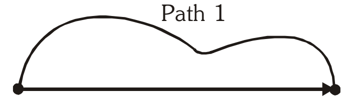
7. MOTION

- **Motion :** An object is said to be in motion if it changes its position with time.
- **Rest :** An object is said to be at rest if it does not change its position with time.
- **Rest & motion are relative terms :** An object which is at rest can also be in motion simultaneously. For example, the passengers of a moving bus are at rest with respect to each other but they are in motion with respect to a stationary objects like electric pole, trees, a person standing on the road side etc.
- **Rectilinear motion :** If a particle moves in a straight line, its motion is called rectilinear motion or one dimensional motion.
- **Rotational motion (Rotatory motion) :** Motion of a body turning about an axis is called rotational motion. In other words, 'a motion in which an object spins about a fixed axis is called rotational motion'. E.g., the Earth's spin on its axis, motion of a fan or motor etc.
- **Two dimensional motion :** The motion of a particle in a plane is called two dimensional motion.

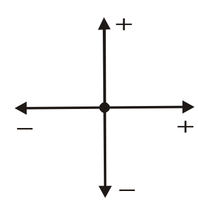
  Examples: Motion of a particle on a circular path, motion of a particle on a parabolic path (projectile motion).
- **Three dimensional motion :** The motion of a particle in space is called three dimensional motion.

  Examples: Motion of a flying bird, motion of a foot ball swinging in air.
- **Distance :** The length of the actual path between initial and final positions of a particle is called distance covered by the particle. (Path 1 in figure shown represents distance).



  - Distance is a scalar quantity.
  - Distance depends on the path.
  - It never decreases with time.
  - Distance is always taken positive.
  - **Unit** : c.g.s.system - centimeter (cm) ; S.I. system - metre (m).
  - Odometer of the vehicle measures the distance.
- **Displacement :** The shortest distance between the initial position and the final position of the particle is called displacement. It is the change in the position of the particle. (Path 2 in figure shown represents displacement).

  Displacement = $x_f - x_i$ Where, x_f = final position ; x_i = initial position.



Sign convention for displacement

  - Displacement is a vector quantity, its direction is always taken from initial position to final position.
  - Displacement depends only on initial position and final position, does not depend on path.
  - Displacement of a particle in motion can be positive, negative or even zero.
  - **Unit** : c.g.s.system - centimeter (cm) ; S.I. system - metre (m).
- Distance is always greater than or equal to the magnitude of displacement.
  - Whenever a particle changes its direction or follows a curved path, distance is always greater than the magnitude of displacement.
  - Distance is exactly equal to displacement (i) when it follows a straight path without changing its direction (ii) when its is in uniform motion.

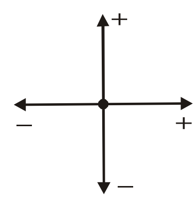
■ **Speed :** The distance travelled by a particle per unit time is called speed.

$$\boxed{\text{Speed} = \frac{\text{Distance}}{\text{time}}}$$

- Speed is a scalar quantity.
- Speed depends on the path.
- $\boxed{1\ \text{km/h} = \frac{5}{18}\ \text{m/s}}$
- Speed gives no idea about the direction of motion of the object.
- Speed can never be negative ; in motion, it is taken positive ; at rest, it is zero.
- **Unit** : c.g.s.system - centimeter/second (cm/s) ; S.I. system - metre/second (m/s).
- **Uniform speed :** An object is said to be moving with a uniform speed, if it covers equal distances in equal intervals of time. That is, magnitude of speed is constant.
- **Non uniform speed :** An object is said to be moving with a variable speed if it covers unequal distances in equal intervals of time. That is, magnitude of speed is variable.
- **Average Speed :** When an object is moving with a variable speed, then the average speed of the object is thought to be that constant speed with which the object covers the same distance in a given time interval as it does while moving with variable speed during the same time interval.
- Average speed is the ratio of the total distance travelled by the object to the total time taken.

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

- **Instantaneous speed :** The speed of the body at any instant of time is called instantaneous speed.
- Speedometer of the vehicle measures its instantaneous speed.
- In uniform motion of a particle, the instantaneous speed is equal to its average speed.



Sign convention for velocity

■ **Velocity :** The rate of change of displacement is called velocity.

- Velocity is a vector quantity.
- Velocity can be negative, positive or zero.
- The direction of average velocity is same as that of the total displacement.
- If average velocity for a journey is positive, it may have a negative instantaneous velocity at some point of time during the journey and vice-versa.
- **Unit** : c.g.s.system - centimeter/second (cm/s) ; S.I. system - metre/second (m/s).
- **Instantaneous Velocity :** It is the velocity at some particular instant of time.
- **Average Velocity :** It is the ratio of total displacement to the total time taken.

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

- **Uniform Velocity :** A particle is said to have uniform velocity, if the magnitude as well as the direction of its velocity remains constant. It is possible only when the particles moves in straight line without changing its direction.
- **Non-uniform Velocity :** A particle is said to have non-uniform velocity, if either of magnitude or direction of its velocity changes (or both changes).
- In uniform motion of a particle, the instantaneous velocity is equal to its average velocity.

- Average speed is always greater than or equal to the magnitude of average velocity.
  - Whenever a particle changes its direction or follows a curved path, average speed is always greater than the magnitude of average velocity.
  - Average speed is exactly equal to average velocity when it follows a straight path without changing its direction.
- If body covers distances x_1, x_2, x_3,----- with speeds v_1, v_2, v_3,----- respectively in same direction then average speed/average velocity of body is given by,

$$\boxed{v_{average} = \frac{x_1 + x_2 + x_3 + ---}{\frac{x_1}{v_1} + \frac{x_2}{v_2} + \frac{x_3}{v_3} + ---}}$$

  - **Case of half journey :** If body covers equal distances with different speeds i.e, $x_1 = x_2 = x$ (let),

$$v_{average} = \frac{x + x}{\left(\frac{x}{v_1} + \frac{x}{v_2}\right)} = \frac{2x}{x\left(\frac{1}{v_1} + \frac{1}{v_2}\right)} = \frac{2}{\left(\frac{v_2 + v_1}{v_1 v_2}\right)} = \boxed{\frac{2v_1 v_2}{v_1 + v_2}}$$

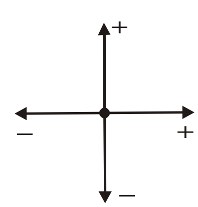
- If a body travels with speeds v_1, v_2, v_3 ,---- during time intervals t_1, t_2, t_3, ---- respectively then the average speed of the body is given by,

$$\boxed{v_{average} = \frac{v_1 t_1 + v_2 t_2 + v_3 t_3 + ---}{t_1 + t_2 + t_3 + ---}}$$

  - **Case of half time :** If the two given time intervals are same i.e., $t_1 = t_2$, then,

$$v_{average} = \frac{v_1 t + v_2 t}{t + t} = \frac{(v_1 + v_2)t}{2t} = \boxed{\frac{v_1 + v_2}{2}}$$

