pi r}{t}$$

Practice Exercise

Multiple Choice Questions

Q 1. A physical quantity which cannot be negative is:

a. displacement b. velocity
c. acceleration d. distance

Q 2. The numerical ratio of displacement to distance for a moving object is: *(NCERT EXEMPLAR)*

a. always less than 1 b. always equal to 1
c. always more than 1 d. equal or less than 1

Q 3. If '*s*' is displacement and '*d*' is distance between two points, then the correct relation is:

a. $s = d$ b. $s > d$
c. $d > s$ d. None of these

Q 4. If the motion is in straight line without change in direction then:

a. distance $\neq$ | displacement |
b. distance > | displacement |
c. distance < | displacement |
d. distance = | displacement |

Q 5. When an object travels equal distances in equal intervals of time, howsoever small the interval may be, the motion of the object is said to be:

a. uniform b. non-uniform
c. circular motion d. oscillatory motion

Q 6. In which of the following cases of motions, the distance moved and the magnitude of displacement are equal? *(NCERT EXEMPLAR)*

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.

Q 7. If an object is moving with constant velocity, then the motion is:

a. speed b. uniform acceleration
c. uniform motion d. non-uniform motion

Q 8. When a body covers unequal distances in equal intervals of time, it is said to be in:

a. linear motion b. uniform motion
c. non-uniform motion d. vibratory motion

Q 9. A bus moves from stop '*A*' to stop '*B*' with a speed of 40 km/h and then from stop '*B*' to stop '*A*' with a speed of 50 km/h. Its average speed is:

a. 48.5 km/h b. 52 km/h
c. 58 km/h d. 44.4 km/h

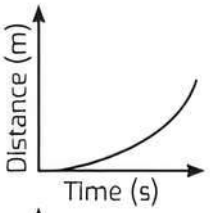
Q 10. If the displacement of an object is proportional to square of time, then the object moves with: *(NCERT EXEMPLAR)*

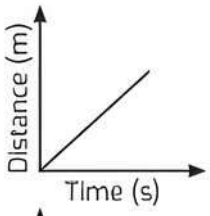
a. uniform velocity
b. uniform acceleration
c. increasing acceleration
d. decreasing acceleration

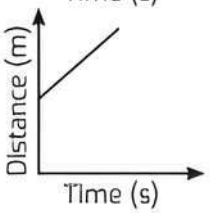
Q 11. A car accelerates uniformly from 18 km h^{-1} to 36 km h^{-1} in 5 s. Calculate the acceleration.

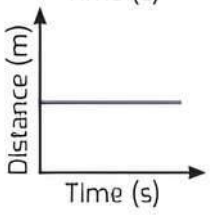
a. 1 m s^{-2} b. 5 m s^{-2} c. 8 m s^{-2} d. 11 m s^{-2}

Q 12. The nature of the distance-time graph for a car moving with non-uniform speed is:

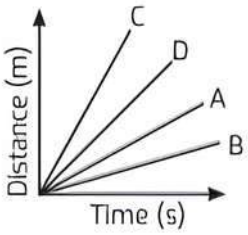
a. 

b. 

c. 

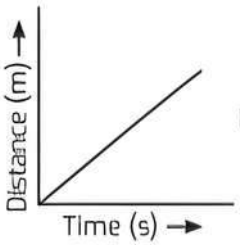
d. 

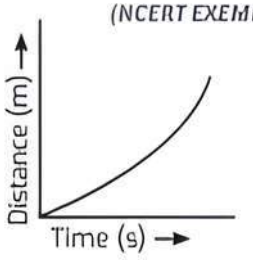
Q 13. Four cars *A*, *B*, *C* and *D* are moving on a levelled road. Their distance *versus* time graphs are shown in figure. Choose the correct statement. *(NCERT EXEMPLAR)*

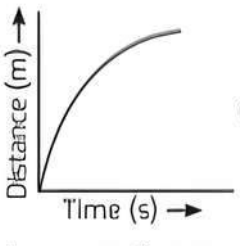


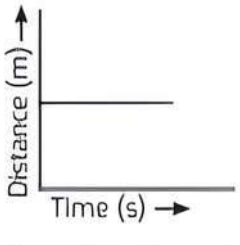
a. Car *A* is faster than car *D*.
b. Car *B* is the slowest.
c. Car *D* is faster than car *C*.
d. Car *C* is the slowest.

Q 14. Which of the following figures represents uniform motion of a moving object correctly? *(NCERT EXEMPLAR)*

a. 

b. 

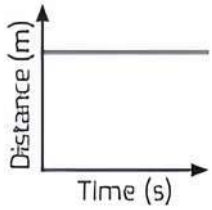
c. 

d. 

Q 15. Displacement-time graph of a uniformly accelerated motion is:

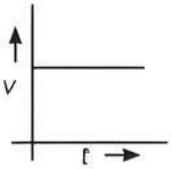
a. parabola b. straight line
c. an inclined line d. None of these

Q 16. The distance-time graph of an object is shown in graph. The object:



a. is at rest
b. moves with a constant speed
c. moves with a variable velocity
d. moves with a constant acceleration.

Q 17. **From the given *v*-*t* graph, it can be inferred that the object is:** *(NCERT EXEMPLAR)*



a. in uniform motion
b. at rest
c. in non-uniform motion
d. moving with uniform acceleration

Q 18. **Slope of a velocity-time graph gives:** *(NCERT EXEMPLAR)*

a. the distance
b. the displacement
c. the acceleration
d. the speed

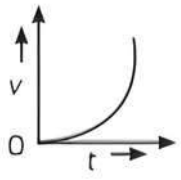
Q 19. **Area under a *v*-*t* graph represents a physical quantity which has the unit:** *(NCERT EXEMPLAR)*

a. m^2
b. m
c. m^3
d. $m\ s^{-1}$

Q 20. **Area under velocity-time graph gives:**

a. displacement
b. acceleration
c. velocity
d. time

Q 21. **The velocity-time graph of a moving body is shown in the figure. Which of the following statement is true?**



a. The acceleration is constant and positive
b. The acceleration is constant and negative
c. The acceleration is increasing and positive
d. The acceleration is increasing and negative

Q 22. **The velocity-time graph of a particle is not a straight line. Its acceleration is:**

a. zero
b. constant
c. negative
d. variable

Q 23. **A ball is dropped from a height of 20m. If its velocity increases uniformly at the rate of 10 m/s^2, after what time will it strike the ground?**

a. 1.414 s
b. 2 s
c. 4 s
d. 1 s

Q 24. **A car with speed 72km/h suddenly applies break. The break has maximum ability to decelerate with 5m/s^2. Find time taken to stop the car after applying brakes.**

a. 2 s
b. 3 s
c. 4 s
d. 5 s

Q 25. **Find the average speed of a bicycle if it completes two round of a circular track of radius 140 m twice in 5min 52 sec.**

a. 10 m/s
b. 5 m/s
c. 2 m/s
d. 4 m/s

Q 26. **An athlete completes one round of a circular track of radius *R* in 40 s. The displacement at the end of 2 min 20 sec will be:**

a. zero
b. $2R$
c. πR
d. $7\pi R$

Q 27. **A particle is moving in a circular path of radius *r*. The displacement after half a circle would be:** *(NCERT EXEMPLAR)*

a. zero
b. πr
c. $2r$
d. $2\pi r$

Q 28. **In a uniform circular motion both:**

a. acceleration and speed changes
b. acceleration and speed are constant
c. acceleration and velocity are constant
d. acceleration and velocity changes

Q 29. **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:** *(NCERT EXEMPLAR)*

a. at rest
b. moving with no acceleration
c. in accelerated motion
d. moving with uniform velocity

Assertion & Reason Type Questions

Directions (Q. Nos. 30-39): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 30. **Assertion (A):** When an object changes its position while moving, it gets displaced.
Reason (R): Displacement is the shortest distance between the initial and final position of the moving object.

