Motion in a Straight Line

Quick Revision

1. **Rest** If the position of an object does not change w.r.t. its surrounding with the passage of time, it is said to be at rest. e.g. Book lying on the table, a person sitting on a chair, etc.
2. **Motion** If the position of an object is continuously changing w.r.t. its surrounding w.r.t time, then it is said to be in the state of motion. e.g. The crawling insects, water flowing down a dam, etc.
3. **Types of Motion**
   On the basis of the nature of path followed, motion is classified as
   - **Rectilinear Motion** The motion in which a particle moves along a straight line is called rectilinear motion. e.g. Motion of a sliding body on an inclined plane.
   - **Circular Motion** The motion in which a particle moves in a circular path is called circular motion. e.g. A string whirled in a circular loop.
   - **Oscillatory Motion** The motion in which a particle moves to and fro about a given point is known as oscillatory motion. e.g. Simple pendulum.

   On the basis of the number of coordinates required to define the motion of an object, motion is classified as
   - **One-dimensional Motion (1-D)** The motion of an object is considered as 1-D, if only one coordinate is needed to specify the position of the object.
   - **Two-dimensional Motion (2-D)** The motion of an object is considered as 2-D, if two coordinates are needed to specify the position of the object. In 2-D motion, the object moves in a plane. e.g. A satellite revolving around the earth.
   - **Three-dimensional Motion (3-D)** The motion of an object is considered as 3-D, if all the three coordinates are needed to specify the position of the object.

     This type of motion takes place in three-dimensional space.

     e.g. Butterfly flying in garden, the motion of water molecules and motion of kite in the sky.
4. **Point Object** An object is considered as point object, if the size of the object is much smaller than the distance travelled by it in a reasonable duration of time. e.g. Earth can be considered as a point object in its orbit.
5. **Position** It is defined as the point where an object is situated.
6. **Path Length or Distance** The length of the path covered by the object in a given time-interval is known as its path length or distance travelled. It is a scalar quantity, i.e. it has only magnitude but no direction.

7. **Displacement** The change in position of an object in a particular direction is termed as displacement, i.e. the difference between the final and initial positions of the object in a given time. It is denoted by Δx. Mathematically, it is represented by

$$\Delta x = x_2 - x_1$$

where, x_1 and x_2 are the initial and final positions of the object, respectively.

Cases

- If $x_2 > x_1$, then Δx is positive.
- If $x_1 > x_2$, then Δx is negative.
- If $x_1 = x_2$, then Δx is zero.

It is a vector quantity as it possesses both, the magnitude and direction.

8. **Uniform Motion in a Straight Line** A body is said to be in a uniform motion, if it travels equal distances in equal intervals of time along a straight line. A distance (x)-time (t) graph for uniform motion is a straight line passing through the origin.

9. **Non-uniform Motion** A body is said to be in non-uniform motion, if it travels unequal displacements in equal intervals of time.

10. **Speed** The path length or the distance covered by an object divided by the time taken to cover that distance is called its speed.

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

It is a **scalar quantity**. The speed of the object for a given interval of time is always positive.

Unit of speed In SI (MKS) system, the unit of speed is ms^{-1} and in CGS, it is cms^{-1}.

Dimensional formula $[M^0LT^{-1}]$

- **Average Speed** Average speed of an object is defined as the total distance travelled divided by the total time taken.

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

- **Instantaneous Speed** Speed at an instant is defined as the limit of the average speed as the time interval (Δt) becomes infinitesimally small or approaches to zero.

  Mathematically, instantaneous speed (v_i) at any instant of time (t) is expressed as

$$v_i = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t}$$

or

$$v_i = \frac{ds}{dt}$$

where, ds is the distance covered in time dt.

11. **Velocity** The rate of change in position or displacement of an object with time is called the velocity of that object.

i.e. $$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

It is a **vector quantity**.

The velocity of an object can be positive, zero and negative according to its displacement.

Unit of velocity In CGS, the unit of velocity is cms^{-1} and in MKS or SI, it is ms^{-1}.

Dimensional formula $[M^0LT^{-1}]$

- **Average Velocity** Average velocity of a body is defined as the change in position or displacement (Δx) divided by the time interval (Δt) in which that displacement occurs.

  Average velocity,

$$v_{av} = \frac{\text{Total displacement } (\Delta x)}{\text{Total time taken } (\Delta t)}$$

- **Instantaneous Velocity** Velocity at an instant is defined as the limit of average velocity as the time interval (Δt) becomes infinitesimally small or approaches to zero.

  Mathematically, instantaneous velocity (v_i) at an instant of time (t) is given by

$$v_i = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

or

$$v_i = \frac{dx}{dt}$$

where, dx is displacement for time dt.

12. **Acceleration** Acceleration of a body can be expressed as the rate of change of velocity with time.

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

It is a vector quantity. The SI unit of acceleration is ms^{-2} and in CGS system, its unit is $cm\ s^{-2}$. Its dimensional formula is $[M^0LT^{-2}]$.

13. **Types of Acceleration**

- **Uniform Acceleration** If an object is moving with uniform acceleration, it means that the change in velocity is equal in equal intervals of time.
- **Non-uniform Acceleration** If an object has variable or non-uniform acceleration, it means that, the change in velocity is unequal in equal intervals of time.
- **Average Acceleration** The average acceleration over a time interval is defined as the change in velocity divided by the time interval.

  Average acceleration,

$$\mathbf{a}_{\text{av}} = \frac{\Delta \mathbf{v}}{\Delta t} = \frac{\mathbf{v}_2 - \mathbf{v}_1}{t_2 - t_1}$$

- **Instantaneous Acceleration** It is defined as the acceleration of a body at a certain instant or the limiting value of average acceleration when time interval becomes very small or tends to zero. So, instantaneous acceleration,

$$\mathbf{a}_{\text{inst}} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{v}}{\Delta t} = \frac{d\mathbf{v}}{dt}$$

  where, $\frac{d\mathbf{v}}{dt}$ is the differential coefficient of $\mathbf{v}$ w.r.t. t.

14. **Kinematic Equations for Uniformly Accelerated Motion** If the change in velocity of an object in each unit of time is constant, then the object is said to be moving with constant acceleration and such a motion is called **uniformly accelerated motion.** An object moves along a straight line with a constant acceleration a and u be the initial velocity at $t = 0$ and v be the final velocity of the object after time (t), then

- **Velocity-Time Relation** $v = u + at$
- **Position-Time Relation** $x = ut + \frac{1}{2}at^2$

  where, x is the position of the object at time t.
- **Position-Velocity Relation** $v^2 = u^2 + 2ax$
- **Displacement of the Object in *n*th Second** $s(n\text{th}) = u + \frac{a}{2}(2n - 1)$

15. **Non-uniformly Accelerated Motion**

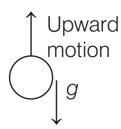
When acceleration of an object is not constant or acceleration is a function of time, then following relations hold for one-dimensional motion

- $v = \frac{dx}{dt}$
- $dx = v\,dt$
- $a = \frac{dv}{dt} = v\frac{dv}{dx}$
- $dv = a\,dt$ or $vdv = adx$

16. **Equations of Motion for the Motion of an Object under Gravity**

When an object is thrown upwards or fall towards the earth under the effect of gravity only, then its motion is called motion under gravity.

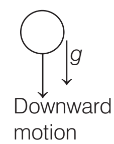
In this case, the equations of motion are given below



$$v = u + (\mp g)\ t$$

$$h = ut + \frac{1}{2}(\mp g)\ t^2$$

$$v^2 = u^2 + 2(\mp g)h$$



In case of upward motion, acceleration due to gravity, g is taken as **negative** and for downward motion, g is taken as **positive**.

17. **Stopping Distance for a Vehicle** When brakes are applied to a moving vehicle, the distance it travels before stopping is called stopping distance.

Stopping distance, $d_s = \frac{u^2}{2a}$

where, u = initial velocity of the vehicle

and a = retardation.