- **Uniform motion :** If the velocity (NOT the speed) of a particle in motion is constant, then its motion is said to be uniform motion.
  - In uniform motion, the magnitude of velocity is constant and its direction is also constant.
  - In uniform motion, a particle covers equal distances in equal interval of time in a particular direction.
  - Uniform motion always takes place in straight line.
  - Only one equation of motion is used in uniform motion which is, $\boxed{v = s/t}$
- **Non-uniform motion :** If the velocity of a particle in motion is not constant, then its motion is said to be uniform motion.
  - A non-uniform motion occurs when either the magnitude of velocity changes or its direction changes or both changes.
  - Motion of a particle along a curved path is always a non-uniform motion.
  - If particle changes its direction during the journey, its motion is always non-uniform.
- **Acceleration :** The rate of change of velocity is called acceleration.
  - It is a vector quantity. Its direction is same as that of change in velocity and NOT of the velocity.
  - It is NOT the rate of change of speed. For example, when a body moving with constant speed along a circular path, there is no change in its speed but there is a change in velocity as its direction is changing continuously at every point. Thus, there must be some acceleration of the body.
  - A change in velocity occurs when (i) only its direction changes, e.g. uniform circular motion. (ii) only its magnitude changes. e.g. a ball dropped from a certain height under gravity (iii) both magnitude as well as direction changes, e.g. a projectile motion. In all these cases, there MUST be some acceleration present in the motion.



Sign convention for acceleration

- Whenever velocity and acceleration are in same direction, the velocity of a particle increases. Such motion is called accelerated motion. Such an acceleration for numericals is usually taken 'positive acceleration'.
- Whenever velocity and acceleration are in opposite direction, the velocity of a particle decreases. Such motion is called retarded motion. Such an acceleration for numericals is usually taken 'negative acceleration' and also called 'retardation' or 'deceleration'.
- Acceleration, $\boxed{a = \dfrac{v - u}{t}}$

  Unit of acceleration : C.G.S.system - centimetre/(second)^2 (cm/s^2) ; S.I. system - metre/(second)^2 (m/s^2).

■ **Non-uniform motion with constant acceleration (uniformly accelerated motion) :** It is a motion in which acceleration is constant in both magnitude as well as direction.

- It is a non-uniform motion. Equations of motion for a uniformly accelerated motion are :

  (i) $v = u + at$ (ii) $s = ut + \frac{1}{2}at^2$ (iii) $v^2 = u^2 + 2as$ (iv) $s = \left(\frac{v+u}{2}\right)t$ (v) $v_{average} = \frac{v+u}{2}$

  Where, u = initial velocity ; v = final velocity ; s = distance travelled ; t = time taken.

- Distance travelled in nth second (i.e., in a particular second) is given by, $\boxed{s_{nth} = u + \frac{1}{2}a(2n-1)}$

■ **Free fall (motion under gravity) :**

- Free fall is the motion of an object subject only to the influence of gravity. An object is in free fall as soon as it is dropped from rest, thrown downward or thrown upward.
- **Acceleration due to gravity :** The constant acceleration of a freely falling body is called the acceleration due to gravity. Its magnitude is denoted with the letter g. The value of g on the surface of Earth is nearly 9.8 m/s^2.
- Earth's gravity always pulls downward, so the acceleration (g) of an object in free fall is always downward and constant in magnitude, regardless of whether the object is moving up, down, or is at rest, and independent of its speed.
- If the object is moving downward, the downward acceleration makes it speed up; if it is moving upward, the downward acceleration makes it slow down.

■ **Equations of motion of freely falling body :**

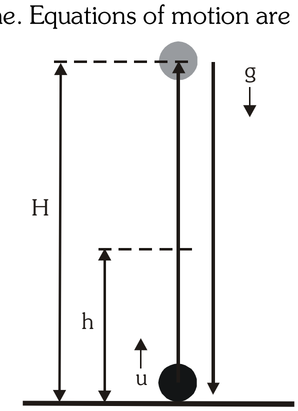
There are two main assumptions in free fall :

(1) Acceleration due to gravity (g) is constant throughout the motion and it acts vertically downwards.

(2) Air resistance is negligible.

- For numericals, we can assume acceleration due to gravity as + g for downward while –g for upward motion.
- **Case 1 :** An object thrown vertically upward and it returns after some time. Equations of motion are :

  (i) $v = u - gt$ (ii) $h = ut - \frac{1}{2}gt^2$ (iii) $v^2 = u^2 - 2gh$



  ▸ **Time taken to reach maximum height :**

  $\boxed{t = \frac{u}{g}}$

  ▸ **Total time of journey :**

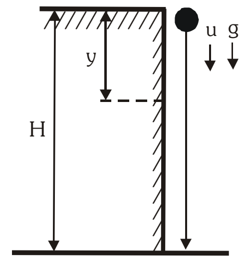
  $\boxed{T = \frac{2u}{g}}$

  ▸ **Maximum height achieved by the object :**

$$\boxed{H = \frac{u^2}{2g}}$$

- The total distance covered, $s = 2H = 2\left(\frac{u^2}{2g}\right) = \frac{u^2}{g}$ while, the total displacement is zero.

- **Case 2 :** An object is thrown vertically downward from a certain height H.



Equations of motion are :

(i) $v = u + gt$ (ii) $y = ut + \frac{1}{2}gt^2$ (iii) $v^2 = u^2 + 2gy$

- **Velocity at ground :** $v = \sqrt{u^2 + 2gH}$

- **Time taken to reach the ground :** $H = ut + \frac{1}{2}gt^2$. This is a quadratic equation that can be solved by factorisation or using quadratic formula.

- If an object is dropped from certain height, its initial velocity is taken zero i.e., u = 0. In such case the eqs.(i),(ii),(iii) will reduce to,

$v = gt$; $y = \frac{1}{2}gt^2$; $v^2 = 2gy$

- **Velocity at ground :** $v = \sqrt{2gH}$

- **Time taken to reach the ground :** $t = \sqrt{\frac{2H}{g}}$.

- **Case 3 :** An object thrown up from a certain height H or dropped from a rising balloon/helicopter. The initial velocity of a body dropped from a moving object is equal to the velocity of the moving object. Equation of motion are :

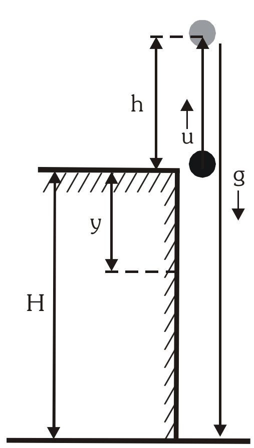
(i) $v = u - gt$

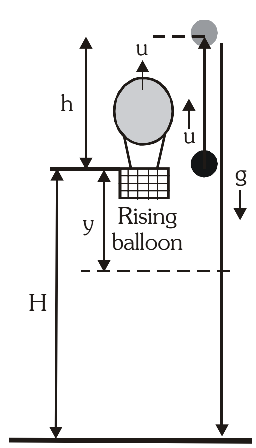
If v comes positive, it means that object is moving upwards. If v comes negative, it means that object is moving downwards.

(ii) $y = ut - \frac{1}{2}gt^2$

If y comes positive, it means that object is above the initial point. If y comes negative, it means that object is below the initial point.