Q 31. **Assertion (A):** If the displacement of the body is zero, the distance covered by it may not be zero.
Reason (R): Displacement is a vector quantity and distance is a scalar quantity.

Q 32. **Assertion (A):** The displacement of an object can be either positive, negative or zero.
Reason (R): Displacement has both the magnitude and direction.

Q 33. **Assertion (A):** The ratio of displacement to distance is equal to or less than 1.
Reason (R): The displacement is the longer distance between initial and final positions.

Q 34. **Assertion (A):** Motion with uniform velocity is always along a straight line path.
Reason (R): In uniform velocity, speed is the magnitude of the velocity and is equal to the instantaneous velocity.

Q 35. **Assertion (A):** The position-time graph of a uniform motion in one dimension of a body can have negative slope.
Reason (R): When the speed of body decreases with time, the position-time graph of the moving body has negative slope.

Q 36. **Assertion (A):** If velocity of the object changes at a uniform rate, then the average velocity of a moving body can be zero.

Reason (R): Average velocity is the velocity of body when it covers unequal distances in equal intervals of time along a fixed direction.

Q 37. Assertion (A): The average speed of a body over a given interval of time is equal to the average velocity of the body in the same interval of time if a body moves in a straight line in one direction.

Reason (R): Here, the distance travelled by a body is equal to the displacement of the body.

Q 38. Assertion (A): A particle can have acceleration even, if its velocity is zero at an instant.

Reason (R): Acceleration is the rate of change of velocity.

Q 39. Assertion (A): A body can have acceleration even its speed is constant.

Reason (R): In uniform circular motion, speed of body is constant but its velocity continuously changes.

Answers

1. (d) distance.

Distance is the actual path travelled by an object during its journey from its initial position to its final position. Distance is scalar quantity which cannot be negative.

2. (d) equal or less than 1

Distance is always be equal to or greater than the displacement, so the ratio of displacement to distance for moving object will be always less than or equal to 1.

3. (c) $d > s$

4. (d) distance = | displacement |

5. (a) uniform

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

7. (c) uniform motion

In uniform motion, a body travels equal distances in equal intervals of time irrespective of direction.

8. (c) non-uniform motion

9. (d) 44.4 km/h

Let the distance from stop A to stop B = D, then distance from stop B to stop A = D

$\therefore$ Total distance = $D + D = 2D$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{2D}{\frac{D}{40} + \frac{D}{50}} = \frac{2D}{\frac{90D}{2000}} = \frac{400}{9} = 44.4 \text{ km/h}$$

10. (b) Uniform acceleration

11. (a) 1 m s^{-2}

We are given that

$u = 18 \text{ km h}^{-1} = 5 \text{ m s}^{-1}$

$v = 36 \text{ km h}^{-1} = 10 \text{ m s}^{-1}$ and

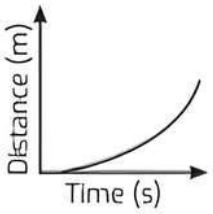
$t = 5 \text{ s}$

From first equation of motion, we have

$$a = \frac{v-u}{t} = \frac{10 \text{ m s}^{-1} - 5 \text{ m s}^{-1}}{5 \text{ s}}$$

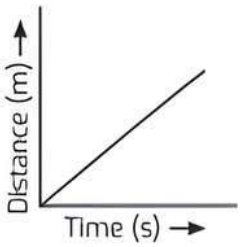
$= 1 \text{ m s}^{-2}$

12. (a)



13. (b) Car B is the slowest.

14. (a)



15. (a) parabola

16. (a) is at rest

When the object is at rest, the graph is a straight line parallel to time axis.

17. (a) in uniform motion

18. (c) the acceleration.

The rate of change of velocity is called acceleration.

19. (b) m

Area under a v-t graph represents a physical quantity which is called distance and unit of distance is metre (m).

20. (a) displacement

21. (c) The acceleration is increasing and positive.

22. (d) variable

23. (b) 2 s

Given, $u = 0$, $a = 10 \text{ m/s}^2$ and $s = 20$ m.

Using second equation of motion,

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

$$\Rightarrow \quad 20 = \frac{1}{2}(10)t^2$$

$$\Rightarrow \quad t^2 = 4$$

$$\Rightarrow \quad t = 2 \text{ s}$$

24. (c) 4 s

Given, $u = 72 \text{ km/h} = 72 \times \frac{5}{18} \text{ m/s} = 20 \text{ m/s}$

$v = 0$

$a = -5 \text{ m/s}^2$

Using first equation of motion,

$v = u + at$

$$\Rightarrow \quad t = \frac{v-u}{a} = \frac{0-20}{-5}$$

$$= \frac{-20}{-5} = 4 \text{ s}$$

25. (b) 5 m/s

Total distance = $2 \times 2\pi r$

$$= 2 \times 2 \times \frac{22}{7} \times 140 = 1760 \text{ m}$$

Time taken, $t = 5$ min 52 s

$= 5 \times 60 + 52 = 352$ s

$\therefore$ Average speed $= \frac{1760}{352} = 5$ m/s

26. (b) $2R$

Total time = 2 min 20 sec = $2 \times 60 + 20$

= 140 s

Rounds completed by athlete in 140 s $= \frac{140}{40} = 3.5$

So, athlete would be on opposite side of starting point. Thus, the displacement will be the diameter or $2R$.

27. (c) $2r$

Displacement after half a circle is the diameter of the circular path, *i.e.*, $2r$.

28. (d) acceleration and velocity changes

29. (c) In accelerated motion

30. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

31. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

As distance being a scalar quantity is always positive but displacement being a vector quantity may be positive, zero and negative depending on situation.

32. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

33. (c) Reason (R) is false because displacement is the shortest distance between the initial and final positions.

34. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

35. (c) Assertion (A) is true but Reason (R) is false.

The negative slope of the position-time graph represents that the body is moving towards the negative direction but if the slope decreases with time then it represent the decrease in speed *i.e.*, retardation in motion. So, the constant negative slope of the position-time graph cannot represent the decrease in speed.

36. (c) Assertion (A) is true but Reason (R) is false.

37. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

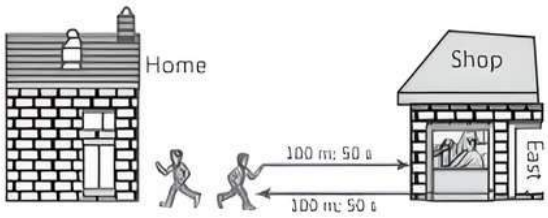
38. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

39. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Suppose the boy first runs a distance of 100 m in 50 seconds in going from his home to the shop in the East direction and then runs a distance of 100 m again in 50 seconds in the reverse direction from the shop to reach back home from where he started.



