NEET Companion

For NEET and AIIMS

PHYSICS

Motion in One Dimension

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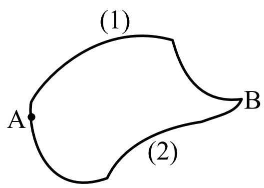
1

MOTION IN ONE DIMENSION

1. DISTANCE

Distance is the actual length of the path. It is the characteristic property of any path i.e. path is always associated when we consider distance between two positions. Distance between A and B while moving through path (1) may or may not be equal to the distance between A and B while moving through path (2).



(i) It is a scalar quantity

(ii) Dimension : $[M^0L^1T^0]$

(iii) Unit : In C.G.S. centimeter (cm), In M.K.S. (m)

2. DISPLACEMENT

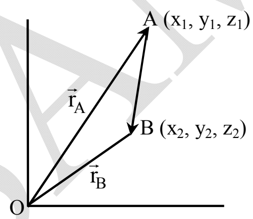
Displacement of a particle is a position vector of its final position w.r.t. initial position.

Displacement =

$$\overrightarrow{AB} = (x_2 - x_1)\ \hat{i}\ + (y_2 - y_1)\ \hat{j} + (z_2 - z_1)\ \hat{k}$$

It is the characteristic property of any point i.e. depends only on final and initial positions.

To Determine The Position Vector :



Position vector of A w.r.t. $O = \overrightarrow{OA}$

$\Rightarrow \vec{r}_A = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$

Position Vector of B w.r.t. $O = \overrightarrow{OB}$

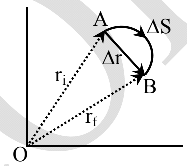
$\Rightarrow \vec{r}_B = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$

Position vector of B w.r.t. A;

$\overrightarrow{AB} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$

3. COMPARATIVE STUDY OF DISTANCE & DISPLACEMENT

Distance is the actual path travelled by a moving body, while displacement is the change in the position.



In the above figure distance travelled is ΔS, while displacement is $\overrightarrow{\Delta r} = \vec{r}_f - \vec{r}_i$

3.1 Regarding distance and displacement it is worth noting that :

(1) Distance is scalar, while displacement is vector both having same dimensions [L] and same SI unit metre.

(2) The magnitude of displacement is equal to minimum possible distance so,

Distance ≥ |Displacement|

(3) For motion between two points displacement is single valued, while distance depends on actual path and so can have many values.

(4) For a moving particle distance can never decreases with time while displacement can. Decrease in displacement means body is moving towards the initial position.

(e) For moving particle distance can never be negative or zero, while displacement can be. (Zero displacement means that body after motion has come back to initial position)

Distance > 0 but |Displacement| > = or < 0

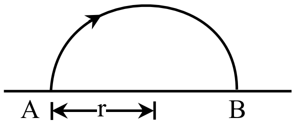
(f) In general magnitude of displacement is not equal to distance. However it can be so if the motion is along a straight line without change in direction.

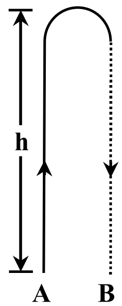
Comparative study of distance & displacement :

Distance = πr,

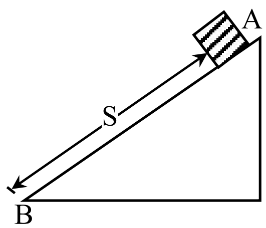
|Displacement| = 2r

|Displacement| = s



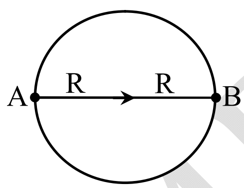


Distance = 2h, Displacement = 0



Distance = s, |Displacement| = s

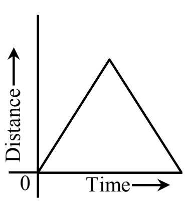
Note : Distance and Displacement, while moving in a circle from A to B and then from B to A.

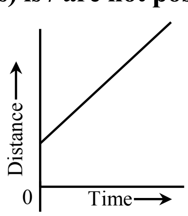


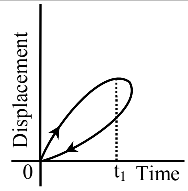
	Half Cycle	Full Cycle
Distance	πR	$2\pi R$
Displacement	2R	0
Direction	1. A → B, When particle moves from A to B 2. B → A, When particle moves from B to A	

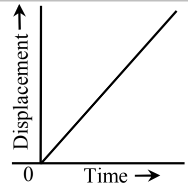
Example

Which of the following graph(s) is / are not possible ?

(1) 

(2) 

(3) 

(4) 

Solution : (1) & (2)

The (1) graph shows that with increase in time distance first increases and then decreases. However, distance can never decrease with time so this graph is not physically possible. The graph (3) shows that at certain instant of time (t_1) body is present at two positions. Also it shows that time first increases then decreases. These conditions are not possible physically.

Hence correct answer is (1) and (3).

Example-1

A body covered a distance of L m along a curved path of a quarter circle. The ratio of distance to displacement is-

(1) $\pi/2\sqrt{2}$ **(2)** $2\sqrt{2}/\pi$

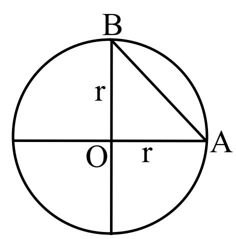
(3) $\pi/\sqrt{2}$ **(4)** $\sqrt{2}/\pi$

Solution : (1)

Length of quarter circle path = L = $2\pi r/4$

$\therefore$ r = $2L/\pi$

Hence displacement AB = $\sqrt{r^2 + r^2} = \sqrt{2}$ r.



From ΔOAB, magnitude of displacement = AB

$= \sqrt{2}\ r \therefore \dfrac{\text{Distance}}{\text{Displacement}} = \dfrac{2\pi r/4}{\sqrt{2}.r} = \pi/2\sqrt{2}$

Hence correct answer is (1).

Example-2

An old man goes for morning walk on a semicircular track of radius 40 m ; if he starts from one end of the track and reaches to other end, the distance covered by the man and his displacement will respectively be-

(1) 126 m, 80 m **(2) 80 m, 126 m**

(3) 80 m, 252 m **(4) 252 m, 80 m**

Solution : (1)

Distance covered by man = Length of the path = πR = $\pi \times 40$ = 126 m

Displacement of the man = The least distance between initial and final points = Diameter of semicircular path = 2R = 2 × 40 = 80 m

The direction of displacement will be from initial point to final point.

Hence correct answer is (1).

4. SPEED

It is the distance covered by the particle in one second.

(i) It is a scalar quantity

(ii) Unit : In M.K.S. m/s or km/sec.

In C.G.S. cm/sec

(iii) Dimension : $[M^0L^1T^{-1}]$

Types of Speed :

(1) Instantaneous speed

(2) Average speed

(3) Uniform speed

(4) Non-uniform speed

(1) Instantaneous Speed :

It is the speed of a particle at particular instant.

Instantaneous speed $= \lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t} = \frac{dS}{dt}$

(2) Average Speed $= \frac{\text{Total distance}}{\text{Total time}}$

(3) Uniform Speed : If during the entire motion speed of the body remains same, the body is said to have uniform speed.

(4) Non-uniform Speed : If speed changes, the body is said to have non-uniform speed.

5. VELOCITY

It is defined as rate of change of displacement.

(i) It is a vector quantity

(ii) Its direction is same as that of displacement

(iii) Unit and dimension : Same as that of speed

Types of Velocity :

(1) Instantaneous velocity

(2) Average velocity

(3) Uniform velocity

(4) Non-uniform velocity

(1) Instantaneous velocity : It is defined as the velocity at some particular instant.

Instantaneous velocity $= \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$

(2) Average velocity :

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

(3) Uniform velocity : A particle is said to have uniform velocity, if magnitudes as well as direction of its velocity remains same and this is possible only when the particles moves in same straight line reversing its direction.

(4) Non-uniform velocity : A particle is said to have non-uniform velocity, if either of magnitude or direction of velocity changes (or both changes).

6. COMPARATIVE STUDY OF INSTANTANEOUS SPEED AND INSTANTANEOUS VELOCITY

Instantaneous velocity or simply velocity is defined as rate of change of particle's position with time

$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$ where the position $\vec{r}$ of a particle at any instant changes by $\Delta \vec{r}$ in a small time Δt

The magnitude of velocity is called speed i.e. speed = | velocity| i.e. $v = |\vec{v}|$

☞ **Note :** In straight line motion there is no change in direction so $\vec{v}$ and v both have same meaning

Example-03

A particle moves along the x-axis in such a way that its x-coordinates varies with time as $x = 2 - 5t + 6t^2$. What will be its initial velocity ?