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



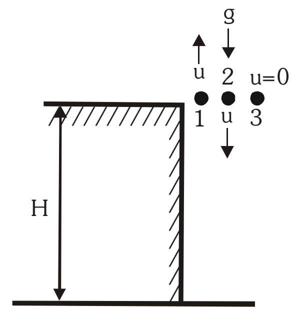


- **Velocity at ground :**

  $v = \sqrt{u^2 + 2gH}$

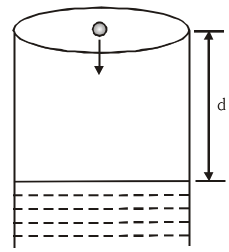
- **Time taken to reach the ground :** $H = -ut + \frac{1}{2}gt^2$. This is a quadratic equation that can be solved by factorisation or using quadratic formula.

- Let three balls 1, 2, and 3 are allowed to fall under gravity from the same height. Ball 1 is thrown vertically upward with speed u and it reaches the ground in time t_1. Ball 2 is thrown vertically downward with the same speed u and it reaches the ground in time t_2. Ball 3 is dropped (i.e., u = 0) from the same height and it reaches ground in time t_3. Then, the relationship between t_1, t_2 and t_3 is given by,



$$\boxed{t_3 = \sqrt{t_1 t_2}}$$

- An object is dropped in a well of depth 'd' and the sound of splash in water is heard after a certain time T.



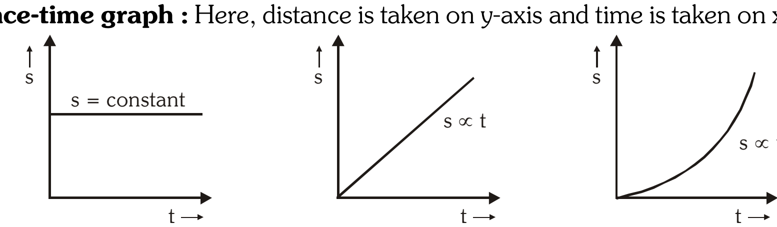
- **Downward motion of object :** $t_1 = \sqrt{\frac{2d}{g}}$

- **Upward motion of sound :** $t_2 = \frac{d}{v}$

  $T = t_1 + t_2 = \sqrt{\frac{2d}{g}} + \frac{d}{v}$

■ **Graphs in motion :** Usually distance-time, displacement-time, speed-time, velocity-time, acceleration-time graphs are used in understanding motion.

- **Distance-time graph :** Here, distance is taken on y-axis and time is taken on x-axis.



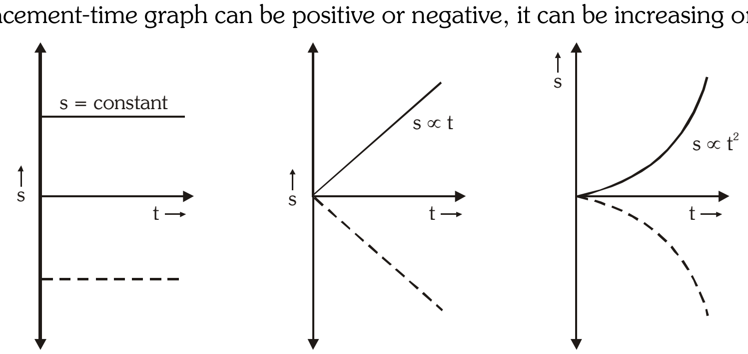
A body at rest (s = constant) (v = 0)

A body in uniform motion (s = v × t)

A body in uniformly accelerated motion ($s = ut + \frac{1}{2}at^2$)

- Distance-time graph is always positive, it is always increasing NEVER decreasing.

- **Displacement-time graph :** Here, displacement is taken on y-axis and time is taken on x-axis.
  - Displacement-time graph can be positive or negative, it can be increasing or decreasing.

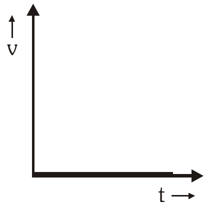


A body at rest (s = constant) (v = 0)

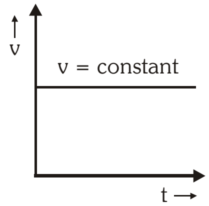
A body in uniform motion (s = v × t)

A body in uniformly accelerated motion ($s = ut + \frac{1}{2}at^2$)

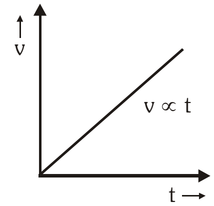
- **Speed-time graph :** Here, speed is taken on y-axis and time is taken on x-axis.
  - Speed-time graph is always positive, it can be increasing or decreasing.



A body at rest
(v = 0)

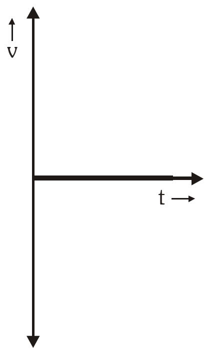


A body in
uniform motion
(v = constant)

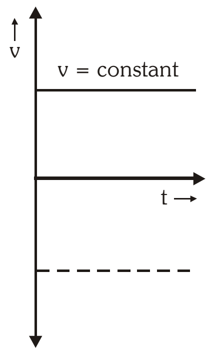


A body in uniformly
accelerated motion
(v = u + at)

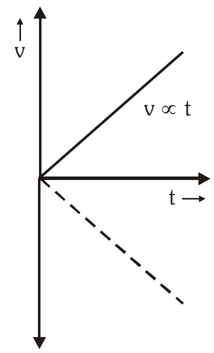
- **Velocity-time graph :** Here, velocity is taken on y-axis and time is taken on x-axis.
  - Velocity-time graph can be positive or negative, it can be increasing or decreasing.



A body at rest
(v = 0)

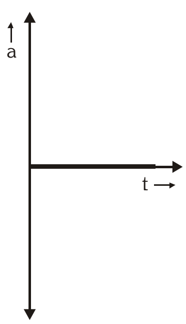


A body in
uniform motion
(v = constant)

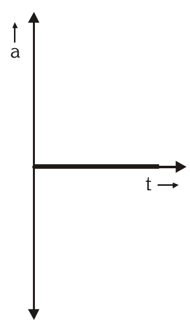


A body in uniformly
accelerated motion
(v = u + at)

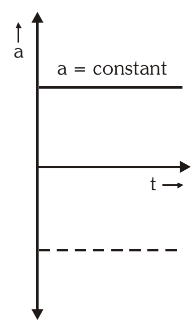
- **Acceleration-time graph :** Here, acceleration is taken on y-axis and time is taken on x-axis.
  - Acceleration-time graph can be positive or negative, it can be increasing or decreasing.



A body at rest
(a = 0)



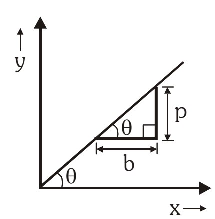
A body in
uniform motion
(a = 0)



A body in uniformly
accelerated motion
(a = constant)

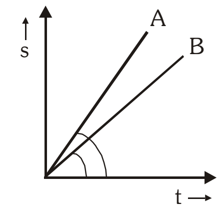
Significance of graphs in motion :

- Slope of a graph = $\tan\theta = \dfrac{\text{perpendicular}}{\text{base}} = \dfrac{p}{b}$ (see adjoining graph)

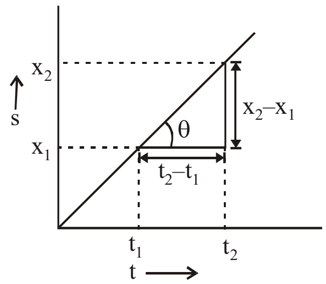


- More the value of θ, more will be the value of slope.
- Slope of a graph can be zero (θ = 0°), positive (0° < θ < 90°), negative (90° < θ < 180°) or even infinite (θ = 90°).