Read the given passage carefully and give the answer of the following questions:

Q 1. Find the speed of the boy.

a. 1 m/s b. 2 m/s
c. 3 m/s d. None of these

Q 2. Find the velocity of the boy.

a. 1 m/s b. 2 m/s
c. 3 m/s d. 0 m/s

Q 3. If the initial velocity of an object is equal to final velocity, then the acceleration is equal to:

a. negative b. positive
c. zero d. infinite

Q 4. If the boy is running from West to East at an average speed of 120 km/h, then how far does this boy run in 6 s?

a. 20 m b. 200 m
c. 900 m d. 500 m

Q 5. A boy walks on a straight road from his home to a shop 2.5 km away with a speed of 5 km/h. Finding the shop closed, he instantly turns and walks back home with a speed of 7.5 km/h. The average speed of the boy over the interval of time 0 to 40 min is equal to:

a. 5 km/h b. $\frac{25}{4}$ km/h

c. $\frac{30}{4}$ km/h d. $\frac{45}{8}$ km/h

Answers

1. (b) 2 m/s

Total distance travelled is 100 m + 100 m = 200 m and the total time taken in 50 s + 50 s = 100 s

$$\text{Speed of boy} = \frac{\text{Distance travelled}}{\text{Time taken}} = \frac{200 \text{ m}}{100 \text{ s}} = 2 \text{ m/s}$$

2. (d) 0 m/s

The boy runs 100 m towards East and then 100 m towards West and reaches at the starting point. So, the displacement will be 100 m – 100 m = 0 m

The total time taken is 50 s + 50 s = 100 s

$$\text{Velocity of boy} = \frac{\text{Displacement}}{\text{Time taken}} = \frac{0\text{ m}}{100\text{ s}} = 0\text{ m/s}$$

3. (c) zero

Given that $v = u$

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

4. (b) 200 m

Given, $v = 120$ km/h $= 120 \times \frac{5}{18}$ m/s $= 33.33$ m/s

$\therefore$ Displacement = $33.33 \times 6 = 200$ m

5. (d) $\frac{45}{8}$ km/h

Speed of boy from his home to shop is 5 km/h.

Distance = 2.5 km and time $= \frac{d}{v} = \frac{2.5}{5} = \frac{1}{2}$ h

and he returns back with speed of 7.5 km/h in rest of time of 10 min.

$$\text{Distance} = 7.5 \times \frac{10}{60} = 1.25\text{ km}$$

So. $$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{(2.5 + 1.25)\text{ km}}{(40/60)\text{ h}} = \frac{45}{8}\text{ km/h}$$

Case Study 2

One day Radhika decided to go her office by her car. She is enjoying the driving along with listening the old songs. Her car is moving along a straight road at a steady speed. On a particular moment, she notices that the car travels 150 m in 5 s.

Read the given passage carefully and give the answer of the following questions:

Q 1. What is its average speed?

a. 20 m/s b. 30 m/s c. 10 m/s d. 40 m/s

Q 2. How far does it travel in 1 s?

a. 20 m b. 30 m c. 10 m d. 40 m

Q 3. How far does it travel in 6 s?

a. 120 m b. 130 m c. 180 m d. 140 m

Q 4. How long does it take to travel 240 m?

a. 2 s b. 4 s c. 6 s d. 8 s

Q 5. Which of the following statement is correct regarding velocity and speed of a moving body?

a. Velocity of a moving body is always higher than its speed

b. Speed of a moving body is always higher than its velocity

c. Speed of a moving body is its velocity in a given direction

d. Velocity of a moving body is its speed in a given direction

Answers

1. (b) 30 m/s

Average speed = total distance travelled/total time taken

= 150/5 = 30 m/s

2. (b) 30 m

Time = 1 s

Distance = average speed × time

= 30 m/s × 1 s = 30 m

3. (c) 180 m Time = 6 s

Distance = average speed × time

= 30 m/s × 6 s

= 180 m

4. (d) 8 s

Distance = 240 m

Time = Distance/Average speed

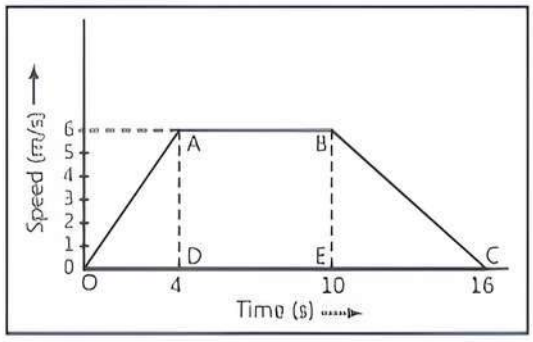
= 240/30

= 8 s

5. (d) Velocity of a moving body is its speed in a given direction.

Case Study 3

Amir started driving his car. He increases the speed till 4 seconds and then he kept his car in constant speed for 6 seconds. Then after he decreased the speed of the car up to another 6 seconds. After reaching at the starting place, he draws the speed-time graph of his 16 seconds driving as shown below:



Read the given passage carefully and give the answer of the following questions:

Q 1. What type of motion is represented by *OA*?

a. Uniform velocity b. Uniform acceleration

c. Negative acceleration d. No acceleration

Q 2. What type of motion is represented by *BC*?

a. Uniform velocity b. Uniform acceleration

c. Negative acceleration d. No acceleration

Q 3. Find out the acceleration of the body.

a. 1.5 m/s^2 b. 2 m/s^2 c. 3 m/s^2 d. 1 m/s^2

Q 4. Calculate the retardation of the body.

a. 1.5 m/s^2 b. 2 m/s^2

c. 3 m/s^2 d. 1 m/s^2

Q 5. Find out the distance travelled by the body from *A* to *B*.

a. 15 m b. 30 m c. 36 m d. 60 m

Answers

1. (b) Uniform acceleration

OA is a straight line graph between speed and time and it is sloping upwards from *O* to *A*.

Therefore, the graph line *OA* represents uniform acceleration.

2. (c) Negative acceleration

BC is a straight line graph between speed and time which is sloping downwards from *B* to *C*.

Therefore, *BC* represents uniform retardation (or negative acceleration).

3. (a) 1.5 m/s^2

The slope of speed-time graph *OA* will give us the acceleration of the body.

Thus, acceleration = Slope of line *OA* = *AD/OD*

From the graph *AD* = 6 m/s and *OD* = 4 s.

$\therefore$ Acceleration = 6 m/s / 4 s = 1.5 m/s^2

4. (d) 1 m/s^2

The slope of speed-time graph *BC* will be equal to the retardation of the body.

So, retardation = Slope of line *BC* = *BE/EC*

From the graph *BE* = 6 m/s

and *EC* = 16 – 10 = 6 seconds.

$\therefore$ Retardation = 6m/s / 6 s

= 1 m/s^2

5. (c) 36 m

Distance travelled from *A* to *B*

= Area under the line *AB* and the time axis

= Area of rectangle *DABE* = *DA* × *DE*

Now, from the given graph, we find that

DA = 6 m/s and *DE* = 10 – 4 = 6 s.

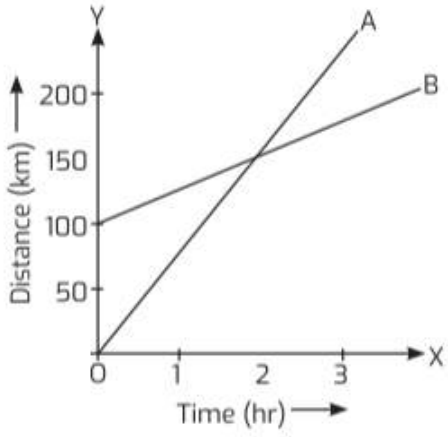
Therefore, Distance travelled from *A* to *B* = 6 × 6

= 36 m

Case Study 4

The change in the position of an object with time can be represented on the distance-time graph adopting a convenient scale of choice. In this graph, time is taken along the *X*-axis and distance is taken along the *Y*-axis. This graph shows that the distance travelled by the trains is directly proportional to time taken.

Study the graph related to distance-time graph of two trains and answer the questions that follow:



Read the given passage carefully and give the answer of the following questions:

Q 1. How much ahead of *A* is *B* when the motion starts?