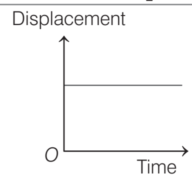
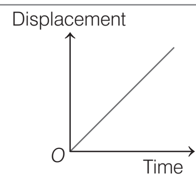
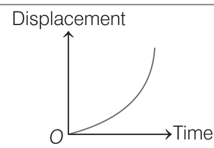
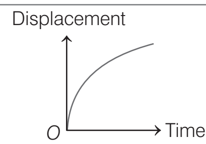
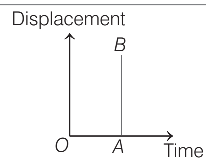
18. **Relative Velocity in 1-D** It is defined as the time rate of change of relative position of one object w.r.t. to another.

If an object A is moving with velocity v_A and an object B is moving with velocity v_B, then the velocity of object A relative to object B is given as $v_{AB} = v_A - v_B$

The relative velocity of object B relative to object A is $v_{BA} = v_B - v_A$

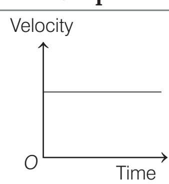
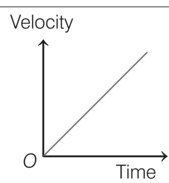
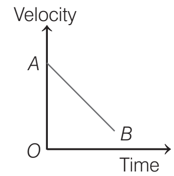
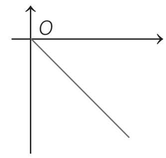
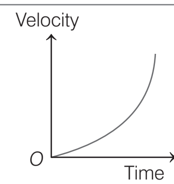
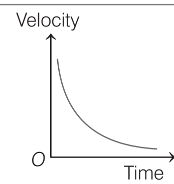
19. **Different Graphs related to Motion are as follows**

Displacement-Time Graph

Condition	Graph
For a stationary body	
Body moving with a constant velocity	
Body moving with a constant acceleration	
Body moving with a constant retardation	
Body moving with infinite velocity, but such motion of a body is never possible.	

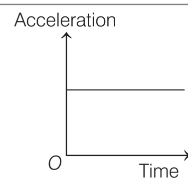
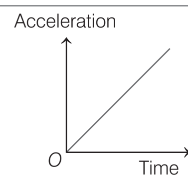
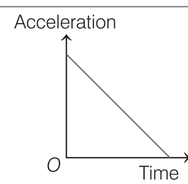
Note Slope of displacement-time graph gives average velocity.

Velocity-Time Graph

Condition	Graph
Body moving with a constant velocity	
Body moving with a constant acceleration having zero initial velocity	
Body moving with a constant retardation and its initial velocity is non-zero	
Body moving with a constant retardation with zero initial velocity	
Body moving with increasing acceleration	
Body moving with decreasing acceleration	

Note Slope of velocity-time graph gives average acceleration.

Acceleration-Time Graph

Condition	Graph
Body moving with a constant acceleration	
Body moving with constant increasing acceleration	
Body moving with constant decreasing acceleration	

Objective Questions

Multiple Choice Questions

1. Which of the following is an example of one-dimensional motion?

(a) Landing of an aircraft
(b) Earth revolving around the sun
(c) Motion of wheels of moving train
(d) Train running on a straight track

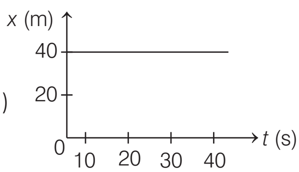
2. The coordinates of object with respect to a frame of reference at $t = 0$ s are $(-1, 0, 3)$. If $t = 5$ s, its coordinates are $(-1, 0, 4)$, then the object is in

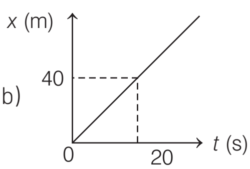
(a) motion along Z-axis
(b) motion along X-axis
(c) motion along Y-axis
(d) rest position between $t = 0$ s and $t = 5$ s

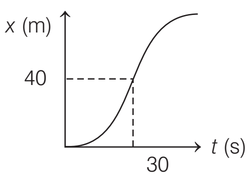
3. A person moves towards east for 3 m, then towards north for 4 m and then moves vertically up by 5 m. What is his distance now from the starting point?

(a) $5\sqrt{2}$ m (b) 5 m (c) 10 m (d) 20 m

4. For a stationary object at $x = 40$ m, the position-time graph is

(a)


(b)


(c)


(d) None of the above

5. The displacement of a car is given as − 240 m, here negative sign indicates

(a) direction of displacement
(b) negative path length
(c) position of car at that point
(d) no significance of negative sign

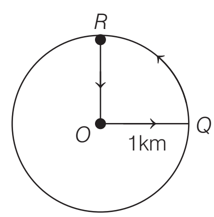
6. Snehit starts from his home and walks 50 m towards north, then he turns towards east and walks 40 m and then reaches his school after moving 20 m towards south. Then, his displacement from his home to school is

(a) 50 m (b) 110 m
(c) 80 m (d) 40 m

7. A vehicle travels half the distance l with speed v_1 and the other half with speed v_2, then its average speed is *(NCERT Exemplar)*

(a) $\frac{v_1 + v_2}{2}$ (b) $\frac{2v_1 + v_2}{v_1 + v_2}$ (c) $\frac{2v_1 v_2}{v_1 + v_2}$ (d) $\frac{l(v_1 + v_2)}{v_1 v_2}$

8. A runner starts from O and comes back to O following path $OQRO$ in 1h. What is his net displacement and average speed?



(a) 0,3.57 km/h (b) 0,0 km/h
(c) 0,2.57 km/h (d) 0,1 km/h

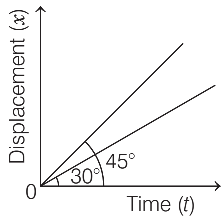
9. The sign (+ ve or − ve) of the average velocity depends only upon

(a) the sign of displacement
(b) the initial position of the object
(c) the final position of the object
(d) None of the above

10. Find the average velocity, when a particle completes the circle of radius 1m in 10 s.

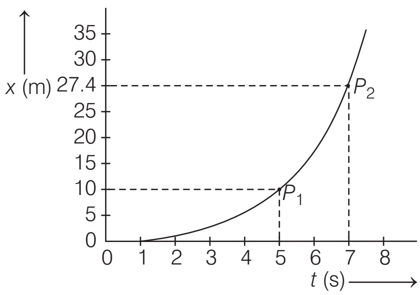
(a) 2 m/s (b) 3.14 m/s (c) 6.28 m/s (d) zero

11. The displacement-time graph of two moving particles make angles of 30° and 45° with the X-axis. The ratio of their velocities is



(a) $1:\sqrt{3}$ (b) 1:2 (c) 1:1 (d) $\sqrt{3}:2$

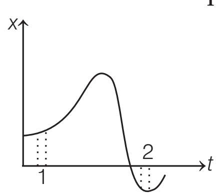
12. In figure, displacement-time $(x - t)$ graph given below, the average velocity between time $t = 5$ s and $t = 7$ s is



(a) 8 ms^{-1} (b) 8.7 ms^{-1}

(c) 7.8 ms^{-1} (d) 13.7 ms^{-1}

13. Figure shows the x-t plot of a particle in one-dimensional motion. Two different equal intervals of time show speed in time intervals 1 and 2 respectively, then



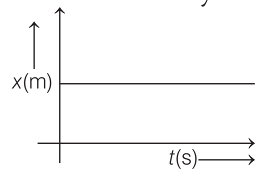
(a) $v_1 > v_2$

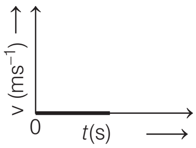
(b) $v_2 > v_1$

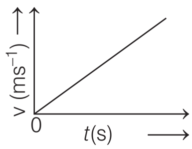
(c) $v_1 = v_2$

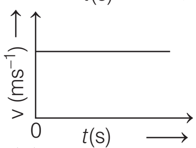
(d) Data insufficient

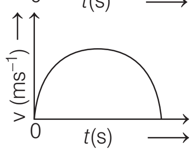
14. For the x-t graph given below, the v - t graph is shown correctly in