(1) 5 m/s **(2) –5 m/s**

(3) 2 m/s **(4) –2 m/s**

Solution : (2)

Here displacement, $x = 2 - 5t + 6t^2$

The velocity at any instant t is given by

$$v = \frac{dx}{dt} = \frac{d}{dt}(2 - 5t + 6t^2)$$

$\Rightarrow v = -5 + 12t$

This is the velocity at time t. Initially t = 0,

$\therefore v = -5$ m/s

Hence correct answer is (2).

Note : Hence speed will be $|\vec{v}| = 5$ m/s.

Example-04

The displacement of a particle moving in one-dimensional direction under a force at time t is given by t = $\sqrt{x}$ + 3, where x is in m and t in sec. The displacement of the particle, when its velocity is zero, will be-

(1) 0 (2) 3m (3) –3m (4) 2m

Solution : (1)

Given t = $\sqrt{x} + 3 \Rightarrow x = t^2 - 6t + 9$

$\Rightarrow \frac{dx}{dt} = 2t - 6$

$\Rightarrow$ Instantaneous velocity, $v = \frac{dx}{dt} = 2t - 6$

when v = 0, 2t – 6 = 0 $\Rightarrow$ t = 3 sec. Thus at t = 3 sec, $x = (t^2 - 6t + 9) = 0$

Hence correct answer is (1).

☛ **Note :**

(1) Velocity is a vector while speed is a scalar having same units (m/s) and dimension $[LT^{-1}]$

(2) If during motion velocity remains constant throughout a given interval of time, the motion is said to be uniform and for uniform motion,

$\vec{v}$ = constant = $\vec{v}_{av}$

However converse may or may not be true i.e. If $\vec{v} = \vec{v}_{av}$, the motion may or may not be uniform.

(3) If velocity is constant, speed (= | velocity |) will also be constant. However converse may or may not be true i.e. if speed = constant, velocity may or may not be constant as velocity has a direction in addition to magnitude which may or may not change. e.g. in case of uniform rectilinear motion. $\vec{v}$ = constant and so speed $|\vec{v}|$ = constant

while in case of uniform circular motion, v = constant but $\vec{v} \neq$ constant due to change in direction.

(4) Velocity can be positive or negative, as it is a vector but speed can never be negative as it is the magnitude of velocity

i.e. $v = |\vec{v}|$

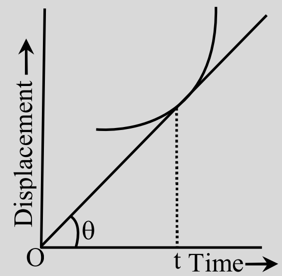
(5) If displacement is given as a function of time, the time derivative of displacement will give velocity and modulus of velocity gives speed.

e.g. $s = A_0 - A_1t + A_2t^2$, $v = \frac{ds}{dt} = -A_1 + 2A_2t$.

So, initially (t = 0), velocity = $-A_1$,

while speed = $|-A_1| = A_1$

(6) As by definition, $v = \frac{ds}{dt}$, the slope of displacement versus time graph gives velocity.

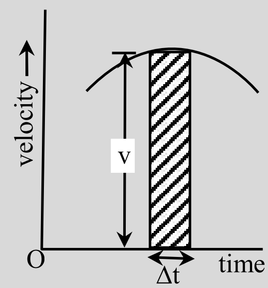


i.e. $v = \frac{ds}{dt} = \tan\theta$ = slope of s-t curve

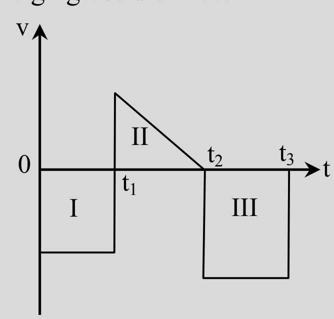
(7) As, $v = \frac{ds}{dt} \Rightarrow ds = vdt$

From figure vdt = dA. so, dA = ds

$\therefore s = \int dA = \int vdt$



Area under velocity versus time graph with proper algebraic sign gives displacement while without sign gives distance.



e.g. From the adjoining v-t graph.
The distance travelled by body in time t_3 = Area I + Area II + Area III and the displacement of body
= Area II – Area III – Area I

Example-05

Can a body have uniform velocity but non-uniform speed ?

(1) Yes

(2) No

(3) Depend on magnitude

(4) Unpredictable

Solution : (2)

No.

Velocity = Speed + Direction

Hence correct answer is (2).

Example-06

Can a body have uniform speed but non-uniform velocity ?

(1) Yes

(2) No

(3) Depend on direction

(4) Unpredictable

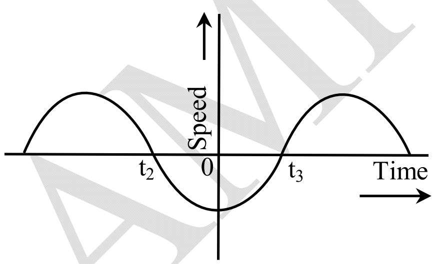
Solution : (1)

Yes, hence correct answer is (1).

e.g. Speed of a particle in circular path is constant but due to change in direction its velocity changes.

Example-07

State whether the following graph can be seen in nature or not. Explain.



(1) Yes

(2) No

(3) Sometime

(4) At a particular instant

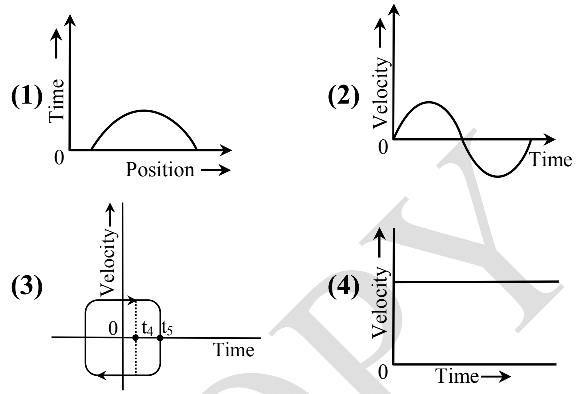
Solution : (2)

This graph shows that speed is negative for some interval of time (t_2 to t_3). Since speed can never be negative, so this graph is physically not possible.

Hence correct answer is (2).

Example-8

Out of the following graph(s), which is/are not possible ?



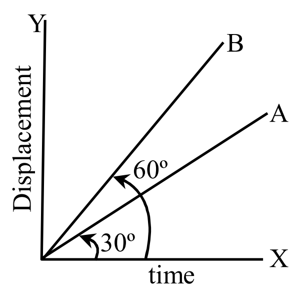
Solution : (1) & (3)

The graph (1) shows that on increasing position (x), time first increases, then decreases, which is impossible. The graph (3) shows that at a given instant of time (t_4) particle has two velocities. Also it shows that at time (t_5) the acceleration is infinite (= slope of $\vec{v}$/t curve). Since both these conditions cannot be achieved practically, then these graphs are not possible.

Hence correct answer is (1) and (3).

Example-9

From the adjoining displacement-time graph for two particles A & B the ratio of velocities $v_A : v_B$ will be-



(1) 1 : 2

(2) 1 : $\sqrt{3}$

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

(4) 1 : 3

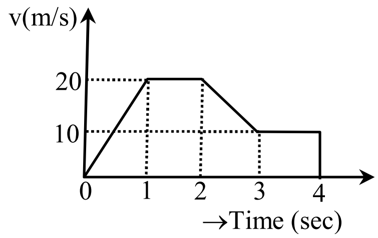
Solution : (4)

The line having greater slope has greater velocity, hence the line making an angle 60º with time axis has greater velocity. Now, $\frac{v_A}{v_B} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3}$

Hence correct answer is (4).

Example-10

From the adjoining graph, the distance traversed by particle in 4 sec, is-

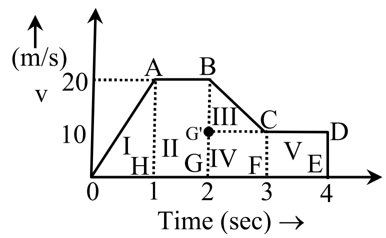


(1) 60 m	**(2) 25 m**
(3) 55 m	**(4) 30 m**

Solution : (3)

The given graph can be drawn as shown in figure

Distance travelled = Area under v-t graph



= Area I + Area II + Area III + Area IV + Area V

= (1/2) (OH × AH) + HG × AH

+ 1/2 (G'C × BG')+ (GF × GG') + (EF × CF)

= (1/2) (1 × 20) + (1 × 20) + 1/2 (1 × 10) + (1 × 10)

+ (1 × 10) = 10 + 20 + 5 + 10 + 10 = 55 m

Hence correct answer is (3).