- Slope of distance-time graph gives speed. Slope of displacement-time graph gives velocity.
- In the adjoining s-t graph, slope of A is more than slope of B, thus, $\mathbf{v_A} > \mathbf{v_B}$.

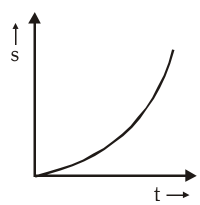


- From the s-t graph shown below, we can find the value of v.

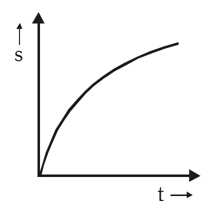


$$v = \frac{p}{b} = \frac{x_2 - x_1}{t_2 - t_1}$$

- In the following graphs, graph 1 represents accelerated motion i.e., v (i.e. slope) increasing with time. Graph 2 represents retarded motion i.e., v decreasing with time.

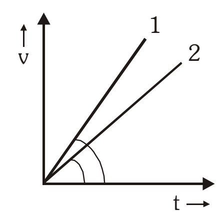


Graph 1
(v increasing with time)
accelerated motion

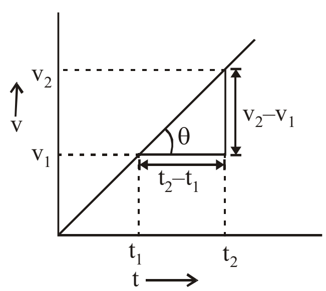


Graph 2
(v decreasing with time)
retarded motion

- Slope of speed-time graph or velocity-time graph gives acceleration.
- In the adjoining v-t graph, slope of 1 is more than slope of 2, thus, $\mathbf{a_1} > \mathbf{a_2}$.

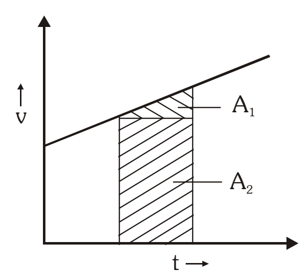


- From the v-t graph shown below, we can find the value of a.

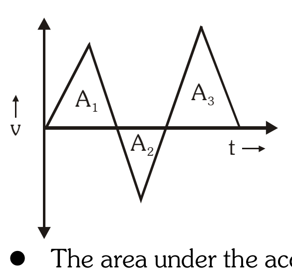


$$a = \frac{p}{b} = \frac{v_2 - v_1}{t_2 - t_1}$$

- Total area under the speed-time graph or velocity-time graph always gives total distance travelled by the body during a given time interval. We can also find displacement using a velocity-time graph which is as shown below :



Distance travelled = A_1 + A

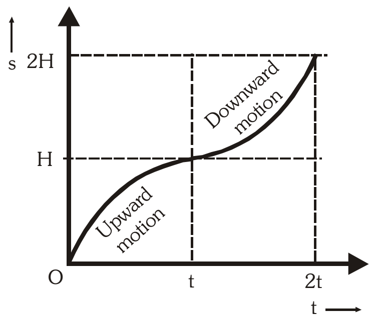


Distance travelled = $A_1 + A_2 + A_3$

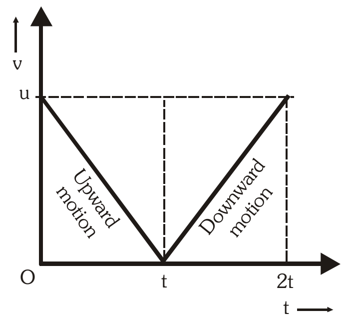
Displacement = $A_1 - A_2 + A_3$

- The area under the acceleration-time graph gives change in velocity during a given time interval.

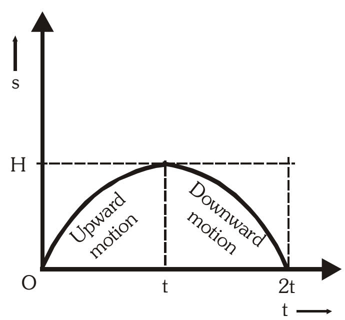
■ **Graphs of motion under gravity :** Upward motion of an object is a retarded motion, while downward motion is an accelerated motion.



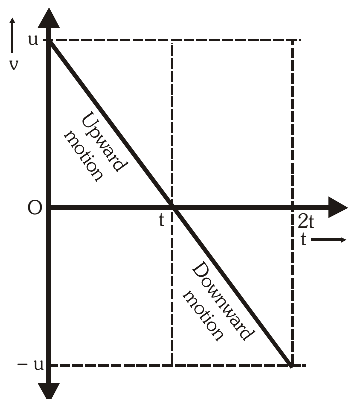
(a) Distance-time graph



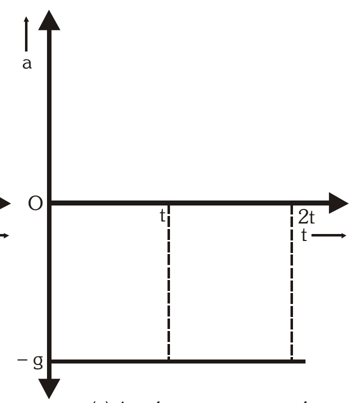
(b) Speed-time graph



(c) Displacment-time graph

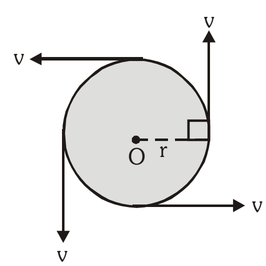


(d) Velocity-time graph

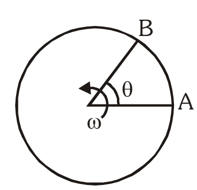


(e) Acceleration-time graph

■ **Circular motion :** When a particle moves along a circular path, its motion is called circular motion.



- A circular motion is always a non-uniform motion i.e., accelerated motion because the direction of velocity changes continuously.
- Velocity of a particle in circular motion is always tangential to the circular path i.e., velocity and radius are always ⊥ to each other.
- **Angular displacement (θ) :** The angle described by particle moving along a circular path is called **angular displacement.**



  - S.I. unit of angular displacement is **radian**.