Q 2. What is the speed of *B* ?

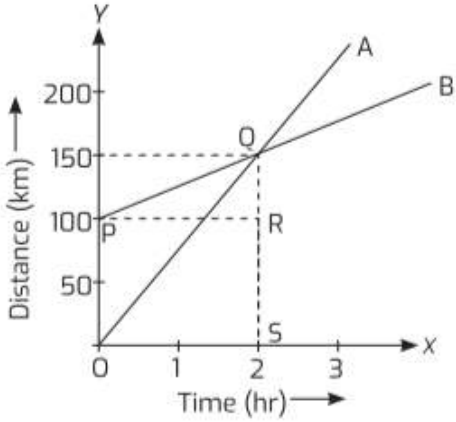
Q 3. When and where will *A* catch *B*?

Q 4. What is the difference between the speeds of *A* and *B*?

Q 5. Is the speed of both the trains uniform? Justify your answer.

Answers

1. B is 100 km ahead of *A*.



2. Speed of $B = \frac{QR}{PR} = \frac{150-100}{2-0} = \frac{50}{2}$

= 25 km/hr

3. *A* will catch *B* after 2 hours at a distance of 150 km.

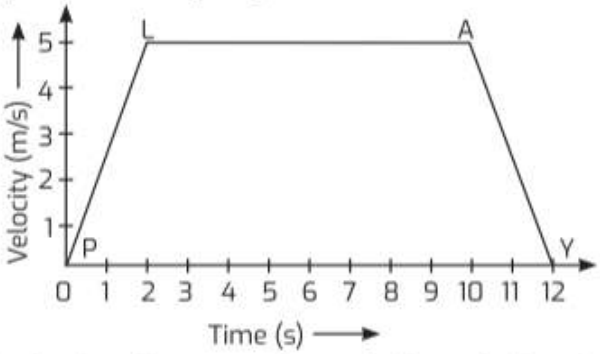
4. Speed of $A = \frac{QS}{OS} = \frac{150-0}{2-0} = \frac{150}{2}$ = 75 km/hr

Difference = 75 – 25 = 50 km/hr

5. Yes, because both are straight line graphs.

Case Study 5

The variation in velocity with time for an object moving in a straight line can be represented by a velocity-time graph. In this graph, time is represented along the *x*-axis and velocity is represented along the *y*-axis.



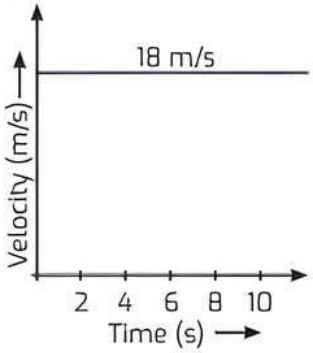
Study the above graph carefully and give the answer of the following questions:

Q 1. Identify the type of motion represented by lines *PL* and *AY*.

Q 2. What is the velocity of object at *t* = 3.7 s?

Q 3. Calculate acceleration:
(i) between 4th and 9th second.
(ii) during last 2 seconds.

Q 4. Based on the data represented in the graph below, find the displacement of body in first 8 seconds.



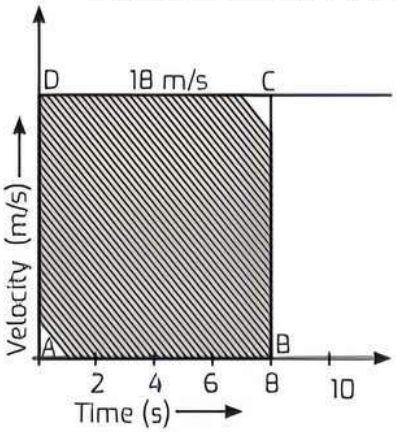
Q 5. In Q. 4, what is the acceleration of the body?

Answers

1. *PL* represents uniformly accelerated motion.
AY represents uniformly retarded motion.
2. At $t = 3.7$ s, velocity of object is 5 m/s.
3. (i) Between 4th and 9th second, $a = 0$
(ii) During last 2 s,

$$\text{acceleration } (a) = \frac{0-5}{12-10} = \frac{-5}{2} = -2.5 \text{ m/s}^2$$

4. Displacement = Area under *v*-*t* graph
= Area of rectangle ABCD
= $DC \times AB$ = 18 m/s × 8 s = 144 m



5. From the graph as shown in Q.4, it is clear that the velocity is not changing with time, *i.e.*, acceleration is zero.

Very Short Answer Type Questions

Q 1. How do we often perceive an object to be in motion?

Ans. We often perceive an object to be in motion when its position changes with respect to a fixed reference point/observer.

Q 2. Give an example where the object is at rest and also in motion at the same time.

Ans. A passenger travelling in a bus is at rest with respect to the fellow passengers but is in motion with respect to the surroundings.

Q 3. Under which condition do the displacement and distance have the same magnitude?

Ans. When the object is in uniform motion, the magnitude of displacement and distance are the same.

Q 4. A boy hits a football high up in the air. He runs and catches the football before it hits the ground. Which of the two, the boy or the football, has had a greater displacement?

Ans. Both have the same displacement, although the distance travelled by the football is greater than the distance travelled by the boy.

Q 5. When is an object in motion considered to be a point object?

Ans. An object in motion is considered to be a point object if the distance covered by it is very large as compared to the dimensions of the object.

Q 6. What is the shape of the path of a body when it is in uniform motion?

Ans. The path will be a straight line.

Q 7. An object travels 16 m in 4 s and then another 16 m in 2 s. What is the average speed of the object? *(NCERT EXEMPLAR)*

Sol. Total distance travelled by the object
= 16 m + 16 m = 32 m
Total time taken = 4 s + 2 s = 6 s

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

$$= \frac{32 \text{ m}}{6 \text{ s}} = 5.33 \text{ m s}^{-1}$$

Therefore, the average speed of the object is 5.33 m s^{-1}.

Q 8. What determines the direction of motion of an object: velocity or acceleration?

Ans. Velocity determines the direction of motion of an object.

Q 9. Can a body have a constant speed and still be accelerating?

Ans. Yes, when the body moves along a circular path with a uniform speed, it possesses centripetal acceleration.

Knowledge BOOSTER

Centripetal acceleration is the property of motion of a body traversing a circular path.

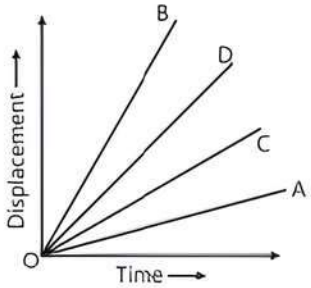
Q 10. If the displacement of a body is proportional to the square of the time elapsed, what type of motion does the body possess?

Ans. The body possesses a uniform accelerated motion.

Q 11. 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.

Q 12. Figure shows the displacement-time graph of four children A, B, C and D. Which child has the highest velocity?



Ans. Velocity = Slope of displacement-time graph.
Since, the slope of child B is greater than other children, so, child B has the highest velocity.

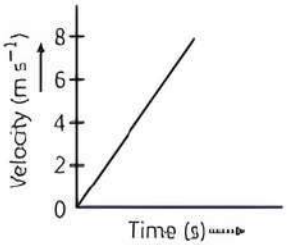
Q 13. What is the slope of the displacement-time graph when the body is in uniform motion?

Ans. The slope of the displacement-time graph shows the value of the uniform velocity.

Q 14. What is the quantity which is measured by the area occupied below the velocity-time graph?