7. COMPARATIVE STUDY OF AVERAGE SPEED & AVERAGE VELOCITY

The average speed of a particle for a given interval of time is defined as the ratio of distance travelled to the time taken, while average velocity is defined as the ratio of displacement to time taken.

$$\text{Average speed} = \frac{\text{Distance traveled}}{\text{Time taken}}$$

i.e. $$v_{av} = \frac{\Delta s}{\Delta t}$$

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

i.e $$\vec{v}_{av} = \frac{\Delta \vec{r}}{\Delta t}$$

Note :

(1) Average speed is a scalar, while average velocity is a vector both having same unit (m/s)

(2) Both have dimension $[M^0LT^{-1}]$

(3) For a given time interval average velocity is single valued, while average speed can have many values depending on path followed.

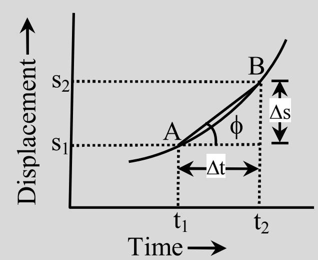
(4) If after motion body comes back to its initial position $\vec{v}_{av} = 0$ [as $\Delta\vec{r} = 0$], but $v_{av} > 0$ and finite (as $\Delta s > 0$)

(5) For a moving body average speed can never be negative or zero (unless $t \to \infty$), while average velocity can be i.e.

$v_{av} > 0$ while $\vec{v}_{av} >= \text{or} < 0$

(6) In general average speed is not equal to magnitude of average velocity (as $\Delta s \neq |\Delta \vec{r}|$). However it can be so if the motion is along a straight line without change in direction (as $\Delta s = |\Delta \vec{r}|$).

(7) If a graph is plotted between distance (or displacement) and time, the slope of chord during a given time interval gives average speed (or velocity)



$$v_{av} = \frac{\Delta s}{\Delta t} = \tan\phi = \text{slope of chord}$$

(8) If a particle travels distances L_1, L_2, L_3 etc at speeds v_1, v_2, v_3 etc. respectively, then

$$v_{av} = \frac{\Delta s}{\Delta t} = \frac{L_1 + L_2 + \ldots\ldots + L_n}{\frac{L_1}{v_1} + \frac{L_2}{v_2} + \ldots\ldots\ldots + \frac{L_n}{v_n}} = \frac{\Sigma L_i}{\Sigma \frac{L_i}{v_i}}$$

If $L_1 = L_2$ ———— $= L_n = L$

then $$\frac{1}{v_{av}} = \frac{1}{n}\left[\frac{1}{v_1} + \frac{1}{v_2} + \ldots\ldots\right] = \frac{1}{n}\Sigma\frac{1}{v_i}$$

Special Note :

If a particle moves a distance at speed v_1 and comes back with speed v_2, then

$$v_{av} = \frac{2v_1v_2}{v_1+v_2}$$

while $\vec{v}_{av} = 0$

[as displacement = 0]

(i) If a particle travels at speeds v_1, v_2 etc. for intervals t_1, t_2 etc. respectively, then

$$v_{av} = \frac{\Delta s}{\Delta t} = \frac{v_1t_1 + v_2t_2 + ...}{t_1 + t_2 + ...} = \frac{\Sigma v_i t_i}{\Sigma t_i}$$

If $t_1 = t_2 = ... = t_n = t$

then $v_{av} = \frac{v_1 + v_2 + ...}{n} = \frac{1}{n}\Sigma v_i$

i.e. average speed is arithmetic mean of individual speeds.

Special Note :

If a particle moves for two equal time-intervals

$$v_{av} = \frac{v_1+v_2}{2}$$

Example-11

A car travels first half distance between two places with a speed of 40 km/h and the rest half distance with a speed of 60 km/h. The average speed of the car will be-

(1) 100 km/hr **(2) 50 km/hr**

(3) 48 km/hr **(4) 200 km/hr**

Solution : (3)

Let the total distance travelled be x.

Time taken to travel first half distance

$$t_1 = \frac{x/2}{40} = \frac{x}{80} \text{ hr}$$

Time taken to travel the rest half distance

$$t_2 = \frac{x/2}{60} = \frac{x}{120} \text{ hr}$$

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

$$= \frac{x}{(x/80)+(x/120)} = 48 \text{ km/hr}$$

Hence correct answer is (3).

Example-12

A table has its minute hand 4.0 cm long. The average velocity of the tip of the minute hand between 6.00 a.m. to 6.30 a.m. and 6.00 a.m. to 6.30 p.m. will respectively be- (in cm/s)

(1) 4.4×10^{-3}, 1.8×10^{-4} **(2) 1.8×10^{-4}, 4.4×10^{-3}**

(3) 8×10^{-3}, 4.4×10^{-3} **(4) 4.4×10^{-3}, 8×10^{-4}**

Solution : (1)

At 6.00 a.m. the tip of the minute hand is at 12 mark and at 6.30 a.m. or 6.30 p.m. it is 180^0 away. Thus the straight line distance between the initial and final positions of the tip is equal to the diameter of the clock.

Displacement = 2 R = 2 × 4 cm = 8 cm

Time taken from 6 a. m. to 6.30 a.m. is 30 minutes = 1800 s. The average velocity is

$$v_{av} = \frac{\text{Displacement}}{\text{time}} = \frac{8.0 \text{ cm}}{1800 \text{ s}} = 4.4\times10^{-3} \text{ cm/s}$$

Again time taken from 6 am to 6.30 p.m.

= 12 hrs + 30 minutes = 45000 s

$$\therefore v_{av} = \frac{\text{Displacement}}{\text{time}} = \frac{8}{45000} = 1.8 \times 10^{-4} \text{ cm/s}$$

Hence correct answer is (1).

Example-13

The average speed and average velocity during one complete cycle of radius R will respectively be-

(T is the time to take one complete revolution)

(1) $\frac{\pi R}{T}, 0$ **(2)** $\frac{2\pi R}{T}, \frac{\pi R}{T}$

(3) $\frac{2\pi R}{T}, 0$ **(4)** $0, \frac{2\pi R}{T}$

Solution : (3)

Average speed $v_{av} = \frac{2\pi R}{T}$ and

average velocity $\vec{v}_{av} = 0/T = 0$

Hence correct answer is (3).

Example-14

A boy covers a distance AB of 2 km with speed of 2.5 km/h, while going from A to B and comes back from B to A with speed 0.5 km/hr, his average speed will be-

(1) 1.5 km/hr **(2) 0.83 km/hr**

(3) 1.2 km/hr **(4) 3 km/hr**

Solution : (2)

As boy goes from A to B and then comes back from B to A hence his average speed

$$v_{av} = \frac{2v_1v_2}{v_1+v_2} = \frac{2\times2.5\times0.5}{2.5+0.5} = \frac{2.5}{3} = 0.8 \text{ km/hr}$$

Hence correct answer is (2).

Example-15

Usually "average speed" means the ratio of total distance covered to the time elapsed. However some time the phrase "average speed" can mean the magnitude of the average velocity. Are the two same?

Solution :

No, usually they have different meanings, as according to I-definition, $v_{av} = \frac{\text{distance}}{\text{time}}$, while according to II-definition $v_{av} = \frac{|\text{displacement}|}{\text{time}}$.

Now as distance $\geq$ | displacement |, so $v_{av} \geq |\vec{v}_{av}|$

i.e. usually average speed is greater than the magnitude of average velocity

e.g. If a body returns to its starting point after some motion, then as distance travelled is finite while displacement is zero so $v_{av} > 0$ but $|\vec{v}_{av}| = 0$. However in case of motion along a straight-line without change in direction, as |displacement| = distance, the two definition will mean same.

8. ACCELERATION

It is defined as the rate of change of velocity.

(i) It is a vector quantity.

(ii) Its direction is same as that of change in velocity and not of the velocity (That is why acceleration in circular motion is towards the centre)

(iii) There are three ways possible in which change in velocity may occur

When only direction	When only magnitude changes	When both the direction and magnitude change
To change the direction net acceleration or net force should be perpendicular to direction of velocity **Example:** Uniform circular motion	In this case, net force or net acceleration should be parallel or anti-parallel to the direction of velocity. (straight line motion) **Example:** When ball is thrown up under gravity	In this case, net force or net acceleration has two components. One component is parallel or anti-parallel to velocity and another one is perpendicular to velocity **Example :** Projectile motion

Types of acceleration :

(1) Instantaneous acceleration :

It is defined as the acceleration of a body at some particular instant.

Instantaneous acceleration

$$= \lim_{\Delta t\to0}\frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

(2) Average acceleration :

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

(3) Uniform acceleration :

A body is said to have uniform acceleration if magnitude and direction of the acceleration remains constant during particle motion.

☞ **Note :**

If a particle is moving with uniform acceleration, this does not necessarily imply that particle is moving in straight line.

Example : Parabolic motion

(4) Non-uniform acceleration :

A body is said to have non-uniform acceleration, if magnitude or direction or both change during motion.

☞ **Note :**

(i) Acceleration is a vector with dimensions $[LT^{-2}]$ and SI units (m/s^2)

(ii) If acceleration is zero, velocity will be constant and motion will be uniform.