    π radian = 180°, 1 radian = 180°/π = 57.3°
  - You can use a formula to find radian from degrees or vice-versa which is given by, $\boxed{\dfrac{R}{\pi} = \dfrac{D}{180}}$

    Where, R is angle in radian, D is angle in degrees.
- **Angular velocity (ω) :** The rate of change of angular displacement is called angular velocity.
  - $\boxed{\omega = \dfrac{\theta}{t}}$
  - S.I. unit of ω : radian per second or rad s^{-1}.
  - Relation between angular velocity and linear speed : $\boxed{v = r\omega}$ (r = radius of circular path)

- **Angular acceleration (α) :** The rate of change of angular velocity is called **angular acceleration**.
  - $\alpha = \frac{\omega_2 - \omega_1}{t}$
  - S.I. unit of α : radian/(second)^2 or rad s^{-2}.
  - Relation between angular acceleration & linear (tangential) acceleration : $a_t = r\alpha$
- **Uniform circular motion :** Motion of a particle along the circumference of a circle with a constant speed is called uniform circular motion.
  - In uniform circular motion, linear speed, v = constant ; angular velocity, ω = constant ; angular acceleration, $\alpha = 0$.
  - Here, linear speed can also be found by formula, $v = \frac{2\pi r}{T}$ (T = time period of 1 revolution)
  - Also, angular velocity ω can be found using formula, $\omega = \frac{2\pi}{T}$
  - If a particle is making N revolutions per minute (denoted as rpm), angular speed, $\omega = \frac{2\pi N}{60}$
- Uniform circular motion is always an accelerated motion. It has a radially inward acceleration called **centripetal acceleration**.
  - Formula for centripetal acceleration : $a_c = \frac{v^2}{r} = r\omega^2$
  - Centripetal acceleration (a_c) and velocity (v) are always perpendicular to each other.
- **Centripetal force :** It is the radially inward force that is required to move an object along a circular path.
  - Formula for centripetal force : $F = ma_c = \frac{mv^2}{r} = mr\omega^2$
  - Centripetal force is always supplied by a real force, the nature of which depends on the situation. While turning a motorcycle on a horizontal circular path, friction provides the necessary centripetal force. The electron moves in a circle around nucleus due to centripetal force provided by the electrostatic force of attraction between positive nucleus and negative electron. While whirling a stone tied with a string, the tension in the string provides the centripetal force. Earth revolves round the Sun due to the centripetal force provided by the gravitational force between the Earth and the Sun.

Multiple choice questions

1. A person sitting in a moving car is at rest with respect to
(1) a tree on the ground
(2) a cyclist on the road
(3) a building on the roadside
(4) the car

2. The motion of the wheel of a cycle is
(1) rotatory
(2) rectilinear
(3) translatory and rotatory
(4) None of these

3. A man has to go 50 m due north, 40 m due east and 20 m due south to reach a field. His displacement from his house to the field is,
(1) 110 m (2) $20\sqrt{5}$ m
(3) 75 m (4) 50 m

4. The numerical ratio of displacement to distance for a moving object is
(1) always less than 1 (2) always equal to 1
(3) always more than 1 (4) equal or less than 1

5. A monkey is moving on circular path of radius 80 m. If the monkey starts at one end of the diameter and reaches the other end, the displacement and the distance covered by the monkey are respectively,
(1) 160 m ; 160 m (2) 160 m ; 80π m
(3) 0 m ; 80π m (4) 160 m ; 160π m

6. In which of the following cases of motions, the distance moved and the magnitude of displacement are equal ?
(1) If the car is moving on straight road
(2) If the car is moving in circular path
(3) The pendulum is moving to and fro
(4) The earth is revolving around the Sun

7. A body moved from one end to another end along a curved path of a quarter circle. The ratio of distance to displacement is
(1) $\frac{\pi}{2\sqrt{2}}$ (2) $\frac{2\sqrt{2}}{\pi}$
(3) $\frac{\sqrt{2}}{\pi}$ (4) $\frac{\pi}{\sqrt{2}}$

8. A ball is thrown up with a certain velocity. It attains a height of 40 m and comes back to the thrower, then
(1) total distance covered by it is 40 m
(2) total displacement covered by it is 80 m
(3) total displacement is zero
(4) total distance covered by it is zero

9. A body moves on three quarters of a circle of radius r. The displacement and distance travelled by it are
(1) displacement = r, distance = 3r
(2) displacement = $\sqrt{2}$r , distance = $\frac{3\pi r}{2}$
(3) distance = 2r, displacement = $\frac{3\pi r}{2}$
(4) displacement = 0, distance = $\frac{3\pi r}{2}$

10. For the motion on a straight line path with constant acceleration, the ratio of the magnitude of the displacement to the distance covered is
(1) = 1 (2) ≥ 1
(3) ≤ 1 (4) < 1

11. A body moves along the circumference of a circular track. It returns back to its starting point after completing the circular track twice. If the radius of the track is R, the ratio of displacement to the distance covered by the body will be
(1) 0 (2) 8πR
(3) $\sqrt{3R}$ (4) $\frac{p}{R}$

12. A particle is travelling with a constant speed. This means that
(1) Its position remains constant as time passes
(2) It covers equal distances is equal time intervals
(3) Its acceleration is zero
(4) It does not change its direction of motion

13. A boy runs for 10 min at a uniform speed of 9 km/h. At what speed should he run for the next 20 min so that the average speed comes to 12 km/h ?
(1) 13.5 km/h (2) 10.2 km/h
(3) 8.2 km/h (4) 7.72 km/h

14. A car moves at a speed of 60 km/hr for 50 km and 80 km/hr for the next 50 km. What is average speed (in km/hr) of car for the journey of 100 km ?

(1) 68.6 (2) 70
(3) 75 (4) 72.6

15. A train moving on linear way travels a distance 'D' at constant velocity of 30 km/h, then it travels in opposite direction with same distance and reaches at original station at a constant velocity of 45 km/h. What is the average speed of train ?

(1) 36 km/h (2) 10 km/h
(3) 0 (4) 75 km/h

16. An object travels 16 m in 4 seconds, then another 16m in 2 seconds. Its average speed is

(1) 6 m/sec (2) 5 m/sec
(3) 8 m/sec (4) 5.3 m/sec

17. The rate of change of displacement with time is

(1) speed (2) acceleration
(3) retardation (4) velocity

18. A car travels a distance A to B at a speed of 40 km/hr and returns to A at a speed of 30 km/hr. The average velocity (in km/hr) for the whole journey is,

(1) 34.3 (2) 0 (3) 35 (4) 36.3

19. A passenger travels along a straight line with velocity v_1 for first half time and with velocity v_2 for next half time, then the mean velocity v is given by,

(1) $v = \sqrt{\frac{v_2}{v_1}}$ (2) $v = \sqrt{v_1 v_2}$

(3) $v = \frac{2v_1 v_2}{v_1 + v_2}$ (4) $v = \frac{v_1 + v_2}{2}$

20. A car travels $\frac{1}{3}$rd distance on a straight road with a velocity of 10 km/hr, next $\frac{1}{3}$rd with velocity 20 km/hr and the last $\frac{1}{3}$rd with velocity 60 km/hr. What is the average velocity of the car in the whole journey?

(1) 4 km/hr (2) 6 km/hr
(3) 12 km/hr (4) 18 km/hr

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

(1) 2π m/sec (2) 2 m/sec
(3) 4π m/sec (4) 4 m/sec

22. A quantity has a value of – 6.0 m/s. It may be the

(1) Speed of a particle
(2) Velocity of a particle
(3) Acceleration of a particle
(4) Position of a particle

23. An insect moves along the sides of a wall of dimensions 12 m $\times$5 m starting from one corner and reaches the diagonally opposite corner. If the insect takes 2 s for its motion then find the ratio of average speed to average velocity of insect.