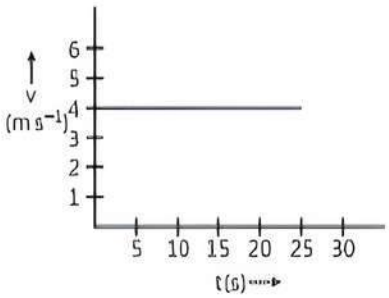
Ans. Displacement is the quantity which is measured by the area under velocity-time graph.

Q 15. Velocity-time graph of a body is shown in figure. What conclusion can be drawn about the type of motion?



Ans. The body is in uniform motion.

Q 16. Velocity-time graph of a body is shown in figure. What conclusion can be drawn about the velocity of the body from this graph?



Ans. The body is moving with a constant velocity of 4 ms^{-1}.

Q 17. Can a body have constant speed but variable velocity?

Ans. Yes, a body in uniform circular motion has constant speed but due to the change in direction of motion, its velocity changes at every point.

Q 18. If the acceleration of a particle is constant in magnitude but not in direction, what type of path is followed by the particle?

Ans. The particle follows a circular path.

Q 19. Why is the motion of a circulating fan non-uniform?

Ans. The motion of a circulating fan is non-uniform because the direction of motion changes at every point.

Short Answer Type-I Questions

Q 1. Distinguish between distance and displacement.

Ans. Distance: The length of the actual path between the initial (*i.e.*, starting or reference point) and the final position of a moving object in the given time interval is known as the distance travelled by the object.

Displacement: The shortest distance between the initial position and the final position of a moving object in the given interval of time is known as the displacement of the object.

Q 2. Two cars moving in opposite directions cover the same distance *'d'* in one hour. If the cars were moving in north-south direction, what will be their displacement in one hour?

Ans. Since both the cars are covering the same distance *'d'* in one hour, their velocity will be the same. Hence, the displacement of each car will also be *'d'* along north and south respectively.

Q 3. 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, even though the moving object comes back to its initial position, the distance travelled is not zero.

Q 4. What is meant by uniform motion? Can you think of an example of a body in uniform motion?

Ans. A body is said to be in uniform motion if it covers equal distances in equal intervals of time, *e.g.*, a car moving in a straight line shows uniform motion if it covers equal distances in equal intervals of time.

Q 5. Usha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed of Usha. *(NCERT EXAMPLE)*

Sol. Total distance covered by Usha in 1 min = 180 m.
Displacement of Usha is 1 min = 0 m

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

$$= \frac{180\,\text{m}}{1\,\text{min}} = \frac{180\,\text{m}}{1\,\text{min}} \times \frac{1\,\text{min}}{60\,\text{s}}$$

$$= 3\ \text{m s}^{-1}$$

Q 6. The odometer of a car reads 2000 km at the start of a trip and 2400 km at the end of the trip. If the trip took 8 h, calculate the average speed of the car in $km\ h^{-1}$ and $m\ s^{-1}$. *(NCERT EXAMPLE)*

Sol. Distance covered by the car,
$s = 2400\ \text{km} - 2000\ \text{km} = 400\ \text{km}$
Time elapsed, $t = 8\ \text{h}$
Average speed of the car is,

$$v_{av} = \frac{s}{t} = \frac{400\,\text{km}}{8\,\text{h}} = 50\ \text{km h}^{-1}$$

$$= 50\,\frac{\text{km}}{\text{h}} \times \frac{1000\,\text{m}}{1\,\text{km}} \times \frac{1\,\text{h}}{3600\,\text{s}} = 13.9\ \text{m s}^{-1}$$

The average speed of the car is 50 $km\ h^{-1}$ or 13.9 $m\ s^{-1}$.

Q 7. Distinguish between speed and velocity.

(NCERT INTEXT)

Ans. Speed is the rate of change of distance. It is a scalar quantity and is always positive.

Velocity is the rate of change of displacement. It is a vector quantity and can be positive, negative or zero.

Q 8. A body is moving with a uniform velocity of 10 m s^{-1}. Find its velocity after 10 s.

Ans. As the motion is uniform, therefore the velocity of the body will remain the same even after 10 s. Therefore, the velocity of the body will be 10 m s^{-1}.

Q 9. Give one example each to differentiate between uniform acceleration and non-uniform acceleration.

Ans. The object has a uniform acceleration if its velocity changes by an equal amount in equal intervals of time, *e.g.*, the motion of an object falling freely from the top of a building.

On the other hand, if velocity of an object changes by an unequal amount in equal intervals of time, then it has a non-uniform acceleration, *e.g.*, the motion of a bus on a hilly track.

Q 10. An object *P* is moving with a constant velocity for 5 minutes. Another object *Q* is moving with changing velocity for 5 minutes. Out of these two objects, which one possesses acceleration? Explain.

Ans. Acceleration $= \frac{\text{Change in velocity}}{\text{Time taken}}$

Since, the velocity of object *P* is not changing or change in velocity of the object is zero, therefore, object *P* has no acceleration.

On the other hand, there is a change in velocity of the object *Q*. This indicates that it possesses acceleration.

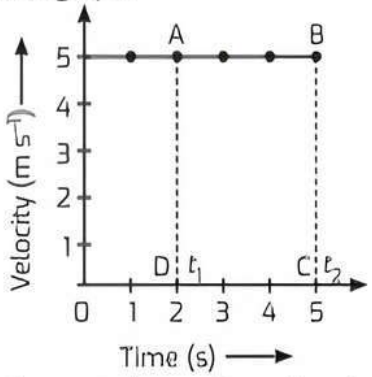
Q 11. What is the nature of the distance-time graphs for uniform and non-uniform motion of an object?

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, not parallel to the time axis.

Q 12. Plot velocity-time graph of a body moving with a constant or uniform velocity.

Ans. Velocity-time graph:



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

Ans. Given, $a = 0$, $\therefore$ $v = u + at = u$

$s = ut + 1/2\,at^2 = ut$ and

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

Q 14. A car starts from rest and attains a velocity of 10 m s^{-1} in 40 s. The driver applies brakes and slows down the car to 5 m s^{-1} in 10s. Find the acceleration of the car in both the cases.

Sol. **First case:**

Initial velocity, $u = 0$

final velocity, $v = 10\ m\ s^{-1}$,

Time, $t = 40\ s$

$a = ?$

Using, $a = \frac{v-u}{t}$,

$$a = \frac{(10-0)\ m\ s^{-1}}{40s} = 0.25\ m\ s^{-2}$$

Second case:

Initial velocity, $u = 10\ m\ s^{-1}$

Final velocity, $v = 5\ m\ s^{-1}$

Time, $t = 10\ s$

$a = ?$

Using, $a = \frac{v-u}{t}$,

$$a = \frac{(5-10)\ m\ s^{-1}}{10\ s} = \frac{-5}{10}\ m\ s^{-2} = -0.5\ m\ s^{-2}$$

In first case, car is accelerating while in the second case, the car is retarding.

Q 15. What is uniform circular motion? How is uniform circular motion regarded as an accelerated motion? Explain.

Ans. The circular motion of a body with a uniform speed is known as uniform circular motion. When a body possesses a uniform circular motion, its velocity changes due to the continuous change in the direction of its motion. Hence, the body is in accelerated motion.

Q 16. What is the difference between uniform motion in a straight line and uniform circular motion?

Ans.

Basis of Difference	Uniform Motion in a Straight Line	Uniform Circular Motion
Effect on direction of motion of object	The direction of motion of an object remains unchanged.	The direction of motion of an object changes continuously.
Effect on acceleration	If an object moves with a constant speed, acceleration of the object is zero.	In uniform circular motion, the object moves with a constant speed but the motion of the object is accelerated motion.