(iii) However if acceleration is constant then acceleration is uniform but motion is non-uniform and if acceleration is not constant then both motion and acceleration are non-uniform.

(iv) If a force $\vec{F}$ acts on a particle of mass m then by Newton's II law $\vec{a} = \vec{F}/m$

(v) As by definition

$$\vec{v} = \frac{d\vec{s}}{dt} \quad \text{so,} \quad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt}\left(\frac{d\vec{s}}{dt}\right) = \frac{d^2\vec{s}}{dt^2}$$

i.e. if $\vec{s}$ is given as a function of time, second time derivative of displacement gives acceleration.

(vi) If velocity is given as function of position then by chain rule

$$a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt}$$

$$\Rightarrow \quad a = v\frac{dv}{dx} \qquad \left[\text{as}\frac{dx}{dt} = v\right]$$

(vii) As acceleration $\vec{a} = \frac{d\vec{v}}{dt}$ the slope of velocity -time graph gives acceleration i.e.

$$\vec{a} = \frac{d\vec{v}}{dt} = \tan\theta$$

(viii) The slope of $\vec{a}$ -t curve, i.e. $\frac{d\vec{a}}{dt}$ is a measure of rate of non-uniformity of acceleration. However we do not define this physical quantity as it is not involved in basic laws or equation of motion.

(ix) Acceleration can be positive or negative. Positive acceleration means velocity is increasing with time while negative acceleration called retardation means velocity is decreasing with time.

Example-16

The displacement x of a particle along a straight line at time t is given by $x = a_0 - a_1t + a_2t^2$. The acceleration of the particle is-

(1) a_0 **(2) a_1** **(3) $2a_2$** **(4) a_2**

Solution : (3)

$x = a_0 - a_1t + a_2t^2$

$$\Rightarrow \frac{dx}{dt} = -a_1 + 2a_2t \quad \Rightarrow \frac{d^2x}{dt^2} = 2a_2$$

Hence correct answer is (3).

Example-17

If the displacement of a particle is proportional to the square of time, then-

(1) velocity is inversely proportional to t

(2) velocity is proportional to t

(3) velocity is proportional to $\sqrt{t}$

(4) acceleration is constant

Solution : (2) & (4)

Given that $s \propto t^2 \Rightarrow s = kt^2$, where k is constant

$\therefore$ velocity $v = \frac{ds}{dt} = 2kt$, velocity varies with time

acceleration $a = \frac{dv}{dt} = 2k =$ constant.

Hence acceleration of particle is constant

Hence correct answer are (2) & (4).

Example-18

The displacement is given by $x = 2t^2 + t + 5$, the acceleration at t = 5 sec will be-

(1) 8 m/s^2 **(2) 12 m/s^2**

(3) 15 m/s^2 **(4) 4 m/s^2**

Solution : (4)

Given, $x = 2t^2 + t + 5 \Rightarrow \frac{dx}{dt} = 4t + 1$

$$\Rightarrow \frac{d^2x}{dt^2} = 4 \Rightarrow \left(\frac{d^2x}{dt^2}\right)_{t=5sec} = 4 \text{ m/s}^2$$

Hence correct answer is (4).

Example-19

A particle moves along the x-axis in such a way that its x-co-ordinate varies with time as $x = 2 - 5t + 6t^2$. The initial velocity and acceleration of particle will respectively be-

(1) –5 m/s, 12 m/s **(2) 5 m/s, –12 m/s**

(3) –5 m/s, –12 m/s **(4) 5 m/s, 12 m/s**

Solution : (1)

$x = 2 - 5t + 6t^2 \Rightarrow v = \frac{dx}{dt} = -5 + 12t$, initially t = 0

$\Rightarrow \therefore v = -5$ m/s,

$$a = \frac{d^2x}{dt^2} = 12 \text{ m/s}^2$$

Hence correct answer is (1).

Example-20

The position x of a particle varies with time (t) as $x = at^2 - bt^3$. The acceleration of the particle will be equal to zero at time -

(1) $\frac{2a}{3b}$ **(2) $\frac{a}{b}$** **(3) $\frac{a}{3b}$** **(4) 0**

Solution : (3)

Given that $x = at^2 - bt^3$

$\therefore$ Velocity $v = \frac{dx}{dt} = 2at - 3bt^2$ and

$$\text{acceleration } a = \frac{d}{dt}\left(\frac{dx}{dt}\right)$$

$$\Rightarrow 0 = 2a - 6bt \Rightarrow t = \frac{2a}{6b} = \frac{a}{3b}$$

Hence correct answer is (3).

Example-21

In the above example, the average acceleration of the particle in the interval t = 1 to t = 3 sec will be-

(1) 12 a – 2b **(2) 2b – 12 a**
(3) 2a – 12b **(4) 12b – 2a**

Solution : (3)

In the light of above example, we have $\frac{dx}{dt} = 2at - 3bt^2$

Now velocity at t = 1 sec,

$v_1 = \left(\frac{dx}{dt}\right)_{t=1} = 2a - 3b$ and

that at t = 3 sec, $v_2 = \left(\frac{dx}{dt}\right)_{t=3} = 6a - 27b$

Thus average acceleration $a_{av} = \frac{v_2 - v_1}{t_2 - t_1}$

$= \frac{6a - 27b - 2a + 3b}{3-1} = \frac{4a - 24b}{2} = 2a - 12b$

Hence correct answer is (3).

Example-22

The velocity v of a moving particle varies with displacement as $x = \sqrt{v+1}$, the acceleration of the particle at x = 5 unit will be-

(1) $\sqrt{6}$ unit **(2) 24 unit**
(3) 240 unit **(4) 25 unit**

Solution : (3)

$x = \sqrt{v+1} \Rightarrow x^2 = v + 1 \Rightarrow v = x^2 - 1$

$\Rightarrow \frac{dv}{dx} = 2x$. Now acceleration

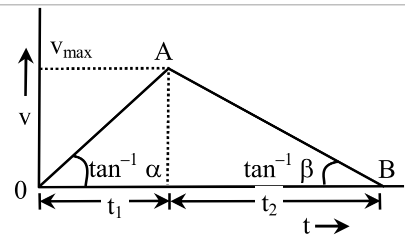
$a = v\frac{dv}{dx}\ (x^2 - 1).\ 2x$

This is the acceleration at position x. Now at x = 5 unit, $a = (5^2 - 1)(2 \times 5) = 240$ unit

Hence correct answer is (3).

Example-23

A car accelerates from rest at a constant rate α for sometime after which it decelerates at constant rate β to come to rest. If the total time elapsed is t sec. The maximum velocity of car will be-



(1) $\frac{\alpha\beta}{t(\alpha+\beta)}$ **(2)** $\frac{\alpha+\beta}{\alpha\beta}t$

(3) $\frac{\alpha\beta}{\alpha+\beta}t$ **(4)** $\frac{\alpha\beta}{(\alpha+\beta)}$

Solution : (3)

If the car accelerates for time t_1 and decelerates for time t_2, then according to given problems

$t = t_1 + t_2$ …. (1)

If v_{max} is the maximum velocity of the car, then from v/t curve, we have

$\alpha = \frac{v_{max}}{t_1}$, $\beta = \frac{v_{max}}{t_2}$

[as slope of v/t curve gives acceleration.]

so $\left(\frac{1}{\alpha} + \frac{1}{\beta}\right) = \frac{t_1 + t_2}{v_{max}} \Rightarrow v_{max} = \frac{\alpha\beta}{(\alpha+\beta)}t$

$[\because t = t_1 + t_2]$

Hence correct answer is (3).

Special Note :

In the above example the total distance travelled by car, s = 1/2 (area Δ OAB)

$s = (1/2)(v_{max})\,t = (1/2)\frac{\alpha\beta}{\alpha+\beta}t$ [as area of v/t graph gives total distance covered]

Example-24

If displacements of a particle varies with time t as $s = 1/t^2$, then.

(1) The particle is moving with constant velocity

(2) The particle is moving with variable acceleration of decreasing order

(3) The particle is moving with constant retardation

(4) The particle has constant speed but variable velocity

Solution : (2)

$s = t^{-2}$, Velocity $v = \frac{ds}{dt} = -2/t^3$,

acceleration $a = \frac{d^2s}{dt^2} = 6/t^4$

Hence correct answer is (2).

Example-25

The retardation of a moving particle, if the relation between time and position is $t = Ax^2 + Bx$ (where A and B are constant) will be-

(1) $2A\,(Ax + B)^{-3}$ **(2) $2A\,(2Ax + B)^{-3}$**

(3) $A/2\,(Ax + B)^{-3}$ **(4) $A/2\,[2Ax + B]^{-3}$**

Solution : (3)

As $t = Ax^2 + Bx \Rightarrow dt/dx = 2Ax + B$

$\Rightarrow v = (2Ax + B)^{-1}$ … (1)

[as dx/dt = v], Now by chain rule

$a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt} = v\frac{dv}{dx}$

$\Rightarrow a = (2Ax + B)^{-1}\ \frac{d}{dx}\ (2Ax + B)^{-1}$

$= -2\,A\,(2Ax + B)^{-3}$

So retardation $= -a = 2A\,(2Ax + B)^{-3}$

Hence correct answer is (3).