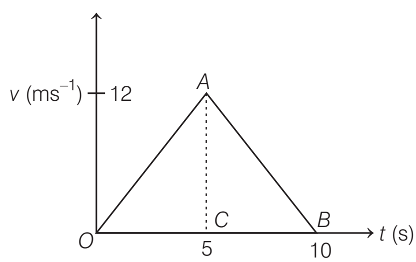
(a)


(b)


(c)


(d)


15. The speed-time graph of a particle moving along a fixed direction is as shown in the figure. The distance traversed by the particle between $t = 0$ s to $t = 10$ s is



(a) 20 m (b) 40 m (c) 60 m (d) 80 m

16. If an object is moving in a straight line, then

(a) the directional aspect of vector can be specified by + ve and – ve signs
(b) instantaneous speed at an instant is equal to the magnitude of the instantaneous velocity at that instant
(c) Both (a) and (b)
(d) Neither (a) nor (b)

17. In one dimensional motion, instantaneous speed v satisfies $0 \le v < v_0$. Then *(NCERT Exemplar)*

(a) displacement in time T must always take non-negative values
(b) displacement x in time T satisfies $-v_0 T < x < v_0 T$
(c) acceleration is always a non-negative number
(d) motion has no turning points

18. The x-t equation is given as $x = 2t + 1$. The corresponding v-t graph is

(a) a straight line passing through origin
(b) a straight line not passing through origin
(c) a parabola
(d) None of the above

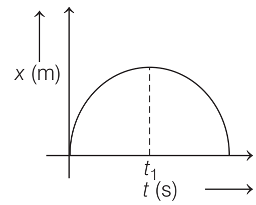
19. The displacement x of an object is given as a function of time, $x = 2t + 3t^2$. The instantaneous velocity of the object at $t = 2$ s is

(a) 16 ms^{-1} (b) 14 ms^{-1}
(c) 10 ms^{-1} (d) 12 ms^{-1}

20. The displacement of a particle starting from rest (at $t = 0$) is given by $s = 6t^2 - t^3$. The time in seconds at which the particle will attain zero velocity again is

(a) 2 (b) 4 (c) 6 (d) 8

21. A car moves along a straight line according to the x-t graph given below. The instantaneous velocity of the car at $t = t_1$ is

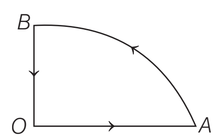


(a) zero
(b) positive
(c) Data insufficient
(d) Cannot be determined

22. A particle moves in a straight line. It can be accelerated

(a) only, if its speed changes by keeping its direction same
(b) only, if its direction changes by keeping its speed same
(c) Either by changing its speed or direction
(d) None of the above

23. An object is moving along the path *OABO* with constant speed, then



(a) the acceleration of the object while moving along to path *OABO* is zero
(b) the acceleration of the object along the path *OA* and *BO* is zero
(c) there must be some acceleration along the path *AB*
(d) Both (b) and (c)

24. The average velocity of a body moving with uniform acceleration travelling a distance of 3.06 m is 0.34 ms^{-1}. If the change in velocity of the body is 0.18 ms^{-1} during this time, its uniform acceleration is

(a) 0.01 ms^{-2}
(b) 0.02 ms^{-2}
(c) 0.03 ms^{-2}
(d) 0.04 ms^{-2}

25. The slope of the straight line connecting the points corresponding to (v_2, t_2) and (v_1, t_1) on a plot of velocity *versus* time gives

(a) average velocity
(b) average acceleration
(c) instantaneous velocity
(d) None of the above

26. The displacement x of a particle at time t along a straight line is given by $x = \alpha - \beta t + \gamma t^2$. The acceleration of the particle is

(a) $-\beta$ (b) $-\beta + 2\gamma$ (c) 2γ (d) -2γ

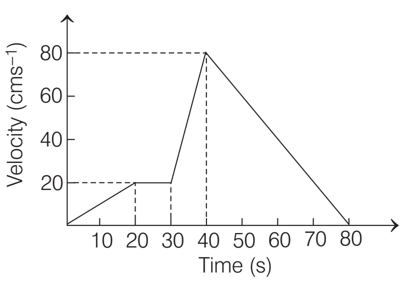
27. The displacement (in metre) of a particle moving along X-axis is given by $x = 18t + 5t^2$. The average acceleration during the interval $t_1 = 2$ s and $t_2 = 4$ s is

(a) 13 ms^{-2} (b) 10 ms^{-2}
(c) 27 ms^{-2} (d) 37 ms^{-2}

28. The relation between time and distance is $t = \alpha x^2 + \beta x$, where α and β are constants. The retardation is

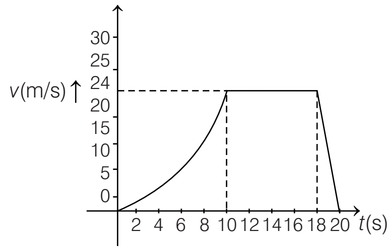
(a) $2\alpha v^3$ (b) $2\beta v^3$
(c) $2\alpha\beta v^3$ (d) $2\beta^2 v^3$

29. The v-t graph of a moving object is shown in the figure. The maximum acceleration is

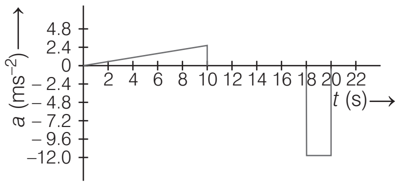


(a) 1 cms^{-2} (b) 2 cms^{-2}
(c) 3 cms^{-2} (d) 6 cms^{-2}

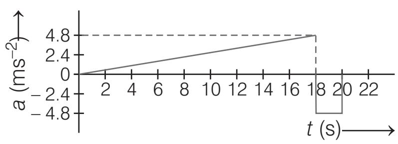
30. The resulting *a-t* graph for the given *v-t* graph is correctly represented in



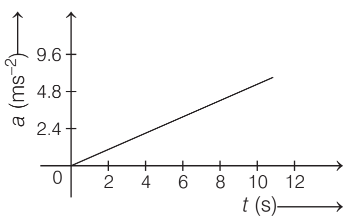
(a)



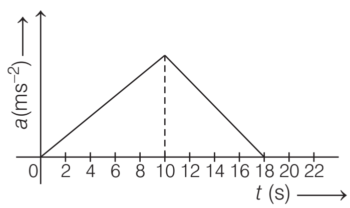
(b)



(c)



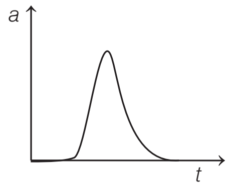
(d)



31. The kinematic equations of rectilinear motion for constant acceleration for a general situation, where the position coordinate at $t = 0$ is non-zero, say x_0 is

(a) $v = v_0 + at$
(b) $x = x_0 + v_0 t + \frac{1}{2}at^2$
(c) $v^2 = v_0^2 + 2a(x - x_0)$
(d) All of the above

32. The given acceleration-time graph represents which of the following physical situations?

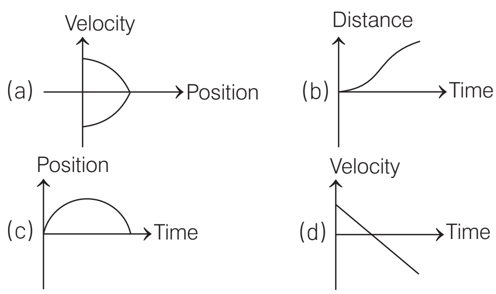


(a) A cricket ball moving with a uniform speed is hit with a bat for a very short time interval.
(b) A ball is falling freely from the top of a tower.
(c) A car moving with constant velocity on a straight road.
(d) A football is kicked into the air vertically upwards.

33. An object is moving with velocity 10 ms^{-1}. A constant force acts for 4 s on the object and gives it a speed of 2 ms^{-1} in opposite direction. The acceleration produced is

(a) 3 ms^{-2} (b) -3 ms^{-2}
(c) 6 ms^{-2} (d) -6 ms^{-2}

34. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.