Short Answer Type-II Questions

Q 1. A taxi driver noted the reading on the odometer fitted in the vehicle as 1052 km when he started the journey. After a 30 minutes drive, he observed that the odometer reading was 1088 km. Find the average speed of the taxi.

Sol. Distance travelled by the taxi = (1088 – 1052) km

= 36 km

Time taken $= 30 \text{ min} = \frac{1}{2}\text{h}$

$\therefore$ Average speed of taxi

$$= \frac{\text{Distance}}{\text{Time}} = \frac{36 \text{ km}}{\frac{1}{2}\text{h}} = 72 \text{ km h}^{-1}$$

$$= 72 \times \frac{5}{18} \text{ m s}^{-1} = 20 \text{ m s}^{-1}$$

Hence, the average speed of the taxi is 20 m s^{-1}.

Q 2. A car moves with a speed of 30 km h^{-1} for half an hour, 25 km h^{-1} for one hour and 40 km h^{-1} for two hours. Calculate average speed of the car.

Sol. Given, time taken, $t_1 = 0.5$ h, $t_2 = 1$ h, $t_3 = 2$ h.

$\therefore$ Total time, $t = t_1 + t_2 + t_3$

$= 0.5 + 1 + 2 = 3.5$ h

Now, speed, $v_1 = 30$ km h^{-1}, $v_2 = 25$ km h^{-1},

$v_3 = 40$ km h^{-1}.

$\therefore$ Distance, $d_1 = v_1 t_1 = 30 \times 0.5 = 15$ km

$d_2 = v_2 t_2 = 25 \times 1 = 25$ km

and $d_3 = v_3 t_3 = 40 \times 2 = 80$ km

$\therefore$ Total distance, $d = d_1 + d_2 + d_3$

$= 15 + 25 + 80 = 120$ km

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{d}{t} = \frac{120}{3.5} = 34.3 \text{ km h}^{-1}$$

Hence, the average speed of the car is 34.3 km h^{-1}.

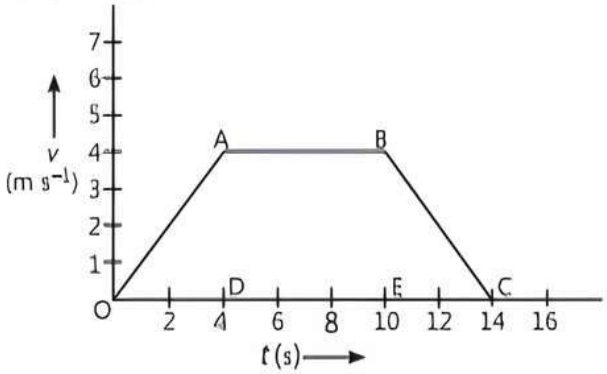
Q 3. Define speed and velocity. Write their SI units. A body is moving with a velocity of 15 m s^{-1}. If the motion is uniform, what will be the velocity after 10 s?

Ans. Speed is the distance travelled by an object in a given time. Its SI unit is m s^{-1}.

Velocity is the speed of an object moving in a direction or the displacement of an object in unit time. SI unit of velocity is m s^{-1}.

Since, the motion is uniform, therefore there will be no change in the velocity of the body and hence its velocity will remain 15 m s^{-1}.

Q 4. Velocity-time graph for the motion of a body is shown below:



Answer the following questions:

(i) Which part of the graph shows accelerated motion? Also calculate the acceleration.

(ii) Which part of the graph shows retarded motion? Also calculate the retardation.

(iii) Calculate the distance travelled by the body in first 4 seconds of the journey.

Ans. (i) *OA* part of the graph shows accelerated motion as velocity of the body is increasing with time.

Acceleration,

$$a = \frac{v - u}{t} = \frac{(4 - 0) \text{ m s}^{-1}}{(4 - 0) \text{ s}} = 1 \text{ m s}^{-2}$$

Knowledge BOOSTER

If velocity of an object decreases with time, then it is said to have negative acceleration. Negative acceleration is also called retardation or deceleration.

(ii) *BC* part of the graph shows retarded motion as velocity of the body is decreasing with time.

Retardation,

$$a = \frac{v - u}{t} = \frac{(0 - 4) \text{ m s}^{-1}}{(14 - 10) \text{ s}} = -1 \text{ m s}^{-2}$$

Here, negative sign shows retardation.

(iii) Distance travelled by the body in first 4 seconds

= Area under *OA* part of the graph

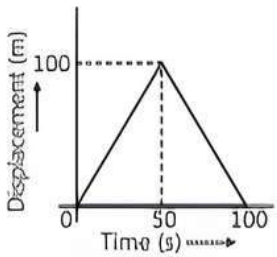
= Area of Δ *OAD*

$$= \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 4 \text{ s} \times 4 \text{ m s}^{-1} = 8 \text{ m}$$

Hence, the distance travelled is 8 m.

Q 5. 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.

(NCERT EXEMPLAR)



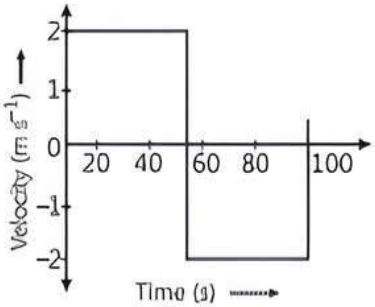
Ans. Velocity from 0 to 50 s is

$$v_1 = \frac{\Delta s}{\Delta t} = \frac{100 - 0}{50 - 0} = 2 \text{ m s}^{-1}$$

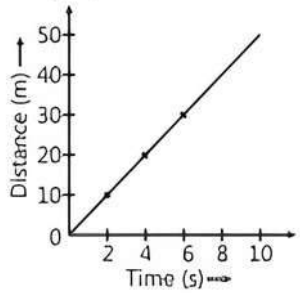
and velocity from 50 s to 100 s is $v_2 = \frac{0 - 100}{100 - 50}$

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

Velocity-time Graph:



Q 6. Make a velocity-time graph from the following distance-time graph.



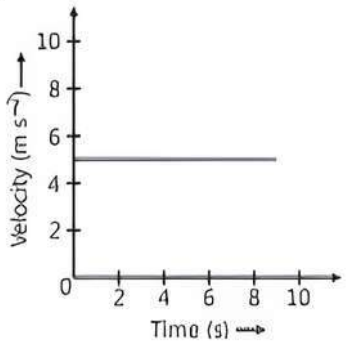
Ans. From the graph, we have

$$\text{velocity after } 2\text{ s} = \frac{10}{2} = 5\text{ m s}^{-1}$$

$$\text{velocity after } 4\text{ s} = \frac{20}{4} = 5\text{ m s}^{-1}$$

and $$\text{velocity after } 6\text{ s} = \frac{30}{6} = 5\text{ m s}^{-1}$$

Since velocity is constant, acceleration will be 0. So, velocity-time graph will be a straight line parallel to time axis.



Q 7. Starting from a stationary position, Rahul paddles his bicycle to attain a velocity of 6 m s^{-1} in 30 s. Then he applies brakes such that the velocity of the bicycle comes down to 4 m s^{-1} in the next 5 s. Calculate the acceleration of the bicycle in both the cases. *(NCERT EXAMPLE)*

Sol. In the first case:
Initial velocity, $u = 0$;
final velocity, $v = 6\text{ m s}^{-1}$;
time, $t = 30\text{ s}$.
We know that,

$$a = \frac{v - u}{t}$$

Substituting the given values of u, v and t in the above equation, we get

$$a = \frac{(6\text{ m s}^{-1} - 0\text{ m s}^{-1})}{30\text{ s}}$$

$$= 0.2\text{ m s}^{-2}$$

In the second case:
Initial velocity, $u = 6\text{ m s}^{-1}$;
final velocity, $v = 4\text{ m s}^{-1}$;
time, $t = 5\text{ s}$.