Example-26

It is possible to be accelerating if you are travelling at constant speed ? Is it possible to round a curve, with zero acceleration ? With constant acceleration ? With variable acceleration ?

(1) No, yes, no, no **(2) Yes, no, yes, yes**

(3) Yes, no, no, no **(4) No, no, yes, yes**

Solution : (2)

If speed is constant, velocity may change due to change in direction and as acceleration is rate of change of velocity so acceleration may not be zero when speed is constant. Actually in uniform circular motion, speed = constant but acceleration $\neq 0$.

For motion on a curve we at least have to change the direction of motion, so we will require a force and hence, acceleration i.e. it is not possible to round a curve with zero acceleration. However, in rounding a curve acceleration may be constant or variable. In case of projectile motion acceleration is constant ($=\vec{g}$) while in case of circular motion acceleration $\neq$ constant, either due to change in direction or both change in direction and magnitude.

Hence correct answer is (2).

Example-27

What does $\frac{d|\vec{v}|}{dt}$ and $\left|\frac{d\vec{v}}{dt}\right|$ represent

Solution :

$\frac{d|\vec{v}|}{dt}$ represents time rate of change of speed as $|\vec{v}| = v$,

while $\left|\frac{d\vec{v}}{dt}\right|$ represents magnitude of acceleration.

9. MOTION WITH UNIFORM ACCELERATION

Let $\vec{u}$ = Initial velocity (at t = 0), $\vec{v}$ = Velocity of the particle after time t

$\vec{a}$ = Acceleration (uniform), $\vec{s}$ = Displacement of the particle during time 't'

(1) Acceleration, $\vec{a} = \frac{\vec{v} - \vec{u}}{t}$ [Because of uniform acceleration, this acceleration is instantaneous as well average acceleration]. From above equation

$$\vec{v} = \vec{u} + \vec{a}t \quad ....(i)$$

(2) Displacement $\vec{s}$ = Average velocity × time,

$$\vec{s} = \frac{\vec{u} + \vec{v}}{2}t \quad ....(ii)$$

[This is very useful equation, when acceleration is not given]

(3) From (i) and (ii) $\vec{s} = \vec{u}\,t + (1/2)\vec{a}\,t^2$ ...(iii)

Again from (i) and (iii)

$$\vec{s} = \vec{v}t - (1/2)\vec{a}t^2$$

[Here negative sign does not indicate that retardation is occurring]

(4) From (i) and (ii) $\vec{v}^{\,2} = \vec{u}^{\,2} + 2\vec{a}.\vec{s}$ ....(iv)

$\vec{s}_n$ = displacement of particle in n^{th} second

$= \vec{s}_n - \vec{s}_{n-1}$

$= \{\vec{u}\,(n) + (1/2)\vec{a}\,n^2\} - \{\vec{u}\,(n-1) + (1/2)\vec{a}\,(n-1)^2\}$

$\vec{s}_n = \vec{u} + 1/2\ \vec{a}\,(2n - 1)$

[This equation is dimensionally non balanced because we have substituted value of t = 1s and second is neglected that's why it seems to be unbalanced]

Equations (i), (iii) and (iv) one called 'equations of motion' and are very useful in solving the problems of motion along a straight line with constant acceleration.

☞ **Note :**

(i) These equations can be applied only and only when acceleration is constant. In case of circular motion or simple harmonic motion as acceleration is not constant (due to change in direction or magnitude) so these equation can not be applied.

(ii) $\vec{v} = \vec{u} + \vec{a}t$

and $\vec{s} = \vec{u}t + (1/2)\,\vec{a}\,t^2$

are vector equation, while

$$\vec{v}.\vec{v} = \vec{u}.\vec{u} + 2\vec{a}.\vec{s}$$

$$\Rightarrow \quad v^2 = u^2 + 2\vec{a}.\vec{s}$$

is a scalar equation

(iii) If the velocity and acceleration are collinear, we conventionally take the direction of motion to be positive, so equation of motions becomes

$v = u + at$, $s = ut + (1/2)\,at^2$, $v^2 = u^2 + 2as$

If the velocity and acceleration are anti-parallel then,

$$v = u - at$$

$$s = ut - (1/2)\,at^2$$

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

Example-28

A particle starts with an initial velocity 2.5 m/s along the positive x-direction and it accelerates uniformly at the rate 0.50 m/s². Time taken to reach the velocity 7.5 m/s will be-

(1) 5 s **(2) 2 s** **(3) 10 s** **(4) 15 s**

Solution : (3)

We have $v = u + at$ or $7.5 = 2.5 + 0.50\,t$

$\Rightarrow t = 10$ s

Hence correct answer is (3)

Example-29

A car accelerates from rest at a constant rate α for sometime after which it decelerates at constant rate β to come to rest. If the total time elapsed is t sec. The maximum velocity will be-

(1) $\dfrac{\alpha\beta}{(\alpha+\beta)t}$ **(2)** $\dfrac{\alpha^2\beta}{(\alpha+\beta)}\,t$

(3) $\dfrac{\alpha\beta}{(\alpha+\beta)}\,t$ **(4)** $\dfrac{\alpha\beta^2 t}{(\alpha+\beta)}$

Solution : (3)

From "v = u + at" we have, for the car,

$$v = 0 + \alpha\, t_1 \text{ and } 0 = v - \beta t_2$$

[**Note :** velocity 'v' after time t_1 will be initial velocity for next motion with retardation β]

from these two equations, we get $v = \dfrac{\alpha\beta t}{(\alpha+\beta)}$

Hence correct answer is (3)

Example-30

A particle starts with an initial velocity 2.5 m/s along the positive x-direction and it accelerates uniformly at the rate 0.50 m/s². The distance travelled by the particle in first two seconds will be-

(1) 4 m **(2) 5m** **(3) 1m** **(4) 6 m**

Solution : (4)

We have, $s = ut + (1/2)\,at^2$

$$= (2.5)\,(2) + (1/2)\,(0.50)\,(2)^2 = 6\text{m}$$

Since the particle does not return back, it is also the distance travelled.

Hence correct answer is (4)

Example-31

A car accelerates from rest at a constant rate α for sometime after which it decelerates at constant rate β to come to rest. If the total time elapsed is t sec. What will be the total distance traveled ?

(1) $\dfrac{\alpha\beta t^2}{\alpha+\beta}$ **(2)** $\dfrac{\alpha+\beta}{\alpha\beta}t^2$

(3) (1/2) $\dfrac{\alpha\beta}{(\alpha+\beta)}t^2$ **(4)** $\dfrac{\alpha\beta t^2}{\alpha+\beta}2t^2$

Solution : (3)

From " $s = ut + (1/2)\,at^2$ ",

we have $s_1 = (1/2)\,\alpha t_1^2$, $s_2 = vt_2 - (1/2)\,\beta t_2^2$

Total distance $= s_1 + s_2 = (1/2)\,\dfrac{\alpha\beta t^2}{\alpha+\beta}$

[Putting value of s_1 and s_2 and $v = \dfrac{\alpha\beta t}{\alpha+\beta}$]

Hence correct answer is (3).

Example-32

A passenger is standing 'd' m away from a bus. The bus begins to move with constant acceleration a. To catch the bus, the passenger runs at a constant speed v towards the bus. The minimum speed of the passenger so that he may catch the bus will be-

(1) 2ad **(2)** $\sqrt{ad}$ **(3)** $\sqrt{2ad}$ **(4) ad**

Solution : (3)

Let the passenger catch the bus after time t. From "$s = ut + (1/2)\ at^2$", the distance travelled by the bus

$$s_1 = 0 + (1/2)\ at^2 \quad \ldots (1)$$

and the distance travelled by the passenger

$$s_2 = ut + 0 \quad \ldots (2)$$

[**Note :** acceleration of passenger = 0]

Now the passenger will catch the bus if,

$$d + s_1 = s_2 \quad \ldots (3)$$

In the light of eq. (1) & (2), eq. (3) gives

$$(1/2)\ at^2 - ut + d = 0 \Rightarrow t = \frac{u \pm \sqrt{u^2 - 2ad}}{a}$$

So the passenger will catch the bus if t is real i.e. $u^2 \geq 2ad \Rightarrow u \geq \sqrt{2ad}$

So, the minimum speed of passenger for catching the bus is $\sqrt{2ad}$

Hence correct answer is (3)

Example-33

A body moving with uniform acceleration describes 4 m in 3rd second and 12 m in the 5th second. The distance described in next three second is-