(1) 15 : 4 (2) 1 : 1 (3) 12 : 7 (4) 17 : 13

24. When the distance travelled by an object is directly proportional to the time, it is said to travel with

(1) constant acceleration (2) uniform velocity
(3) zero velocity (4) constant speed

25. The rate of change of velocity with time is

(1) Speed (2) Displacement
(3) Distance (4) Acceleration

26. A bus decreases its speed from 80 km/hr to 60 km/hr in 5 sec. The acceleration of the bus is

(1) 2.1 m/s^2 (2) – 3.4 m/s^2
(3) – 1.1 m/s^2 (4) 3.2 m/s^2

27. The CGS unit of acceleration is

(1) m/s^2 (2) m/s (3) cm/min^2 (4) cm/s^2

28. Which of the following is not a vector quantity?

(1) Retardation
(2) Acceleration due to gravity
(3) Average speed
(4) Displacement

29. A rubber ball dropped from a certain height is an example of

(1) non-uniform acceleration
(2) uniform retardation
(3) uniform speed
(4) non-uniform speed

30. If the displacement of an object is proportional to square of time, then the object moves with

(1) uniform velocity
(2) uniform acceleration
(3) increasing acceleration
(4) decreasing acceleration

31. If the velocity of a body does not change, its acceleration is

(1) zero (2) infinite

(3) unity (4) none of these

32. A body whose speed is constant

(1) has a constant velocity

(2) might be accelerated

(3) must be accelerated

(4) cannot be accelerated

33. When the brakes are applied on a moving cycle, the directions of velocity and acceleration are

(1) opposite (2) same

(3) perpendicular (4) not related

34. The velocity acquired by a body moving with uniform acceleration is 20 m/s in first 2 sec and 40 m/s in first 4 sec. The initial velocity of the body is

(1) 40 m/s (2) 20 m/s

(3) 10 m/s (4) 0 m/s

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

(1) 160 m (2) 200 m

(3) 320 m (4) 400 m

36. A person travelling at 43.2 km/hr applies the brakes giving a deceleration of 12 m/s^2 to his bike. The distance it travels before coming to rest is

(1) 12 m (2) 4 m

(3) 6 m (4) 9 m

37. A bullet going with speed 150 m/s enters in a concrete wall and penetrates a distance of 15 cm before coming to rest. The retardation that offered by the wall is

(1) 15×10^4 m/s^2 (2) 7.5×10^4 m/s^2

(3) 3.75×10^4 m/s^2 (4) 30×10^4 m/s^2

38. A particle moving with a uniform acceleration travels 24 m and 64 m in the first two consecutive intervals of 4 sec each. Its initial velocity (in m/s) is

(1) 1 (2) 10

(3) 5 (4) 2

39. A particle experiences a constant acceleration for 20 sec after starting from rest. If it travels a distance S_1 in the first 10 sec and a distance S_2 in the next 10 sec, then

(1) $S_1 = S_2$ (2) $S_1 = S_2/3$

(3) $S_1 = S_2/2$ (4) $S_1 = S_2/4$

40. A body starts from rest and accelerates uniformly. Ratio of distances travelled in one, two and three seconds of its motion is

(1) 1 : 3 : 5 (2) 1 : 4 : 9

(3) 1 : 2 : 3 (4) 9 : 4 : 1

41. A body covers 200 cm in the first 2 sec and 220 cm in next 4 sec. What is the velocity of the body at the end of 7th second?

(1) 40 cm/sec (2) 20 cm/sec

(3) 10 cm/sec (4) 5 cm/sec

42. A body moving along a straight line at 20 m/sec undergoes an acceleration of 4 m/sec^2. After two seconds its speed will be :

(1) 12 m/sec (2) 28 m/sec

(3) 72 m/sec (4) 20 m/sec

43. Average velocity of an object is equal to the mean of its initial and final velocities if the acceleration is

(1) variable (2) uniform

(3) both of the above (4) Can't be said

44. A body starts from rest and moves with uniform acceleration for 2s. It then decelerates uniformly for 3s and stops. If deceleration is 4 ms^{-2}, the acceleration of the body is _______ ms^{-2}.

(1) 10 (2) 8.7 (3) 4 (4) 6

45. In the equation of motion : $s = at + bt^2$, the units of a and b are respectively.

(1) m/s^2, m/s^2 (2) m/s, m/s^2

(3) m/s^2, m/s^3 (4) m/s, m/s^3

46. A body travels a distance of 20 m in the 7th second and 24 m in 9th second. The distance travelled by it in the 15th second is,

(1) 36 m (2) 32 m (3) 42 m (4) 44 m

47. A particle starts from rest and moves with uniform acceleration. Then the ratio of distance covered in n^{th} sec. to that in n sec. is

(1) $\frac{n^2}{2n+1}$ (2) $\frac{2n-1}{n^2}$

(3) $\frac{n^2}{2n-1}$ (4) $\frac{2n+1}{n^2}$

48. The initial velocity of a particle is 10 m/sec and its retardation is 2 m/sec^2. The distance moved by the particle in 5th sec of its motion is :

(1) 31 m (2) 52 m (3) 1 m (4) 1 cm

49. A heavy ball falls freely, starting from rest. Between t = 3 s and t = 4 s, it travels a distance of ($g = 9.8\ m/s^2$)

(1) 4.9 m (2) 9.8 m

(3) 29.4 m (4) 34.3 m

50. A stone is dropped from the top of a tower. If it travels 34.3 m in the last second before it reaches the ground, find the height of the tower ($g = 9.8\ m/s^2$)

(1) 39.2 m (2) 58.8 m

(3) 78.4 m (4) 98 m

51. A body starting from rest and moving with a constant acceleration covers a distance S_1 in the 4th second and a distance S_2 in the 6th second. The ratio S_1/S_2 is

(1) 2/3 (2) 4/9 (3) 6/11 (4) 7/11

52. A body with an initial velocity of 3 m/s moves with an acceleration of 2 m/s^2, then the distance travelled in the 4th second is

(1) 10 m (2) 6 m (3) 7 m (4) 28 m

53. A stone is dropped into a well in which the level of water is h, below the top of the well. If v is velocity of sound, then time T after which the splash is heard is equal to

(1) $\frac{2h}{v}$ (2) $\sqrt{\frac{2h}{v}}+\frac{h}{g}$

(3) $\sqrt{\frac{2h}{g}}+\frac{h}{v}$ (4) $\sqrt{\frac{h}{2g}}+\frac{2h}{v}$

54. If two bodies of different masses m_1 and m_2 are dropped from different heights h_1 and h_2, then ratio of the time taken by the two to drop through these distances is

(1) $h_1 : h_2$ (2) h_2/h_1

(3) $\sqrt{h_1} : \sqrt{h_2}$ (4) $h_1^2 : h_2^2$

55. A stone is thrown vertically upward with an initial velocity u from the top of a tower, reaches the ground with a velocity 3u. The height of the tower is

(1) $\frac{3u^2}{g}$ (2) $\frac{4u^2}{g}$ (3) $\frac{6u^2}{g}$ (4) $\frac{9u^2}{g}$

56. Acceleration of a body projected upwards with a certain velocity is

(1) 9.8 m/s^2 (2) – 9.8 m/s^2

(3) zero (4) insufficient data

57. A body is dropped from the top of a tower and reaches the ground in 3 sec. Then the height of the tower is :

(1) 44.1 m (2) 40.2 m

(3) 62.3 m (4) None of these

58. A body is projected up with an initial velocity of 10 m/sec. It will return to its starting point after:

(1) 6 seconds (2) 10 seconds

(3) 2 seconds (4) 2 hours

59. At the maximum height of a body thrown vertically up

(1) Velocity is not zero but acceleration is zero

(2) Acceleration is not zero but velocity is zero

(3) Both acceleration and velocity are zero

(4) Both acceleration and velocity are not zero

60. A ball is thrown vertically upwards with a velocity of 49 m/s. The maximum height to which it rises and the total time it takes to return to the surface of the earth are respectively ($g = 9.8\ m/s^2$),

(1) 100 m ; 4 s (2) 110.5 m ; 6 s

(3) 150 m ; 5 s (4) 122.5 m ; 10 s

61. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10\ m/s^2$, what is the net displacement and the total distance covered by the stone when it returns to earth ?