35. Velocity of a body moving along a straight line with uniform acceleration a reduces by (3/4)th of its initial velocity in time t_0. The total time of motion of the body till its velocity becomes zero is

(a) $\frac{4}{3}t_0$ (b) $\frac{3}{2}t_0$ (c) $\frac{5}{3}t_0$ (d) $\frac{8}{3}t_0$

36. A particle is situated at $x = 3$ units at $t = 0$. It starts moving from rest with a constant acceleration of 4 ms^{-2}. The position of the particle at $t = 3$ s is

(a) $x = +21$ units (b) $x = +18$ units
(c) $x = -21$ units (d) None of these

37. Consider the relation for relative velocities between two objects A and B,

$$v_{BA} = -v_{AB}$$

The above equation is valid, if

(a) v_A and v_B are average velocities
(b) v_A and v_B are instantaneous velocities
(c) v_A and v_B are average speed
(d) Both (a) and (b)

38. A person is moving with a velocity of 10 ms^{-1} towards north. A car moving with a velocity of 20 ms^{-1} towards south crosses the person.
The velocity of car relative to the person is

(a) -30 ms^{-1} (b) $+20$ ms^{-1}
(c) 10 ms^{-1} (d) -10 ms^{-1}

39. A motion of a body is said to be ……, if it moves along a straight line in any direction.

(a) one-dimensional
(b) two dimensional
(c) three-dimensional
(d) All of the above

40. The numerical ratio of displacement to the distance covered by an object is always equal to or less than …… .

(a) 1 (b) zero
(c) Both (a) and (b) (d) infinity

41. The time taken by a 150 m long train to cross a bridge of length 850 m is 80 s. It is moving with a uniform velocity of …… km/h.

(a) 45 (b) 90
(c) 60 (d) 70

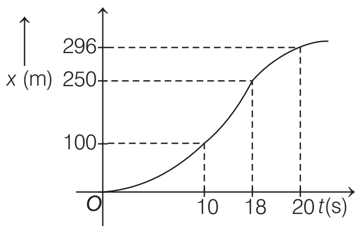
42. The distance-time graph of …… is a straight line.

(a) uniform motion
(b) non-uniform motion
(c) uniform acceleration
(d) None of the above

43. Which of the following statement is correct?

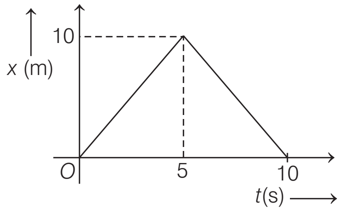
(a) The magnitude of average velocity is the average speed.
(b) Average velocity is the displacement divided by time interval.
(c) When acceleration of particle is constant, then motion is called as non-uniformly accelerated motion.
(d) When a particle returns to its starting point, its displacement is non-zero.

44. For motion of the car between $t = 18$ s and $t = 20$ s, which of the given statement is correct?



(a) The car is moving in a positive direction with a positive acceleration.
(b) The car is moving in a negative direction with a positive acceleration.
(c) The car is moving in positive direction with a negative acceleration.
(d) The car is moving in negative direction with a negative acceleration.

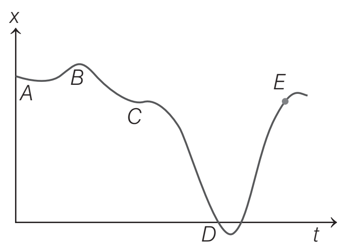
45. The x-t graph for motion of a car is given below



With reference to the graph, which of the given statement(s) is/are incorrect?

(a) The instantaneous speed during the interval $t = 5$ s to $t = 10$ s is negative at all time instants during the interval.
(b) The velocity and the average velocity for the interval $t = 0$ s to $t = 5$ s are equal and positive.
(c) The car changes its direction of motion at $t = 5$ s.
(d) The instantaneous speed and the instantaneous velocity are positive at all time instants during the interval $t = 0$ s to $t = 5$ s.

46. A graph of x *versus* t is shown in figure. Choose correct statement given below.



(a) The particle having some initial velocity at $t = 0$.
(b) At point B, the acceleration $a > 0$.
(c) At point C, the velocity and the acceleration vanish.
(d) The speed at E exceeds that at D.

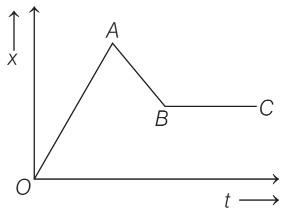
47. Match the Column I with Column II and select the correct option from the codes given below

	Column I		Column II
A.	$d\,\mathbf{v}/dt$	p.	Acceleration
B.	$d\,\lvert\mathbf{v}\rvert/dt$	q.	Rate of change of speed
C.	$\frac{d\,\mathbf{r}}{dt}$	r.	Velocity
D.	$\frac{d\,\lvert\mathbf{r}\rvert}{dt}$	s.	Magnitude of velocity

Codes

	A	B	C	D
(a)	p	q	r	s
(b)	p	r	s	q
(c)	q	p	r	s
(d)	s	r	p	q

48. Given x-t graph represents the motion of an object. Match the Column I (parts of graph) with Column II (representation) and select the correct option from the codes given below.

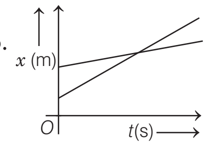
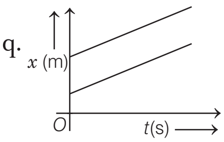
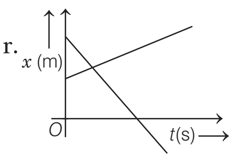


	Column I		Column II
A.	Part *OA* of graph	p.	Positive velocity
B.	Part *AB* of graph	q.	Object at rest
C.	Part *BC* of graph	r.	Negative velocity
D.	Point *A* in the graph	s.	Change in direction of motion

Codes

	A	B	C	D
(a)	p	q	r	s
(b)	p	r	q	s
(c)	q	p	r	s
(d)	s	r	q	p

49. Match the Column I (position-time graph) with Column II (representation) and select the correct option from the codes given below.

	Column I		Column II
A.	Position-time graph of two objects with equal velocities.	p.	
B.	Position-time graph of two objects with unequal velocities but in same direction.	q.	
C.	Position-time graph of two objects with velocities in opposite direction.	r.	

Codes

	A	B	C		A	B	C
(a)	p	q	r	(b)	q	p	r
(c)	p	r	q	(d)	q	r	p

Assertion-Reasoning MCQs

*For question numbers 50 to 63, two statements are given-one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below*

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

50. Assertion In real-life, in a number of situations, the object is treated as a point object.

Reason An object is treated as point object, as far as its size is much smaller than the distance, it moves in a reasonable duration of time.

51. Assertion If the displacement of the body is zero, the distance covered by it may not be zero.

Reason Displacement is a vector quantity and distance is a scalar quantity.

52. Assertion An object can have constant speed but variable velocity.

Reason SI unit of speed is m/s.

53. Assertion The speed of a body can be negative.

Reason If the body is moving in the opposite direction of positive motion, then its speed is negative.

54. Assertion For motion along a straight line and in the same direction, the magnitude of average velocity is equal to the average speed.

Reason For motion along a straight line and in the same direction, the magnitude of displacement is not equal to the path length.

55. Assertion An object may have varying speed without having varying velocity.

Reason If the velocity is zero at an instant, the acceleration is zero at that instant.

56. Assertion Acceleration of a moving particle can change its direction without any change in direction of velocity.

Reason If the direction of change in velocity vector changes, direction of acceleration vector does not changes.

57. Assertion The v-t graph perpendicular to time axis is not possible in practice.

Reason Infinite acceleration cannot be realised in practice.

58. Assertion In realistic situation, the x-t, v-t and a-t graphs will be smooth.

Reason Physically acceleration and velocity cannot change values abruptly at an instant.

59. Assertion A body cannot be accelerated, when it is moving uniformly.

Reason When direction of motion of the body changes, then body does not have acceleration.

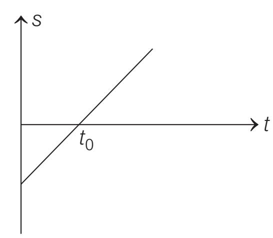
60. Assertion For uniform motion, velocity is the same as the average velocity at all instants.