(1) 100 m (2) 80 m (3) 60 m (4) 20 m

Solution : (3)

Let u is the initial velocity and a is the acceleration then

$S_n = u + (1/2)\ a(2n - 1)$

$\therefore \quad S_3 = u + (1/2)\ a(3 \times 2 - 1)$

$$\Rightarrow 4 = u + \frac{5}{2}\ a \quad \ldots(i)$$

similarly for 5th second

$S_5 = u + (1/2)\ a\ (2 \times 5 - 1)$

$$\Rightarrow 12 = u + (9/2)\ a \quad \ldots(ii)$$

From (i) & (ii) $u = -6$ m/s and $a = 4$ m/s^2,

so, distance travelled in 5 sec,

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

$s = -6 \times 5 + (1/2) \times 4 \times 5^2 = 20$ m

Similarly distance travelled in 8 sec

$= -6 \times 8 + (1/2)\ 4 \times 8^2 = 80$ m

So distance travelled in next 3 sec

$= 80 - 20 = 60$ m

Hence correct answer is (3)

Example-34

A particle starts with an initial velocity 2.5 m/s along the positive x-direction and it accelerates uniformly at the rate 0.50 m/s^2. The distance covered in reaching the velocity 7.5 m/s will be-

(1) 25 m (2) 50 m

(3) 75 m (4) 100 m

Solution : (2)

We have, $v^2 = u^2 + 2a\ x$

or $(7.5)^2 = (2.5)^2 + 2(0.50)\ x \Rightarrow x = 50$ m

Hence correct answer is (2)

Example-35

A particle starts moving from position of rest under a constant acceleration. If it travels a distance x in t sec. The distance it will travel in next t sec will be-

(1) 2x (2) 3x (3) 4x (4) 5x

Solution : (2)

The velocity of particle after time t will be

$v = u + at = 0 + at = at$

Now for next t sec, it will be the initial velocity,

From " $s = u't + (1/2)\ at^2$", we have

$\Rightarrow x' = (at)\ t + (1/2)\ at^2$ [Here $u' = at$]

$$x' = 3/2\ at^2 \quad \ldots(1)$$

This is the distance travelled in next t sec

Also given that particle travels x distance in t sec. so again using "$s = ut + (1/2)\ at^2$"

We have, $$x = \frac{1}{2}\ at^2 \quad \ldots(2)$$

From (1) & (2), we have, $x' = 3x$

Hence correct answer is (2)

Example-36

A truck and a car are brought to a hault by application of same breaking force. Which one will come to stop in shorter distance if they are moving with same (1) velocity (2) K.E. (3) momentum

(1) Both car, truck

(2) Truck, car, car

(3) Car, both, truck

(4) Car, truck, truck

Solution : (3)

By breaking force the body is brought to rest so, $v = 0$ and $a = (-F/m)$ (as it is retardation)

If s is the distance travelled in stopping (called stopping distance), from $v^2 = u^2 + 2as$

we have, $0 = u^2 - 2(F/m)s$

$\Rightarrow s = \frac{mu^2}{2F}$,

But $KE = (1/2)\, mu^2$ and also

$KE = \frac{p^2}{2m}$ ($\because$ $p = mu$)

So $s = \frac{mu^2}{2F} = \frac{KE}{F} = \frac{p^2}{2mF}$.

From this it is clear that,

(1) If u is same, $s \propto \frac{mu^2}{2F} \Rightarrow s \propto m$

Now as mass of car is lesser than that of truck, so car will stop in shorter distance.

(2) If K.E. is same, $s \propto \frac{KE}{F}$

So both will stop after travelling same distance.

(3) If p is same, $s \propto \frac{p^2}{2mF} \Rightarrow s \propto \frac{1}{m}$

Now as mass of truck is more than that of car so truck will stop in a shorter distance.

Hence correct answer is (3)

☞ **Note :**

As $s = \frac{mu^2}{2F}$, so for a given body if breaking force remains unchanged. $s \propto u^2$

[as m is constant]

i.e. if the speed of a moving body is made n times the stopping distance will become n^2 times.

10. MOTION UNDER GRAVITY

Ideal Motion :

The most important example of motion in a straight line with constant acceleration is motion under gravity. In case of motion under gravity unless stated it is taken for granted that.

(i) The acceleration is constant, i.e.

$$\vec{a} = \vec{g} = 9.8 \text{ m/s}^2$$

and directed vertically downwards.

(ii) The motion is in vacuum i.e. viscous force or thrust of the medium has no effect on the motion.

Now in the light of above assumptions, there are two possibilities.

10.1 Body Falling Freely Under Gravity :

Taking initial position as origin and direction of motion (i.e. downward direction) as positive, here we have $u = 0$ (as body starts from rest)

$$a = +g$$

(as acceleration is in the direction of motion)

So, if the body acquires velocity v after falling a distance h in time t, equations of motion viz

$$v = u + at$$

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

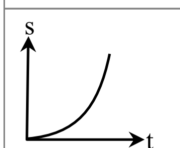
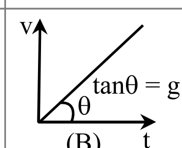
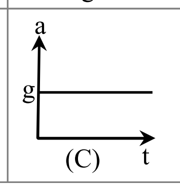
and $v^2 = u^2 + 2as$

reduces to $v = gt$ ....(1)

$$s = \left(\frac{1}{2}\right) gt^2 \quad ....(2)$$

$$v^2 = 2\, gh \quad ....(3)$$

These equations can be used to solve most of the problems of freely falling as

t is given	h is given	v is given
From eq. (1) & (2)	From eq. (2) & (3)	From eq. (3) & (1)
$v = gt$	$t = \sqrt{\frac{2h}{g}}$	$t = \frac{v}{g}$
and $s = \frac{1}{2} gt^2$	$v = \sqrt{2gh}$	$s = \frac{v^2}{2g}$
 (A)	 (B)	 (C)

☞ **Note :**

(1) If the body is dropped from a height H, as in time t, it has fallen a distance h from its initial position, the height of the body from the ground will be $h' = H - h$, with $h = 1/2\, gt^2$.

(2) As $h = (1/2)\, gt^2$ i.e. $h \propto t^2$, distance fallen in time t, 2t, 3t etc. will be in the ratio of $1^2 : 2^2 : 3^2 :$ ——— i.e. square of integers.

(3) The distance fallen in n^{th} sec.,

$$h_n - h_{n-1} = (1/2)\, g(n)^2 - (1/2)\, g(n-1)^2$$
$$= (1/2)\, g(2n - 1)$$

So distance fallen in I^{st}, II^{nd}, III^{rd} sec will be in the ratio 1 : 3 : 5 i.e. odd integers only.

10.2 Body is projected vertically up :

Taking initial position as origin and direction of motion (i.e. vertically up) as positive, here we have v = 0 [as at the highest point, velocity = 0], a = – g [as acceleration is downwards while motion upwards].

So, if the body is projected with velocity u and reaches the highest point at a distance h above the ground in time t, the equations of motion viz

$$v = u + at$$

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

and $$v^2 = u^2 + 2as \text{ reduces to}$$

$$0 = u - gt$$

$$h = ut - 1/2\, gt^2$$

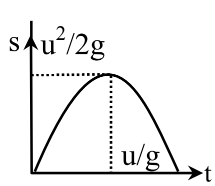
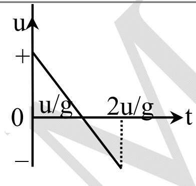
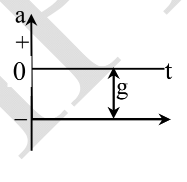
and $$0 = u^2 - 2gh$$

or $$u = gt \quad ....(1)$$

$$h = 1/2\, gt^2 \quad ....(2)$$

$(\because u = gt)$, $$u^2 = 2\, gh \quad ....(3)$$

These equations can be used to solve most of the problems of bodies projected vertically up as, if

If is given	If h is given	is u given
From eq. (1) & (2)	From eq. (2) & (3)	From eq. (3) & (1)
$u = gt$	$t = \sqrt{2h/g}$	$t = u/g$
$h = \frac{1}{2} gt^2$	$u = \sqrt{2hg}$	$h = u^2/2g$
 (A)	 (B)	 (C)

Discussion :

From cases (10.1) and (10.2) it is clear that :

(1) In case of motion under gravity for a given body, mass, acceleration and mechanical energy remains constant while speed, velocity, momentum, kinetic energy and potential energy changes.

(2) The motion is independent to the mass of the body as in any equation of motion mass is not involved. This is why a heavy and light body when released from same height reaches the ground simultaneously and with same velocity.

i.e. $t = \sqrt{2h/g}$

and $v = \sqrt{2gh}$

However, momentum, kinetic energy or potential energy depends on the mass of the body

(all $\propto$ mass)

(3) As from case (2) time taken to reach a height h,

$$t_U = \sqrt{2h/g}$$

And from case (1) time taken to fall down through a distance h,

$$t_D = \sqrt{2h/g}$$

so $$t_U = t_D = \sqrt{2h/g}$$

So in case of motion under gravity time taken to go up is equal to the time taken to fall down through the same distance.