Then, $$a = \frac{(4\text{ m s}^{-1} - 6\text{ m s}^{-1})}{5\text{ s}}$$

$$= -0.4\text{ m s}^{-2}$$

The acceleration of the bicycle in the first case is 0.2 m s^{-2} and in the second case, it is –0.4 m s^{-2}.

Q 8. A driver applies the brakes and slows down the velocity of the bus from 80 km h^{-1} to 60 km h^{-1} in 5 s. Calculate the acceleration of the bus.

Sol. Given, initial velocity, $u = 80\text{ km h}^{-1}$

$$= 80 \times \frac{5}{18}\text{ m s}^{-1} = 22.22\text{ m s}^{-1}$$

and final velocity, $v = 60\text{ km h}^{-1}$

$$= 60 \times \frac{5}{18}\text{ m s}^{-1} = 16.67\text{ m s}^{-1}$$

Time, $t = 5\text{ s}$
Acceleration, $a = ?$
We know that,

$$a = \frac{v - u}{t}$$

$$= \frac{(16.67 - 22.22)\text{ m s}^{-1}}{5\text{ s}} = \frac{-5.55\text{ m s}^{-1}}{5\text{ s}}$$

$$= -1.11\text{ m s}^{-2}$$ *i.e.*, negative acceleration.

Hence, acceleration of the bus is –1.11 m s^{-2}.

Q 9. A car starts from rest and acquires a velocity of 54 km h^{-1} in 2 minutes. Find:
(i) the acceleration and
(ii) distance travelled by the car during this time. Assume, motion of the car is uniform.

Sol. Here, initial velocity, $u = 0$

Final velocity, $v = 54\text{ km h}^{-1} = 54 \times \frac{5}{18}\text{ m s}^{-1} = 15\text{ m s}^{-1}$

Time $t = 2\text{ min} = 2 \times 60 = 120\text{ s}$, $a = ?$, $s = ?$
(i) Using $v = u + at$, we get

$$a = \frac{v - u}{t} = \frac{(15 - 0)\text{ m s}^{-1}}{120\text{ s}} = \frac{1}{8}\text{ m s}^{-2}$$

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

$$s = 0 + \frac{1}{2} \times \frac{1}{8}\text{ m s}^{-2} \times (120\text{ s})^2$$

$$= \frac{1}{16} \times 120 \times 120\text{ m} = 900\text{ m}$$

Q 10. A child drops a ball from a height of 10 m. Assume that its velocity increases uniformly at a rate of 10 m s^{-2}. Find:
(i) the velocity with which the ball strikes the ground and
(ii) the time taken by the ball to reach the ground.

Sol. Here, $s = 10\text{ m}$, $a = 10\text{ m s}^{-2}$
$u = 0$ ($\because$ ball was simply dropped)
$v = ?$, $t = ?$
(i) Using $v^2 - u^2 = 2as$, we get

$$v^2 - 0 = 2 \times 10\text{ m s}^{-2} \times 10\text{ m}$$

or $$v^2 = 200\text{ m}^2\text{ s}^{-2}$$

or $$v = \sqrt{200\text{ m}^2\text{s}^{-2}} = 14.14\text{ m s}^{-1}$$

(ii) Using $v = u + at$, we get

$$14.14 = 0 + 10t \text{ or } t = \frac{14.14}{10} = 1.414\text{ s}$$

Q 11. 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 distance will the car cover in 12 seconds since it started from the rest? *(NCERT EXEMPLAR)*

Sol. The distance travelled in first 8 seconds.

$$x_1 = 0 + \frac{1}{2}(5)(8)^2 = 160\text{ m}$$

At this point, the velocity,

$$v = u + at = 0 + (5 \times 8)$$
$$= 40\text{ m s}^{-1}$$

Therefore, the distance covered in last 4 seconds,

$$x_2 = (40 \times 4)\text{ m} = 160\text{ m}$$

Thus, the total distance,

$$x = x_1 + x_2 = (160 + 160)\text{ m}$$
$$= 320\text{ m}$$

Q 12. An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 h to revolve around the earth.

Sol. Given, radius of the circular orbit, $r = 42250$ km

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

Speed of a circular moving object,

$$v = \frac{2\pi r}{t} = \frac{2 \times 3.14 \times 42250}{24}\text{ km h}^{-1}$$

$$= 11055.42\text{ km h}^{-1}$$

Hence, the speed of the artificial satellite is 11055.42 km h^{-1}.

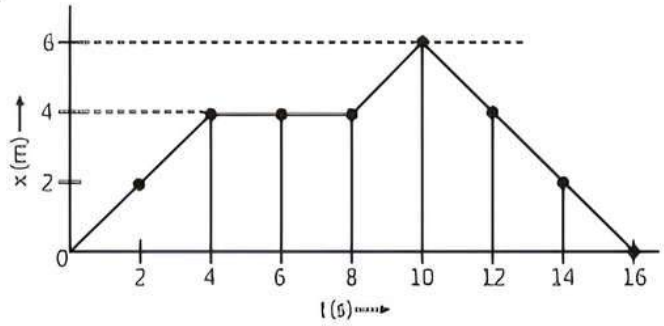
Long Answer Type Questions

Q 1. Using following data, draw time-displacement graph for a moving object: *(NCERT EXEMPLAR)*

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

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

Ans.



We know that,

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

Average velocity for first 4 s,

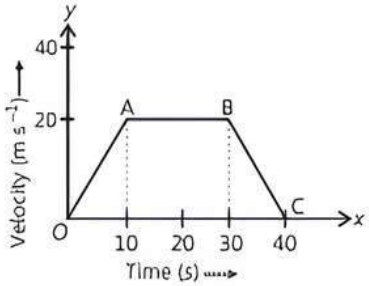
$$v = \frac{4-0}{4-0} = \frac{4}{4} = 1\text{ m s}^{-1}$$

For next 4 s, $v = \frac{4-4}{8-4} = \frac{0}{4} = 0\text{ m s}^{-1}$

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

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

Q 2. The velocity-time graph of a body is shown in the following figure. Answer the following questions.



(i) State the kind of motion represented by *OA* and *AB*.

(ii) What is the velocity of the body after 10 s and after 40 s?

(iii) Calculate the negative acceleration of the body.

(iv) Calculate the distance covered by the body between 10th and 30th second.

Ans. (i) *OA* represents uniform acceleration and *AB* represents zero acceleration or constant velocity.

(ii) Velocity of the body after 10 s = 20 ms^{-1} and after 40 s, it will be 0 *i.e.*, body comes to rest.

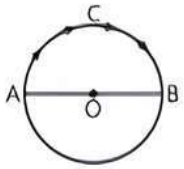
(iii) Negative acceleration (Retardation)

$$= \frac{0-20}{40-30} = \frac{-20}{10} = -2\text{ m/s}^{-2}$$

(iv) Distance between 10th and 30th second

$$= (30-10)\text{ s} \times 20\text{ m s}^{-1}$$
$$= 400\text{ m}$$

Q 3. An insect moves along a circular path of radius 10 cm with a constant speed. It takes 1 min to move from a point on the path to the diametrically opposite point. Find:



(i) the distance covered

(ii) the speed

(iii) the displacement

(iv) the average velocity

Sol. Let the insect was at A initially and it moves along ACB to reach the opposite point B in 1 min.