Reason In uniform motion along a straight line, the object covers equal distances in equal intervals of time.

61. Assertion A body is momentarily at rest at the instant, if it reverse the direction.

Reason A body cannot have acceleration, if its velocity is zero at a given instant of time.

62. Assertion In the s-t diagram as shown in figure, the body starts moving in positive direction but not from $s = 0$.



Reason At $t = t_0$, velocity of body changes its direction of motion.

63. **Assertion** If acceleration of a particle moving in a straight line varies as $a \propto t^n$, then $s \propto t^{n+2}$.

Reason If a-t graph is a straight line,then s-t graph may be a parabola.

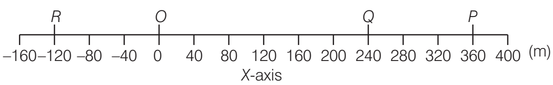
Case Based MCQs

***Direction** Answer the questions from 64-68 on the following case.*

Motion in a Straight Line

If the position of an object is continuously changing w.r.t. its surrounding, then it is said to be in the state of motion. Thus, motion can be defined as a change in position of an object with time. It is common to everything in the universe.

In the given figure, let P, Q and R represent the position of a car at different instants of time.



64. With reference to the given figure, the position coordinates of points P and R are

(a) $P \equiv (+360, 0, 0)$; $R \equiv (-120, 0, 0)$
(b) $P \equiv (-360, 0, 0)$; $R \equiv (+120, 0, 0)$
(c) $P \equiv (0, +360, 0)$; $R \equiv (-120, 0, 0)$
(d) $P \equiv (0, 0, +360)$; $R \equiv (0, 0, -120)$

65. Displacement of an object can be

(a) positive
(b) negative
(c) zero
(d) All of the above

66. The displacement of a car in moving from O to P and its displacement in moving from P to Q are

(a) + 360 m and − 120 m
(b) − 120 m and + 360 m
(c) + 360 m and + 120 m
(d) + 360 m and − 600 m

67. If the car goes from O to P and returns back to O, the displacement of the journey is

(a) zero (b) 720 m
(c) 420 m (d) 340 m

68. The path length of journey from O to P and back to O is

(a) 0 m (b) 720 m
(c) 360 m (d) 480 m

***Direction** Answer the questions from 69-73 on the following case.*

Average Speed and Average Velocity

When an object is in motion, its position changes with time. So, the quantity that describes how fast is the position changing w.r.t. time and in what direction is given by average velocity.

It is defined as the change in position or displacement (Δx) divided by the time interval (Δt) in which that displacement occur. However, the quantity used to describe the rate of motion over the actual path, is average speed. It defined as the total distance travelled by the object divided by the total time taken.

69. A 250 m long train is moving with a uniform velocity of 45 kmh^{-1}. The time taken by the train to cross a bridge of length 750 m is

(a) 56 s (b) 68 s
(c) 80 s (d) 92 s

70. A truck requires 3 hr to complete a journey of 150 km. What is average speed?

(a) 50 km/h (b) 25 km/h
(c) 15 km/h (d) 10 km/h

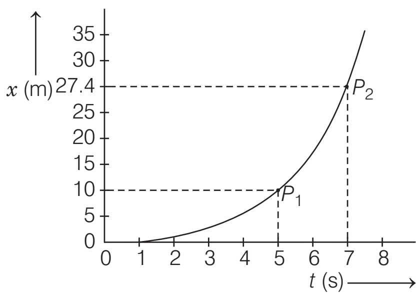
71. Average speed of a car between points A and B is 20 m/s, between B and C is 15 m/s and between C and D is 10 m/s. What is the average speed between A and D, if the time taken in the mentioned sections is 20s, 10s and 5s, respectively?

(a) 17.14 m/s (b) 15 m/s
(c) 10 m/s (d) 45 m/s

72. A cyclist is moving on a circular track of radius 40 m completes half a revolution in 40 s. Its average velocity is

(a) zero (b) 2 ms^{-1}
(c) 4π ms^{-1} (d) 8π ms^{-1}

73. In the following graph, average velocity is geometrically represented by



(a) length of the line P_1P_2
(b) slope of the straight line P_1P_2
(c) slope of the tangent to the curve at P_1
(d) slope of the tangent to the curve at P_2

Direction *Answer the questions from 74-78 on the following case.*

Uniformly Accelerated Motion

The velocity of an object, in general, changes during its course of motion. Initially, at the time of Galileo, it was thought that, this change could be described by the rate of change of velocity with distance. But, through his studies of motion of freely falling objects and motion of objects on an inclined plane, Galileo concluded that, the rate of change of velocity with time is a constant of motion for all objects in free fall.

This led to the concept of acceleration as the rate of change of velocity with time.

The motion in which the acceleration remains constant is known as to be **uniformly accelerated motion**. There are certain equations which are used to relate the displacement (x), time taken (t), initial velocity (u), final velocity (v) and acceleration (a) for such a motion and are known as kinematics equations for uniformly accelerated motion.

74. The displacement of a body in 8 s starting from rest with an acceleration of 20 cms^{-2} is

(a) 64 m (b) 640 m
(c) 64 cm (d) 0.064 m

75. A particle starts with a velocity of 2 ms^{-1} and moves in a straight line with a retardation of 0.1 ms^{-2}. The first time at which the particle is 15 m from the starting point is

(a) 10 s (b) 20 s
(c) 30 s (d) 40 s

76. If a body starts from rest and travels 120 cm in 6th second, then what is its acceleration?

(a) 0.20 ms^{-2} (b) 0.027 ms^{-2}
(c) 0.218 ms^{-2} (d) 0.03 ms^{-2}

77. An object starts from rest and moves with uniform acceleration *a*. The final velocity of the particle in terms of the distance *x* covered by it is given as

(a) $\sqrt{2ax}$ (b) $2ax$
(c) $\sqrt{\frac{ax}{2}}$ (d) $\sqrt{ax}$

78. A body travelling with uniform acceleration crosses two points *A* and *B* with velocities 20 ms^{-1} and 30 ms^{-1}, respectively. The speed of the body at mid-point of *A* and *B* is

(a) 25 ms^{-1} (b) 25.5 ms^{-1}
(c) 24 ms^{-1} (d) $10\sqrt{6}$ ms^{-1}

ANSWERS

Multiple Choice Questions

1. (d)	*2. (a)*	*3. (a)*	*4. (a)*	*5. (a)*	*6. (a)*	*7. (c)*	*8. (a)*	*9. (a)*	*10. (d)*
11. (a)	*12. (b)*	*13. (b)*	*14. (a)*	*15. (c)*	*16. (c)*	*17. (b)*	*18. (b)*	*19. (b)*	*20. (b)*
21. (a)	*22. (c)*	*23. (d)*	*24. (b)*	*25. (b)*	*26. (c)*	*27. (b)*	*28. (a)*	*29. (d)*	*30. (a)*
31. (d)	*32. (a)*	*33. (b)*	*34. (b)*	*35. (a)*	*36. (a)*	*37. (d)*	*38. (a)*	*39. (a)*	*40. (a)*
41. (a)	*42. (a)*	*43. (b)*	*44. (a)*	*45. (a)*	*46. (c)*	*47. (a)*	*48. (b)*	*49. (b)*	

Assertion-Reasoning MCQs

50. (a)	*51. (b)*	*52. (b)*	*53. (d)*	*54. (c)*	*55. (d)*	*56. (d)*	*57. (a)*	*58. (a)*	*59. (d)*
60. (b)	*61. (c)*	*62. (c)*	*63. (b)*						

Case Based MCQs

64. (a)	*65. (d)*	*66. (a)*	*67. (a)*	*68. (b)*	*69. (c)*	*70. (a)*	*71. (a)*	*72. (b)*	*73. (b)*
74. (c)	*75. (a)*	*76. (c)*	*77. (a)*	*78. (b)*					

SOLUTIONS

1. In one-dimensional motion, only one coordinate is required to specify the position of the object. So, a train running on a straight track is an example of one-dimensional motion.