(4) If a body projected vertically up reaches a height h then from case (2), $u = \sqrt{2gh}$ and if a body falls freely through a height h from case (1),

$$v = \sqrt{2gh}$$

So in case of motion under gravity the speed with which a body is projected up is equal to the speed with which it comes back to the point of projection

Example-37

From the top of a building a ball is dropped, while another is thrown horizontally at the same time. Which ball will strike the ground first ?

(1) The ball projected horizontally

(2) The ball projected vertically

(3) Both at the same time

(4) It depends upon mass of the balls

Solution : (3)

Both the balls will reach the ground simultaneously as horizontal velocity does not effect the vertical motion, $t_1 = t_2 = \sqrt{(2h/g)}$ [from "$h = 1/2\, gt^2$", as u = 0]

Note : However for the ball dropped vertically, $v_1 = \sqrt{(2gh)}$, while for the ball projected horizontally :

horizontal velocity $(v_H)_2 = u$ and

vertical velocity $(v_v)_2 = \sqrt{(2gh)}$,

so that $v_2 = \sqrt{(u^2 + 2gh)}$

i.e. on hitting the ground speed of horizontally projected ball will be more than the ball dropped vertically

Hence correct answer is (3)

Example-38

A body is released from a height and falls freely towards the earth. Exactly 1 sec later another body is released. What is the distance between the two bodies 2 sec after the release of the second body ? If $g = 9.8\ m/s^2$.

(1) 2.45 m **(2) 24.5 m**
(3) 4.9 m **(4) 9.8 m**

Solution :

According to given problem 2^{nd} body falls for 2 s so that

$h_2 = (1/2)\ g\ (2)^2$ … (1)

While I^{st} has fallen for 2 + 1 = 3 s,

so $h_1 = (1/2)\ (3)^2\ g$ … (2)

∴ Separation between two bodies 2 s after the release of II^{nd} body

$d = h_1 - h_2 = (1/2)\ g(3^2 - 2^2) = 4.9 \times 5 = 24.5$ m

Hence correct answer is (2)

Example-39

If a body travels half its total path in the last second of its fall from rest. The time and height of its fall, will respectively be- ($g = 9.8\ m/s^2$)

(1) 0.59 s, 57 m **(2) 3.41 s, 57 m**
(3) 5.9 s, 5.7 m **(4) 5.9 s, 34.1 m**

Solution : (2)

If the body falls a height h in time t, from 2^{nd} equation of motion we have

$h = 1/2\ gt^2$ ….(1)

[u = 0 as body starts from rest]

Now the distance fallen in (t – 1) s will be

$h = 1/2\ g(t-1)^2$ …(2)

So from eq. (1) & (2) distance fallen in the last second

$h - h' = (1/2)\ gt^2 - (1/2)\ g\ (t-1)^2$,

$h - h' = (1/2)\ g\ (2t - 1)$

But according to given problem as

$(h - h') = h/2$

i.e. $(1/2)\ h = (1/2)g\ (2t - 1)$

or $(1/2)\ gt^2 = g(2t - 1)$

[as from eq. (1) $h = (1/2)\ gt^2$]

or $t^2 - 4t + 2 = 0$

or $t = [4 \pm \sqrt{(4^2 - 4 \times 2)}\ ]/2$

or $t = 2 \pm \sqrt{2}$ or $t = 0.59$ or 3.41 s

0.59 s is physically unacceptable as it gives the total time t taken by the body to reach ground is lesser than one sec while according to the given problem time of motion must be greater than 1 s.

So t = 3.41 s &

$h = (1/2) \times (9.8) \times (3.41)^2 = 57$ m

Hence correct answer is (2)

Example-40

Statement given below is true or false ? Give reason in brief. "Two balls of different masses are thrown vertically upwards with the same speed. They reach through the point of projection in their downward motion with the same speed".

(1) True

(2) False

(3) Depend upon conditions

(4) None of these

Solution : (1)

The statement is true as motion under gravity is independent of mass of the body and as body comes back to the point of projection with same speed, so

$v_1 = u_1$ and $v_2 = u_2$, Here $u_1 = u_2 = u$ (given)

so, $v_1 = v_2 = u$

Hence correct answer is (1)

Example-41

A man standing on the edge of a cliff throws a stone straight up with initial speed u and then throws another stone straight down with the same initial speed and from the same position. Find the ratio of the speed the stones would have attained when they hit the ground at the base of the cliff.

(1) $\sqrt{2}$: 1 **(2) 1 : $\sqrt{2}$**
(3) 1 : 1 **(4) 1 : 2**

Solution : (3)

As the stone thrown vertically up will come back to the point of projection with same speed, both the stones will move downward with same initial velocity, so both will hit the ground with velocity

$v^2 = u^2 + 2gh$ i.e., $v = \sqrt{(u^2 + 2gh)}$

So, the ratio of speeds attained when they hit the ground is 1 : 1

Hence correct answer is (3)

☞ **Note :**

However the stone projected up will take (2u/g) time more to reach the ground than the stone projected downwards.

Example-42

A juggler throws balls into air. He throws one, when ever the previous one is at its highest point. How high do the balls rise if he throws n balls such each sec, accelerating due to gravity is-

(1) g/n^2 **(2) $g/2n^2$**
(3) $2n/g$ **(4) $2n^2/g$**

Solution : (2)

A juggler is throwing n balls each second and 2nd when the first is at its highest point, so time taken by one ball to reach the highest point t = (1/n) sec and as at highest point v = 0,

From 1st equation of motion

$0 = u - (g)(1/n)$, i.e. $u = (g/n)$ .....(1)

Now from 3 rd equation of motion

i.e. $v^2 = u^2 + 2as$, $0 = u^2 - 2gh$

i.e. $h = (u^2/2g)$

$$h = \frac{g}{2n^2}\left[\text{From Eq.(1)} u = \frac{g}{n}\right]$$

Hence correct answer is (2)

Example-43

A pebble is thrown vertically upwards from bridge with an initial velocity of 4.9 m/s. It strikes the water after 2s. If acceleration due to gravity is 9.8 m/s^2. The height of the bridge and velocity with which the pebble strike the water will respectively be-

(1) 4.9 m, 1.47 m/s **(2) 9.8 m, 14.7 m/s**
(3) 49 m, 1.47 m/s **(4) 1.47 m, 4.9 m/s**

Solution : (2)

Taking the point of projection as origin and downward direction as positive. By 2nd equation of motion, i.e. $s = ut + (1/2)at^2$, We have,

$h = -4.9 \times 2 + (1/2)\, 9.8 \times 2^2 = 9.8$

(u is taken to be negative as it is upwards)

From 1st equation of motion

i.e. $v = u + at$, $v = -4.9 + 9.8 \times 2 = 14.7$ m/s

Hence correct answer is (2)

Example-44

A rocket is fired vertically up from the ground with a resultant vertical acceleration of 10 m/s^2. The fuel is finished in 1 minute and it continues to move up. (1) the maximum height reached. (2) After how much time from then will the maximum height be reached (Take g = 10 m/s^2)

(1) 36 km, 1 min **(2) 6 km, 1 min**
(3) 36 km, 1 sec **(4) 36 km, 1 sec**

Solution : (1)

(1) The distance travelled by the rocket during burning interval (1 minute = 60 s) in which resultant acceleration is vertically upwards is 10 m/s^2 will be

$h_1 = 0 \times 60 + (1/2) \times 10 \times 60^2$

$= 18000$ m ....(1)

And velocity acquired by it will be

$v = 0 + 10 \times 60 = 600$ m/s ....(2)

Now after 1 minute the rocket moves vertically up with initial velocity of 600 m/s and acceleration due to gravity oppose its motion. So, it will go to a height h_2 till its velocity becomes zero that

$0 = (600)^2 - 2gh_2$ $\Rightarrow h_2 = 18000$ m

[as $g = 10\ m/s^2$] ....(3)

So from eq. (1) and (3) the maximum height reached by the rocket from the ground.

$H = h_1 + h_2 = 18 + 18 = 36$ km

(2) As after burning of fuel the initial velocity from Eq. (2) is 600 m/s and gravity opposes the motion of rocket, so from 1st equation of motion time taken by it to reach the maximum height (for which v = 0)

$0 = 600 - gt$, i.e. t = 60 s

after finishing of fuel, the rocket goes up for 60 sec i.e., 1 minute more.

Hence correct answer is (1)

Example-45

A ball is projected vertically up with an initial speed of 20 m/s on a planet where acceleration due to gravity is 10 m/s^2

(1) How long does it take to reach its highest point?

(2) How high does it rise above the point of projection?

(3) How long will it take for the ball to reach a point 10 m above the point of projection?