(1) 0 m ; 150 m

(2) 0 m ; 160 m

(3) 75 m ; 150 m

(4) 80 m ; 160 m

62. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 m/s. When and where the two stones will meet ? (Take, $g = 10\ m/s^2$)

(1) The stones will meet at a height of 20 m above the ground after 4 s

(2) The stones will meet at a height of 16 m above the ground after 4 s

(3) The stones will meet at a height of 24 m above the ground after 6 s

(4) The stones will meet at a height of 18 m above the ground after 3 s

63. An object is thrown vertically upward at 35 m/s. Taking $g = 10 \text{ m/s}^2$, the velocity of the object 5 s later is

(1) 15 m/s down (2) 7.0 m/s up

(3) 15 m/s up (4) 85 m/s down

64. A stone is released from a balloon that is descending at a constant speed of 10 m/s. Neglecting air resistance, after 20 s the speed of the stone is ($g = 9.8 \text{ m/s}^2$)

(1) 2160 m/s (2) 1760 m/s

(3) 206 m/s (4) 196 m/s

65. A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top ? Given, $g = 10 \text{ ms}^{-2}$; speed of sound = 340 m/s.

(1) 11.47 s (2) 10 s

(3) 13.5 s (4) 15.42 s

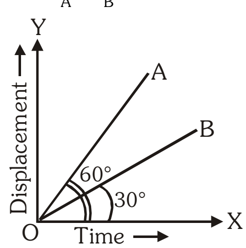
66. If the time of fall of two objects are in the ratio 1 : 2, find the ratio of the heights from which they fall.

(1) 1: 2 (2) 2: 1 (3) 1: 4 (4) 4: 1

67. Two bodies are held separated by 9.8 m vertically one above the other. They are released simultaneously to fall freely under gravity. After 2 s the distance between them is

(1) 4.9 m (2) 19.6 m (3) 9.8 m (4) 39.2 m

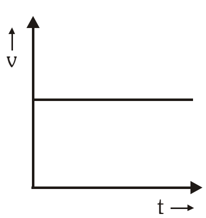
68. From the position time graph for two particles A and B is shown below. Graph A and graph B are making angles 60^0 and 30^0 with the time axis. The ratio of velocities $v_A : v_B$ is



(1) 1 : 1 (2) 3 : 1

(3) $\sqrt{3} : 1$ (4) 1 : 3

69. From the given v – t graph, it can be inferred that the object is



(1) in uniform motion

(2) at rest

(3) in non-uniform motion

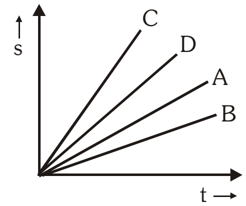
(4) moving with uniform acceleration

70. Area under a v – t graph represents a physical quantity which has the unit

(1) m^2 (2) m

(3) m^3 (4) $m \, s^{-1}$

71. Four cars A, B, C and D are moving on a levelled road. Their distance versus time graphs are shown in fig.. Choose the correct statement



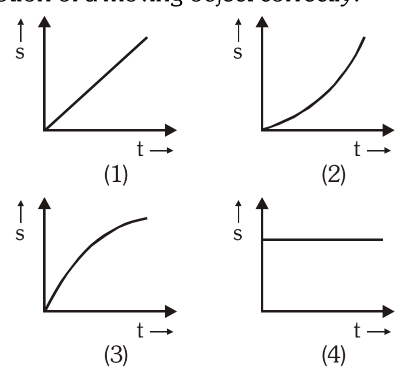
(1) Car A is faster than car D.

(2) Car B is the slowest.

(3) Car D is faster than car C.

(4) Car C is the slowest.

72. Which of the following figures represents uniform motion of a moving object correctly?

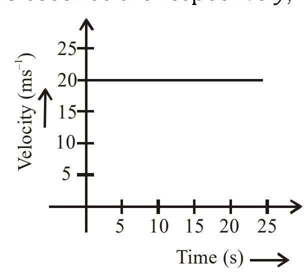


73. Slope of a velocity – time graph gives

(1) the distance (2) the displacement

(3) the acceleration (4) the speed

74. The velocity-time graph shows the motion of a cyclist. Its acceleration and the distance covered by the cyclist in 15 seconds are respectively,



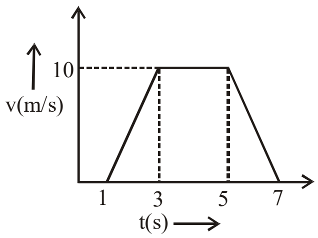
(1) 1.33 m/s^2 ; 150 m

(2) 0 m/s^2 ; 150 m

(3) 1.33 m/s^2 ; 300 m

(4) 0 m/s^2 ; 300 m

75. A particle moves according to given velocity-time graph. Then, the ratio of distance travelled in last 2 seconds to the total distance travelled is



(1) 1/4 (2) 1/2

(3) 1/8 (4) 1/6

76. The velocity of a body increases for sometime, then remains constant and then decreases until it comes to rest. When velocity is plotted against time the fig. obtained is :

(1) triangle

(2) trapezium

(3) circle

(4) None of the above

77. The area under the acceleration-time graph represents :

(1) change in velocity (2) speed

(3) velocity (4) acceleration

78. When a graph between one quantity versus another results in a straight line with positive slope, the quantities are

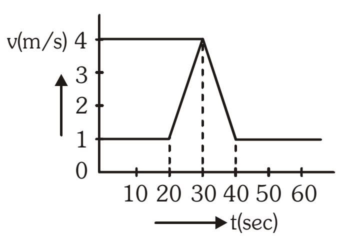
(1) directly proportional

(2) both constant

(3) inversely proportional

(4) zero

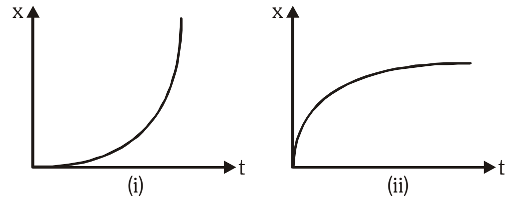
79. Velocity time (v – t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-zero acceleration and retardation is



(1) 60 m (2) 50 m

(3) 30 m (4) 40 m

80. Figures (i) and (ii) below show the displacement-time graphs of two particles moving along the x-axis. We can say that



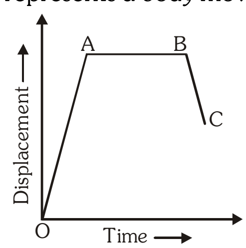
(1) Both the particles are having a uniformly accelerated motion