2. Given, at $t=0$ s, position of an object is $(-1,0,3)$ and at $t=5$ s, its coordinate is $(-1,0,4)$. So, there is no change in x and y-coordinates, while z-coordinate changes from 3 to 4. So,the object is in motion along Z-axis.

3. Distance from starting point

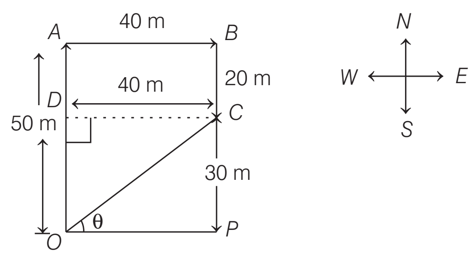
$$= \sqrt{(3)^2 + (4)^2 + (5)^2} = 5\sqrt{2} \text{ m}$$

4. For a stationary object, the position-time graph is a straight line parallel to the time axis, so for the given object at $x = 40$ m, x-t graph is correctly shown in option (a).

5. In I-D motion, positive and negative signs are used to specify the direction of motion.

Since, displacement is a vector quantity, so negative sign in −240 m indicates the direction of displacement.

6. Let O be the starting point, i.e. home. So, according to the question, Snehit moves from O to A (50 m) towards north, then from A to B (40 m) towards east and from B to C (20 m) towards south as shown in the figure below.



Displacement of Snehit is OC, which can be calculated by Pythagoras theorem, i.e.

In ΔODC, $OC^2 = OD^2 + CD^2 = (30)^2 + (40)^2$

$$= 900 + 1600 = 2500$$

$$\Rightarrow \quad OC = 50 \text{ m}$$

7. Time taken to travel first half distance,

$$t_1 = \frac{l/2}{v_1} = \frac{l}{2v_1}$$

Time taken to travel second half distance,

$$t_2 = \frac{l}{2v_2}$$

$$\text{Total time} = t_1 + t_2 = \frac{l}{2v_1} + \frac{l}{2v_2} = \frac{l}{2}\left[\frac{1}{v_1} + \frac{1}{v_2}\right]$$

We know that, v_{av} = average speed

$$= \frac{\text{total distance}}{\text{total time}} = \frac{l}{\frac{l}{2}\left[\frac{1}{v_1} + \frac{1}{v_2}\right]} = \frac{2v_1 v_2}{v_1 + v_2}$$

8. As runner starts from O and comes back to O, so net displacement is zero.

Average speed

$$= \frac{\text{Total distance}}{\text{Total time}} = \frac{OQ + QR + RO}{\text{Total time}}$$

$$= \frac{1\text{ km} + (2\pi r)\left(\frac{90^\circ}{360^\circ}\right)\text{km} + 1\text{ km}}{1\text{h}}$$

($\because$ angle of sector OQR is 90°)

$$= \frac{1 + 2\pi \times 1\left(\frac{1}{4}\right) + 1}{1}$$

$$= 2 + \frac{\pi}{2} = 3.57\text{ km/h}$$

9. Since, average velocity,

$$v = \frac{\Delta x}{\Delta t} = \frac{\text{Displacement}}{\text{Time interval}}$$

So, average velocity depends on the displacement and hence it depends on the sign of the displacement.

10. When a particle completes one revolution in circular motion, then average displacement travelled by particle is zero.

Hence, average velocity

$$= \frac{\text{average displacement}}{\Delta t} = \frac{0}{\Delta t} = 0$$

11. In case x - t graph is a straight line, the slope of this line gives velocity of the particle.

As slope = $\tan\theta$, where θ is the angle which the tangent to the curve makes with the horizontal in anti-clockwise direction.

The velocities of two particles A and B are

$$v_A = \tan 30^\circ = \frac{1}{\sqrt{3}}$$

$$v_B = \tan 45^\circ = 1$$

The ratio of velocities,

$$v_A : v_B = \frac{1}{\sqrt{3}} : 1 = 1 : \sqrt{3}$$

12. Given, $x_2 = 27.4$ m, $x_1 = 10$ m, $t_2 = 7$ s and $t_1 = 5$ s.

Average velocity between 5 s and 7s,

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{27.4 - 10}{7 - 5}$$

$$= \frac{17.4}{2} = 8.7\text{ ms}^{-1}$$

13. Slope of x-t graph in a small interval

= Average speed in that interval

As, slope for interval 2 > slope for interval 1.

$\therefore$ $v_2 > v_1$

14. The x - t graph shown, is parallel to time axis. This means that, the object is at rest. So, the velocity of the object is zero for all time instants. Hence, v -t graph coincides with the time axis as shown in graph (a).

15. Distance travelled by the particle between time interval $t = 0$ s to $t = 10$ s

= Area of triangle OAB

$$= \frac{1}{2} \times \text{Base} \times \text{Height}$$

$$= \frac{1}{2} \times OB \times AC$$

$$= \frac{1}{2} \times 10 \times 12 = 60\text{ m}$$

16. In one-dimensional motion, i.e. motion along a straight line, there are only two directions in which an object can move and these two directions can be easily specified by + ve and – ve signs.

Also, in this motion instantaneous speed or simply speed at an instant is equal to the magnitude of instantaneous velocity at the given instant.

17. For maximum and minimum displacements, we have to keep in mind the magnitude and direction of maximum velocity.

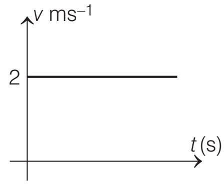
As, maximum velocity in positive direction is v_0 and maximum velocity in opposite direction is also $-v_0$.

Maximum displacement in one direction = $v_0 T$

Maximum displacement in opposite directions = $-v_0 T$

Hence, the range of displacement will be $-v_0 T < x < v_0 T$.

18. $v = \frac{dx}{dt} = 2\ \text{ms}^{-1}$ = constant



Hence, option (b) is correct.

19. Given, $x = 2t + 3t^2$

$$v = \frac{dx}{dt} = 2 + 6\,t$$

For $t = 2$ s, $v = 2 + 6\,(2) = 14\ \text{ms}^{-1}$

20. Displacement of the particle,

$$s = 6t^2 - t^3$$

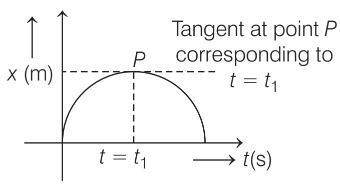
Velocity of the particle,

$$v = \frac{ds}{dt} = \frac{d}{dt}(6t^2 - t^3)$$

$$v = 12t - 3t^2$$

For $\quad v = 0 \Rightarrow 12t = 3t^2 \quad \Rightarrow t = 4$ s

21. The instantaneous velocity is the slope of the tangent to the x-t graph at that instant of time.



At $t = t_1$, the tangent is parallel to time axis as shown above and hence its slope is zero. Thus, instantaneous velocity at $t = t_1$ is zero.

22. Since velocity is a vector quantity, having both magnitude and direction. So, a change in velocity may involve change in either or both of these factors. Therefore, acceleration may result from a change in speed (magnitude), a change in direction or changes in both.

23. For paths OA and BO, the magnitude of velocity (speed) and direction is constant, hence acceleration is zero. For path AB, since this path is a curve, so the direction of the velocity changes at every moment but the magnitude of velocity (speed) remains constant.

Since, the direction of velocity is changing, i.e. there must be some acceleration along the path AB.

24. $\text{Time} = \frac{\text{Distance}}{\text{Average velocity}} = \frac{3.06}{0.34} = 9$ s

Acceleration

$$= \frac{\text{Change in velocity}}{\text{Time}}$$

$$= \frac{0.18}{9} = 0.02\ \text{ms}^{-2}$$

25. Average acceleration is defined as the average change of velocity per unit time. On a plot of v -t, the average acceleration is the slope of the straight line connecting the points corresponding to (v_2, t_2) and (v_1, t_1).