(i) The distance covered in 1 min = πr

$$= 3.14 \times 10 = 31.4\text{ cm}$$

(ii) Speed = $\frac{\text{Distance}}{\text{Time}} = \frac{31.4}{1} = 31.4\text{ cm min}^{-1}$

(iii) Displacement, $AB = 2r = 2 \times 10 = 20$ cm

(iv) Average velocity, $v_{av} = \frac{\text{Displacement}}{\text{Time}} = \frac{20\text{ cm}}{1\text{ min}}$

$$= 20\text{ cm min}^{-1}$$

Chapter Test

Multiple Choice Questions

Q 1. A quality has a value of −6 m/s. It may be the:

a. speed of a particle
b. velocity of a particle
c. position of a particle
d. displacement of a particle

Q 2. Calculate the speed of the tip of second's hand of a watch of length 1.5 cm.

a. 3.14 cm/s
b. 0.16 cm/s
c. 2 cm/s
d. 0.05 cm/s

Q 3. What is the SI unit of acceleration?

a. m
b. m/s
c. m/s^2
d. ms^2

Q 4. Acceleration is a vector quantity which indicates that its value:

a. is always negative
b. is zero
c. can be positive, negative or zero
d. is always positive

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is* ***Assertion*** *(A) and the other is* ***Reason*** *(R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): An object may have acceleration even if it is moving with uniform velocity.

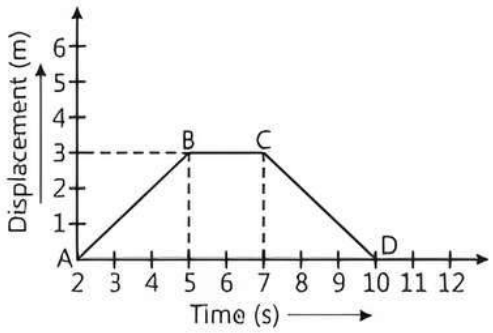
Reason (R): An object may be moving with uniform velocity but it may be changing its direction of motion.

Q 6. Assertion (A): Velocity-time graph of a particle in uniform motion along a straight path is a line parallel to the time axis.

Reason (R): In uniform motion the velocity of a particle increases as the square of the time elapsed.

Case Study Based Question

Q 7. Rahul was driving on a bicycle along a straight road, first, he rides towards the east and then comes back to its initial position and the below graph is used to represent this change in displacement with respect to time.



Read the given passage carefully and give the answer of the following questions:

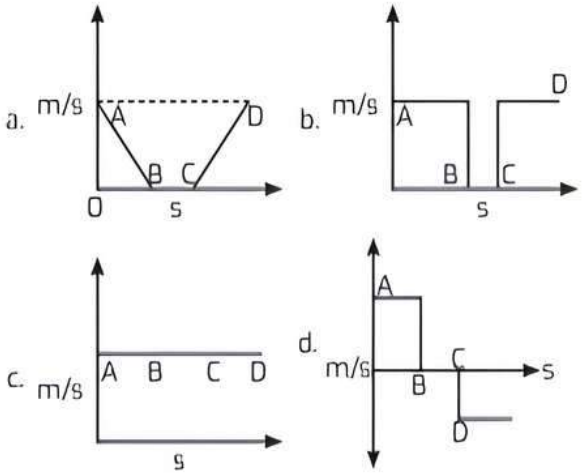
(i) From the given graph the velocity between A and B is .....

a. 0.1 km/hr
b. 1 m/s
c. 20 m/s
d. – 1 m/s

(ii) From the given graph the velocity between C and D is .....

a. 0.1 km/s
b. 1 m/s
c. –1 m/s
d. – 20 m/s

(iii) In the given case which of the following graph correctly represents relation between velocity and time?



(iv) The average speed of a body can never be .....

a. zero
b. less than 1
c. greater than 1
d. None of the above

Very Short Answer Type Questions

Q 8. Can the speed of a body be negative?

Q 9. Define the term velocity.

Short Answer Type-I Questions

Q 10. State if the following situations are possible by giving an example of each of these:

(i) A body is moving with a constant acceleration but with zero velocity.

(ii) A body is moving horizontally with an acceleration in vertical direction.

Q 11. The data regarding the motion of two different objects A and B are given in the table.

Time	Distance travelled by A (in m)	Distance travelled by B (in m)
9 : 30 AM	5	2
9 : 35 AM	10	10
9 : 40 AM	15	19
9 : 45 AM	20	25
9 : 50 AM	25	25

Examine them carefully and state whether the motion of objects is uniform or non-uniform.

Q 12. A train travels the first 30 km of 120 km track with a uniform speed of 30 km h^{-1}. What should be the speed of the train to cover the remaining distance of the track so that its average of the track so that its average speed is 60 km h^{-1} for the entire trip?

Short Answer Type-II Questions

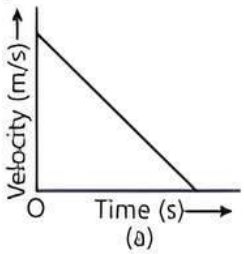
Q 13. Joseph jogs from one end *A* to the other end *B* of a straight 300 m road in 2 minutes 30 seconds and then turns around and jogs 100 m back to point *C* in another 1 minute. What are Joseph's average speeds and velocities in jogging:

(i) from *A* to *B* and

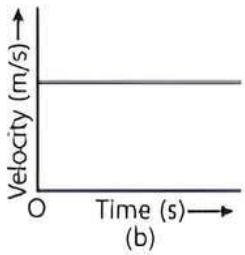
(ii) from *A* to *C*?

Q 14. A stone tied to one end of a string is rotated in a circle. Explain what happens when the stone is released.

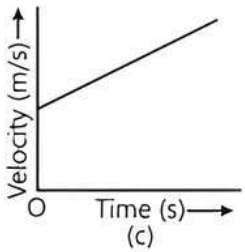
Q 15. (a) Identify the following graphs and answer the questions :



(a)



(b)



(c)

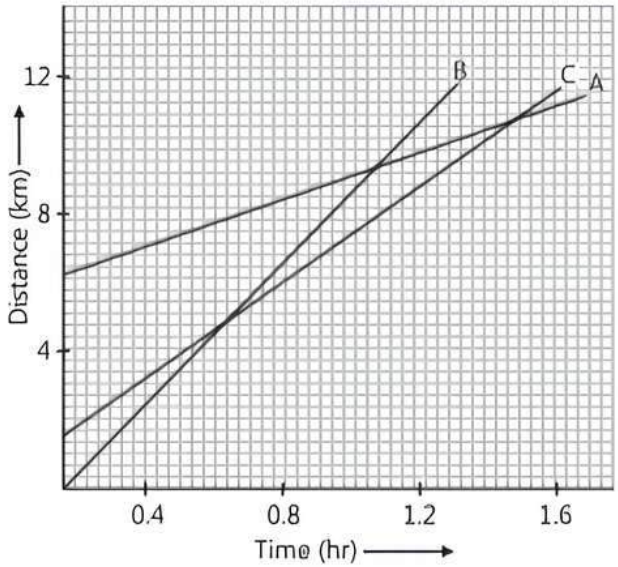
(i) Which of the graphs indicate negative acceleration? Why?

(ii) What do you infer from the graph where velocity-time graph is parallel to the time axis?

(iii) Which of the graphs represent a body moving with initial velocity not equal to zero but with constant acceleration? Justify your answer.

Long Answer Type Questions

Q 16. Following figure shows the distance-time graph of three objects *A*, *B* and *C*. Study the graph and answer the following questions:



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

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

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

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

Q 17. A car starts from rest and attains a velocity of 10 m s^{-1} in 40 s. The driver applies brakes and slows down the car to 5 m s^{-1} in 10 s. Find the acceleration of the car in both the cases.

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