(2) Both the particles are having a uniformly retarded motion

(3) Particle (i) is having a uniformly accelerated motion while particle (ii) is having a uniformly retarded motion

(4) Particle (i) is having a uniformly retarded motion while particle (ii) is having a uniformly accelerated motion

81. In fig, BC represents a body moving



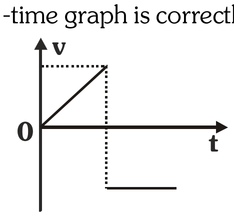
(1) Backward with uniform velocity

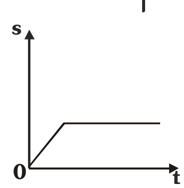
(2) Forward with uniform velocity

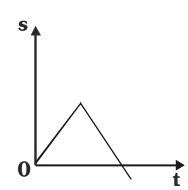
(3) Backward with non-uniform velocity

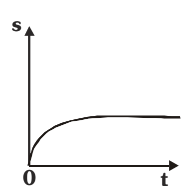
(4) Forward with non-uniform velocity

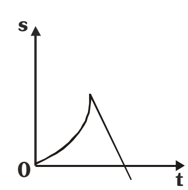
82. The velocity-time graph for a particle moving along x-axis is shown in the figure. The corresponding displacement -time graph is correctly shown by



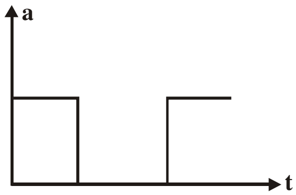
(1)


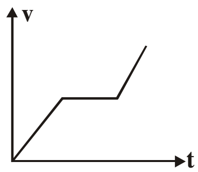
(2)


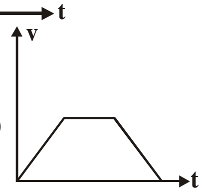
(3)


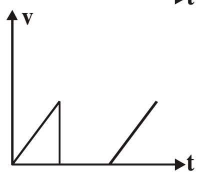
(4)


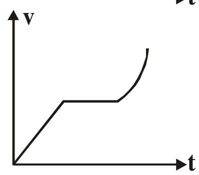
83. Which of the following graphs would probably show the velocity plotted against time graph for a body whose acceleration-time graph is shown in the figure?



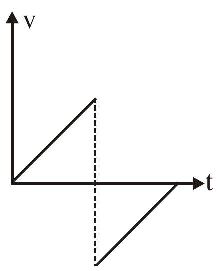
(1)


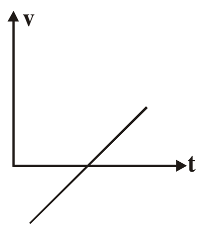
(2)


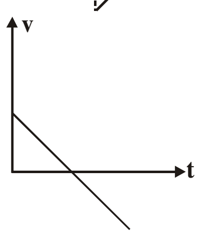
(3)


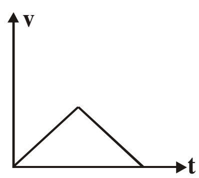
(4)


84. The velocity-time graph of a body falling from rest under gravity and rebounding from a solid surface is represented by which of the following graphs?

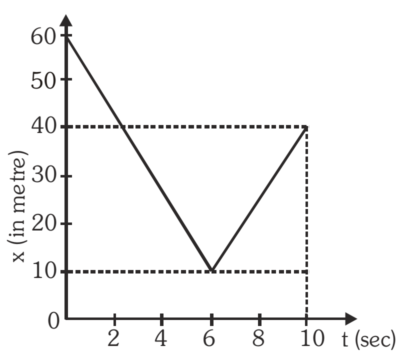
(1)


(2)


(3)


(4)


85. The fig. shows the displacement-time graph of a particle moving on a straight line path. What is the average velocity of the particle over 10 seconds ?



(1) 2 ms^{-1} (2) 4 ms^{-1} (3) 6 ms^{-1} (4) 8 ms^{-1}

86. 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

(1) at rest

(2) moving with no acceleration

(3) in accelerated motion

(4) moving with uniform velocity

87. The constant quantity in a uniform circular motion is

(1) linear speed (2) centripetal force

(3) acceleration (4) momentum

88. Two cars of masses m_1 and m_2 are moving along the circular paths of radius r_1 and r_2 respectively. The speeds are such that they complete one round at the same time. The ratio of angular speeds of two cars is

(1) $m_1 : m_2$ (2) $r_1 : r_2$

(3) 1 : 1 (4) $m_1r_1 : m_2r_2$

89. A wheel is of diameter 1m. If it makes 30 revolutions/sec., then the linear speed (in m/s) of a point on its circumference is

(1) 30π (2) π (3) 60π (4) $\pi/2$

90. The angular velocity (in rad/hr) of the earth's rotation about its axis is

(1) $12/\pi$ (2) $\pi/12$

(3) $48/\pi$ (4) $\pi/24$

91. An aeroplane revolves in a horizontal circle above the surface of the earth with a uniform speed of 100 km/hr. The change in velocity (in km/hr) after completing 1/2 revolution is

(1) 200 (2) 150

(3) 300 (4) 400

92. In uniform circular motion

(1) acceleration & velocity both remain constant

(2) acceleration & speed both remain constant

(3) acceleration & velocity both keep on changing

(4) acceleration constant but speed changes

93. Angular velocity of minute hand of a watch is

(1) $\pi/3600$ rad/s (2) $\pi/1800$ rad/s

(3) $\pi/7200$ rad/s (4) $\pi/900$ rad/s

94. The ratio of angular speed of hour's hand and second's hand of a clock is

(1) 1 : 1 (2) 1 : 60

(3) 1 : 720 (4) 1 : 3600

95. The angular speed (in rad/s) of a fly wheel making 120 revolutions/minute is

(1) 2π (2) 8π (3) π (4) 4π

96. A particle is moving in a horizontal circle with constant speed. It has constant

(1) Velocity (2) Acceleration

(3) Kinetic energy (4) Displacement

97. The earth's radius is 6400 km. It makes one rotation about its own axis in 24 hrs. The centripetal acceleration of a point on its equator is nearly

(1) 340 cm/s^2 (2) 34 cm/s^2

(3) 3.4 cm/s^2 (4) 0.34 cm/s^2

98. The acceleration of a point on the rim of flywheel 1 m in diameter, if it makes 1200 revolutions per minute is

(1) $8\pi^2$ m/s^2 (2) 80 π^2 m/s^2

(3) 800 π^2 m/s^2 (4) none of these

99. A particle revolves in a circular path. The acceleration of the particle is :

(1) along the tangent

(2) zero

(3) along the radius

(4) None of these

100. Which equation is used to find out the speed of object moving in uniform circular motion ?

(1) $\frac{\pi r}{T}$ (2) $\frac{\pi r}{2T}$

(3) $\frac{2\pi r}{T}$ (4) $\frac{2\pi r}{(T/2)}$

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	3	4	4	2	1	1	3	2	1	1	2	1	1	1	4	4	2	4	
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	2	4	4	4	3	4	3	4	2	1	2	1	4	3	3	2	1	2	
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	2	2	4	2	1	2	3	4	3	4	1	3	3	2	2	1	3	2	
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	1	1	3	1	3	3	2	1	2	2	1	3	4	1	2	1	1	2	
Que.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	1	3	1	2	1	3	2	3	4	3	3	3	3	