26. Given, $x = \alpha - \beta t + \gamma t^2$

$$v = \frac{dx}{dt} = \frac{d}{dt}(\alpha - \beta t + \gamma t^2) = -\beta + 2\gamma t$$

$$a = \frac{dv}{dt} = \frac{d}{dt}(-\beta + 2\gamma t) = 2\gamma$$

27. Given, $x = 18t + 5t^2$

$$v = \frac{dx}{dt} = \frac{d}{dt}(18t + 5t^2) = 18 + 10t$$

$\therefore \quad v = 10t + 18$

At $t_1 = 2$ s, $v_1 = 10\,(2) + 18 = 38$ m/s

At $t_2 = 4$ s, $v_2 = 10\,(4) + 18 = 58$ m/s

$\therefore \quad a = \frac{v_2 - v_1}{t} = \frac{58 - 38}{2} = \frac{20}{2} = 10\ \text{ms}^{-2}$

28. Given, $t = \alpha x^2 + \beta x$

$$\frac{dt}{dx} = 2\,\alpha\,x + \beta$$

$$\Rightarrow \quad \frac{dx}{dt} = v = \frac{1}{2\alpha x + \beta}$$

As, acceleration, $a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt}$

$$\Rightarrow a = v \cdot \frac{dv}{dx} = \frac{1}{2\alpha x + \beta}\left(\frac{-v2\alpha}{2\alpha x + \beta}\right)$$

$$= -2\alpha\,v \cdot v^2 \quad = -2\alpha v^3$$

$\therefore$ Retardation $= 2\alpha v^3$

29. Maximum acceleration means maximum change in velocity in minimum time interval.

In time interval $t = 30$ s to $t = 40$ s,

$$a = \frac{\Delta v}{\Delta t} = \frac{80 - 20}{40 - 30} = \frac{60}{10} = 6\ \text{cms}^{-2}$$

30. Average acceleration for different time intervals is the slope of v-t graph, which are as follows

For 0 s -10 s, $\bar{a} = \frac{(24-0)\ \text{ms}^{-1}}{(10-0)\ \text{s}} = 2.4\ \text{ms}^{-2}$

For 10 s -18 s, $\bar{a} = \frac{(24-24)\ \text{ms}^{-1}}{(18-10)\ \text{s}} = 0\ \text{ms}^{-2}$

For 18 s - 20 s, $\bar{a} = \frac{(0-24)\ \text{ms}^{-1}}{(20-18)\ \text{s}} = -12\ \text{ms}^{-2}$

So, the corresponding a -t graph for the given v -t graph is shown correctly in graph (a).

31. All the equations given in options (a), (b) and (c) are the kinematic equations of rectilinear motion for constant acceleration.

32. The acceleration-time graph represents the motion of a uniformly moving cricket ball turned back by hitting it with a bat for a very short time interval.

33. Given, $v = -2\ \text{ms}^{-1}$ (opposite direction),

$t = 4$ s and $u = 10\ \text{ms}^{-1}$

$\therefore\ v = u + at$ or $-2 = 10 + 4a$ or $a = -3\,\text{ms}^{-2}$

34. If velocity *versus* time graph is a straight line with negative slope, then acceleration is constant and negative.

With a negative slope, distance-time graph will be parabolic $\left(s = ut - \frac{1}{2}at^2\right)$.

Hence, options (a), (c) and (d) are correct, so option (b) will be incorrect.

35. According to kinematic equation of motion,

$$v = u - at$$

where, $v = u - \frac{3u}{4} = u/4 \Rightarrow \frac{u}{4} = u - at_0$

Negatve sign signifies that the body will decelerate, since the final velocity is decreasing.

or $\frac{u}{a} = \frac{4}{3}t_0$

Now, $0 = u - at$ or $t = \frac{u}{a} = \frac{4}{3}t_0$

36. Given, $x_0 = 3$ units, $a = 4\ \text{ms}^{-2}$, $t = 3$ s

Using relation, $x = x_0 + v_0\,t + \frac{1}{2}at^2$

$$= 3 + \frac{1}{2} \times 4 \times (3)^2 = +\ 21 \text{ units}$$

37. Given, $v_{BA} = -v_{AB}$

The above relation is true for both average velocities of particles and instantaneous velocities of particles.

As speed is scalar quantity, ignorant of direction, so average speed may not be equal.

38. Let south to north direction be positive.

Velocity of car, $v_C = -20\ \text{ms}^{-1}$

Velocity of person, $v_P = +10\ \text{ms}^{-1}$

$$v_{CP} = v_C - v_P = (-20) - (10) = -30\ \text{ms}^{-1}$$

39. **One-dimensional motion** is a motion along a straight line in any direction. e.g. A train is moving on a platform.

Hence, option (a) is correct.

40. Since, displacement d is always less than or equal to the distance D but never greater than it, i.e. $d \le D$. So, numerical ratio of displacement to the distance covered by an object is always equal to or less than one.

41. Total distance = Length of train + Length of bridge

$$= (150 + 850)\ \text{m} = 1000\ \text{m}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Velocity}} \Rightarrow 80 = \frac{1000}{v}$$

$$v = \frac{1000}{80}\ \text{m/s} \Rightarrow v = \frac{1000}{80} \times \frac{18}{5} = 45\ \text{km/h}$$

42. In uniform motion, the velocity of an object does not change or it remains constant with time.

So, the graph of distance-time is a straight line.

43. Statement given in option (b) is correct but the rest are incorrect and these can be corrected as,

In general, average speed is not equal to magnitude of average velocity. It can be so, if the motion is along a straight line without change in direction.

When acceleration of particle is not constant, then motion is called as non-uniformly accelerated motion.

Displacement is zero, when a particle returns to its starting point.

44. For negative acceleration, the x - t graph moves downward. But the car is moving in positive direction as the position coordinate is increasing in the positive direction.

Thus, the statement given in option (a) is correct, rest are incorrect.

45. The instantaneous speed is always positive as it is the magnitude of the velocity at an instant, so it is positive during $t = 5$ s to $t = 10$ s.

For $t = 0$ s to $t = 5$ s, the motion is uniform and x-t graph has positive slope. So, the velocity and average velocity, instantaneous velocity and instantaneous speed are equal and positive.

During $t = 0$ s to $t = 5$ s, the slope of the graph is positive, hence the average velocity and the velocity both are positive.

During $t = 5$ s to $t = 10$ s, the slope of the graph is negative, hence the velocity is negative. Since, there is a change in sign of velocity at $t = 5$ s, so the car changes its direction at this instant.

Hence, option (a) is incorrect, while all others are correct.

46. As, point A is the starting point, therefore particle is starting from rest.

At point B, the graph is parallel to time axis, so the velocity is constant here. Thus, acceleration is zero.

Also point C, the graph changes slope, hence velocity also changes.

After graph at C is almost parallel to time axis, hence we can say that velocity and acceleration vanishes.

From the graph, it is clear that

$$|\text{ slope at } D\,| > |\text{ slope at } E\,|$$

Hence, speed at D will be more than at E.

47. $\dfrac{d\mathbf{v}}{dt}$ is the rate of change of velocity, so it represents acceleration.

$\dfrac{d\,|\mathbf{v}|}{dt}$ is rate of change of speed of the particle.

$\dfrac{d\mathbf{r}}{dt}$ is the rate by which distance of particle from the origin is changing.

$\left|\dfrac{d\mathbf{r}}{dt}\right|$ is the magnitude of rate of change of position of particle. This means it represents magnitude of velocity.

Hence, A $\rightarrow$ p, B $\rightarrow$ q, C $\rightarrow$ r and D $\rightarrow$ s.

48. In x-t graph, $OA \rightarrow$ Positive slope $\rightarrow$ Positive velocity

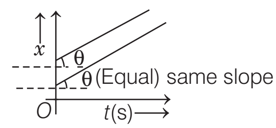
$AB \rightarrow$ Negative slope $\rightarrow$ Negative velocity

$BC \rightarrow$ Zero slope $\rightarrow$ Object is at rest

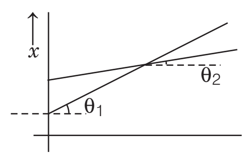
At point A, there is a change in sign of velocity, hence the direction of motion must have changed at A.

Hence, A $\rightarrow$ p, B $\rightarrow$ r, C $\rightarrow$ q and D $\rightarrow$ s.

49. A. For equal velocities, the slope of the straight lines must be same as shown below



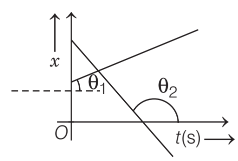
B. For unequal velocity, slope is different, but since, the objects are moving in the same direction, the slope for both the graphs must be of same sign (positive or negative) and they meet at a point as shown below



C. For velocities in opposite direction, slopes must be of opposite sign. Slope = tan θ, where θ is the angle of the straight line with horizontal in anti-clockwise direction. As, we know, $\tan\theta_1 > 0$, $\tan\theta_2 < 0$.

Hence, slopes are of opposite sign.

This condition is shown below



Hence A $\rightarrow$ q, B $\rightarrow$ p and C $\rightarrow$ r.

50. The approximation of an object as point object is valid only, when the size of the object is much smaller than the distance it moves in a reasonable duration of time.

Therefore, both A and R are true and R is the correct explanation of A.

51. Distance is the total path length travelled by the object. But displacement the shortest distance between the initial and final positions of the object. So, distance can never be negative or zero. But displacement can be zero, positive and negative.

Also, distance is a scalar quantity. It means that, it is always positive but however displacement is a vector quantity. So, it may be positive, zero or negative depending on given situation.

Therefore, both A and R are true but R is not the correct explanation of A.

52. Velocity is a vector quantity, so it has both direction and magnitude. Hence, an object can have variable velocity by keeping its magnitude constant, i.e. speed and by changing direction only.

The SI unit of speed is m/s.

Therefore, both A and R are true but R is not the correct explanation of A.

53. Speed can never be negative because it is a scalar quantity. So, if a body is moving in negative direction, then also the speed will be positive.

Therefore, A is false and R is also false.

54. For motion in a straight line and in the same direction,

Displacement = Total path length

$\Rightarrow$ Average velocity = Average speed

Therefore, A is true but R is false.

55. If speed varies, then velocity will definitely vary.

When a particle is thrown upwards, at highest point $a \neq 0$ but $v = 0$.

Therefore, A is false and R is also false.

56. Accleration, $a = \dfrac{\mathbf{v}_f - \mathbf{v}_i}{\Delta t} = \dfrac{d\mathbf{v}}{dt}$, i.e. direction of acceleration is same as that of change in velocity vector or in the direction of $\Delta \mathbf{v}$.

Therefore, A is false and R is also false.

57. Acceleration, $a = \dfrac{dv}{dt}$ = Slope of v-t graph

It v-t graph is perpendicular to t-axis, slope $= \infty$

$\therefore \qquad a = \infty$

Therefore, both A and R are true and R is the correct explanation of A.

58. In realistic situation, the x - t, v - t and a - t graphs will be smooth, as the values of acceleration and velocity cannot change abruptly since changes are always continuous.

Therefore, both A and R are true and R is the correct explanation of A.

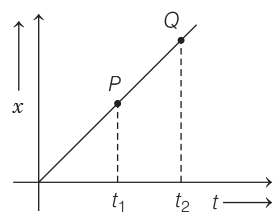
59. The uniform motion of a body means that, the body is moving with constant velocity.

But if the direction of motion is changing (such as in uniform circular motion), its velocity changes and thus uniform acceleration is produced in the body.

Therefore, A is false and R is also false.

60. In uniform motion along a straight line, the object covers equal distances in equal intervals of time.

For uniform motion, x - t graph is represented as a straight line inclined to time axis. The average velocity during any time interval $t = t_1$ to $t = t_2$ is the slope of the line PQ which coincides with the graph.



Also, velocity at any instant say $t = t_1$ is the slope of the tangent at point P which again coincides with PQ or with the graph. Hence, velocity is same as the average velocity at all instants.

Therefore, both A and R are true but R is not the correct explanation of A.

61. When a particle is released from rest position under gravity, then $v = 0$ but $a \neq 0$.

Also, a body is momentarily at rest at the instant, if it reverse the direction.

Therefore, A is true but R is false.

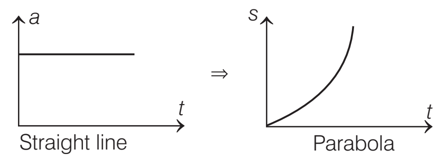
62. Slope of s-t graph = velocity = positive

At $t = 0$, $s \neq 0$, further at $t = t_0 : s = 0, v \neq 0$.

Therefore, A is true but R is false.

63. By differentiating a-t equation two times, we will get s-t equation.

Further



Therefore, both A and R are true but R is not the correct explanation of A.

64. The position coordinates of point $P = (+360, 0, 0)$ and point $R = (-120, 0, 0)$.

65. Displacement is a vector quantity, it can be positive, negative and zero.

66. Displacement, $\Delta x = x_2 - x_1$

For journey of car in moving from O to P,

$$x_2 = +\,360 \text{ m}$$
$$x_1 = 0$$
$$\Rightarrow \quad \Delta x = x_2 - x_1 = 360 - 0 = +\,360 \text{ m}$$

For journey, of car in moving from P to Q,

$$x_2 = +\,240 \text{ m}$$
$$x_1 = +\,360 \text{ m}$$
$$\Rightarrow \quad \Delta x = x_2 - x_1 = 240 - 360 = -120 \text{ m}$$

Here, –ve sign implies that the displacement is in –ve direction, i.e. towards left.

67. Displacement, $\Delta x = x_2 - x_1 = 0 - 0 = 0$

68. Path length of the journey

$= OP + PO = +\,360\text{m} + (+\,360) \text{ m} = 720 \text{ m}$

69. Total time taken $= \dfrac{\text{Total distance}}{\text{Speed}}$

$$t = \frac{250 + 750}{45 \times \frac{5}{18}} = 80 \text{ s}$$

70. Average speed $= \dfrac{\text{Total distance}}{\text{Total time}}$

$$= \frac{150}{3} = 50 \text{ km/h}$$

71. Total distance $(d = vt)$

$$= 20 \times 20 + 15 \times 10 + 10 \times 5 = 600 \text{ m}$$

Total time $= 20 + 10 + 5 = 35$ s

Therefore, average speed

$$= 600 / 35 = 17.14 \text{ m/s}$$

72. Given, $R = 40$ m and $t = 40$ s

Average velocity $= \dfrac{\text{Displacement}}{\text{Time taken}}$

$$= \frac{2R}{t} = \frac{2 \times 40}{40} = 2 \text{ ms}^{-1}$$

73. From the position-time graph, average velocity is geometrically represented by the slope of curve, i.e. slope of straight line P_1P_2.

74. Displacement, $s = \dfrac{1}{2} \times (0.2)\,(64) = 64$ cm

75. From equation of motion, $s = ut - \dfrac{1}{2} at^2$

$$15 = 2t - \frac{1}{2} \times (0.1) t^2 \quad \Rightarrow \quad t = 10 \text{ s}$$

76. From equation of motion,

$$s_n = u + \frac{a}{2}(2n - 1)$$
$$\Rightarrow \quad 1.2 = 0 + \frac{a}{2}(2 \times 6 - 1)$$
$$\Rightarrow \quad a = \frac{1.2 \times 2}{11} = 0.218 \text{ ms}^{-2}$$

77. Given, $v_0 = 0$

Using relation, $v^2 = v_0^2 + 2ax$

$$v^2 = 2ax$$
$$\therefore \quad v = \sqrt{2ax}$$

78. Let the acceleration of the car $= a$ and distance between A and $B = d$

Given, $v = 30 \text{ ms}^{-1}$ and $u = 20 \text{ ms}^{-1}$

$$2ad = (30)^2 - (20)^2$$
$$ad = \frac{900 - 400}{2} = 250$$

When the car is at the mid-point of AB, then speed of car is v_1.

$$v_1^2 - (20)^2 = 2a\,(d/2)$$
$$v_1^2 = ad + 400$$
$$= 250 + 400 = 650$$

Therefore, $v_1 = 25.5 \text{ ms}^{-1}$