(1) 2 s, 20 m, 3.41 s **(2) 5 s, 20 m, 3.41 s**
(3) 2 s, 10 m, 0.59 s **(4) 2 s, 5 m, 0.59 s**

Solution : (1)

As here motion is vertically upwards a = – g and v = 0

(1) From 1st equation of motion

i.e., $v = u + at$

$\Rightarrow$ $0 = 20 - 10t$, i.e., t = 2s

(2) From 3rd equation of motion

i.e., $v^2 = u^2 + 2as$

$\Rightarrow$ $0 = (20)^2 - 2 \times 10 \times h$, i.e., h = 20 m

(3) From 2nd equation of motion,

i.e., $s = ut + (1/2)\,at^2$

$\Rightarrow\ 10 = 20t - (1/2) \times 10 \times t^2$

$t^2 - 4t + 2 = 0$, i.e. $t = 2 \pm \sqrt{2}$

i.e. t = 0.59 s or 3.41 s

i.e. there are two such times, as the ball passes twice through h = 10 m once when going up and once when coming down.

Hence correct answer is (1)

11. MOTION WITH VARIABLE ACCELERATION

There are only two equations in this type of motion.

(1) $v = \dfrac{dx}{dt}$ **(2)** $a = \dfrac{dv}{dt} = \dfrac{d^2x}{dt^2}$

Example-46

The displacement of particle is zero at t = 0 and at t = t it is x. It starts moving in the x direction with velocity, which varies as $v = k\sqrt{x}$, where k is constant. The velocity-

(1) varies with time

(2) independent to time

(3) inversely proportional to time

(4) nothing can be said

Solution : (1)

$v = k\sqrt{x} \Rightarrow \dfrac{dx}{dt} = k\sqrt{x}$

$\Rightarrow \displaystyle\int \frac{dx}{\sqrt{x}} = \int kdt \Rightarrow \frac{x^{+1/2}}{1/2} = kt + c$

Given that, at t = 0, x = 0 $\therefore$ c = 0

Now, $2x^{1/2} = kt \Rightarrow \sqrt{x} = (1/2)\,kt$,

Now, $v = k\,(1/2\ kt) = k^2t/2$

Thus velocity varies with time. Hence correct answer is (1)

Example-47

The acceleration of a particle is given as $a = 3x^2$. At t = 0, v = 0, x = 0. The velocity at t = 2 sec will be-

(1) 0.05 m/s **(2) 0.5 m/s**

(3) 5 m/s **(4) 50 m/s**

Solution : (2)

$a = 3x^2 \Rightarrow v\dfrac{dv}{dx} = 3x^2$

$\Rightarrow vdv = 3x^2\ dx$

$\Rightarrow \dfrac{v^2}{2} = 3\dfrac{x^2}{3} + c$

at t = 0, v = 0, x = 0

$\therefore$ c = 0 Now, $\dfrac{v^2}{2} = x^3$

$v^2 = 2x^3 \Rightarrow v = \sqrt{2}\ x^{3/2}$ … (1)

$\Rightarrow \dfrac{dx}{dt} = \sqrt{2}\ x^{3/2}$

Remember, when a is function of x.

use $a = v\dfrac{dv}{dx}$

when a is function of t, $a = \dfrac{dv}{dt}$, $dx = \sqrt{2}\ x^{3/2}\ dt$

$\Rightarrow \dfrac{dx}{x^{3/2}} = \sqrt{2}\ t + c'$, at t = 0, x = 0, v = 0

$\therefore$ c' = 0

Now $\dfrac{-2}{\sqrt{x}} = \sqrt{2}\ t \Rightarrow 4 = 2xt^2$

$\Rightarrow x = \dfrac{2}{t^2}$ …(2)

From (1) and (2) $v = \sqrt{2}\left(\dfrac{2}{t^2}\right)^{3/2}$,

at t = 2 sec $\Rightarrow$ v = 1/2 m/sec

Hence correct answer is (2)

Example-48

The acceleration of a particle is given by a = 3t and at t = 0, v = 0, x = 0. The velocity and displacement at t = 2 sec will be-

(1) 6 m/s, 4 m **(2) 4 m/s, 6 m**

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

Solution : (1)

$a = 3t \Rightarrow \dfrac{dv}{dt} = 3t \Rightarrow \displaystyle\int dv = \int 3tdt$

$\Rightarrow v = \dfrac{3t^2}{2} + c$

Substituting the initial conditions,

At t = 0, v = 0 and x = 0

$\therefore$ c = 0 Hence, $v = \dfrac{3t^2}{2}$,

Velocity at t = 2 sec is $\dfrac{3 \times 2^2}{2} = 6$ m/s

Also, $\frac{dx}{dt} = \frac{3t^2}{3} \Rightarrow \int dx = \frac{3}{2}\int t^2 dt$

$\Rightarrow x = \frac{3}{2}\frac{t^3}{3} + c'$

at $t = 0, x = 0 \therefore c' = 0, \therefore x = \frac{t^3}{2}$,

Now displacement at t = 2 sec is $\frac{2^3}{2} = 4$ m

Hence correct answer is (1)

☞ **Note :**

Prohibit the use of definite integral to avoid blunders as constant may change from the given initial conditions.

12. RELATIVE – VELOCITY

(i) There is nothing in absolute rest or absolute motion.

(ii) Motion is a combined property of the object under study and the observer.

Example :

(i) A book placed on the table in a room is at rest, if it is viewed from the room but it is in motion, if it is viewed from the moon (another frame of reference). The moon is moving w.r.t. the book and the book w.r.t. the moon.

(ii) A robber enters a train moving at great speed with respect to the ground, brings out his pistol and says " Don't move, stand still".

The passengers stand still. The passengers are at rest with respect to the robber but are moving with respect to the rail track.

(iii) Relative motion means, the motion of a body with respect to another. Now if $\vec{V}_A$ and $\vec{V}_B$ are velocities of two bodies relative to earth, the velocity of B relative to A will be given by

$$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$$

☞ **Note :**

(1) If two bodies are moving along the same line in same direction with velocities V_A and V_B relative to earth, the velocity of B relative to A will be given by $V_{BA} = V_B - V_A$.

If it is positive the direction of V_{BA} is that of B and if negative the direction of V_{BA} is opposite to that of B.

(2) However, if the bodies are moving towards or away from each other, as direction of V_A and V_B are opposite, velocity of B relative to A will have magnitude

$V_{BA} = V_B - (-V_A)$

$= V_B + V_A$ and directed towards A or away from A respectively.

(3) In dealing the motion of two bodies relative to each other $\vec{V}_{rel.}$ is the difference of velocities of two bodies, if they are moving in same direction and is the sum of two velocities if they are moving in opposite direction.

(4) If a man can swim relative to water with velocity $\vec{V}$ and water is flowing relative to ground with velocity $\vec{V}_R$, velocity of man relative to ground $\vec{V}_m$ will be

$\vec{V} = \vec{V}_m - \vec{V}_R$ i.e. $\vec{V}_m = \vec{V} + \vec{V}_R$

So if the swimming is in the direction of flow of water $V_m = V + V_R$

And if the swimming is opposite to the flow of water $V_m = V - V_R$

(5) If a boy is running with velocity $\vec{V}_{rel.}$ on a train moving with velocity $\vec{V}$ relative to the ground. The velocity of boy relative to ground, $\vec{v}$ will be given by $\vec{V}_{rel.} = \vec{v} - \vec{V}$

$\Rightarrow \qquad \vec{v} = \vec{V}_{rel.} + \vec{V}$

So, if the boy is running on the train in the direction of motion of train $v = V_{rel.} + V$

And if the boy is running on the train in a direction opposite to the motion of train

$v = V_{rel.} - V$

✍ **Special Note :**

In case of motion of a body A on a moving body B, the velocity of A relative to ground is the sum of two velocities if A is moving on B in the same direction and is equal to difference of two velocities if they are moving in opposite direction.

Example-49

Two trains along the same straight rails moving with constant speed 60 km/hr and 30km/h respectively towards each other. If at time t = 0, the distance between them is 90 km, the time when they collide is-

(1) 1hr (2) 2 hr (3) 3 hr (4) 4 hr

Solution : (1)

The relative velocity

$$v_{rel.} = 60 - (-30) = 90 \text{ km/hr}$$

Distance between the train

$$S_{rel.} = 90 \text{ km}$$

∴ Time when they collide

$$= \frac{S_{rel.}}{v_{rel.}} = \frac{90}{90} = 1 \text{ hr}$$

Hence correct answer is (1)

Example-50

Two cars are moving in the same direction with the same speed 30 km/hr. They are separated by a distance of 5 km, the speed of a car moving in the opposite direction if it meets these two cars at an interval of 4 minutes, will be –

(1) 40 km/hr (2) 45 km/hr

(3) 30 km/hr (4) 0 km/hr

Solution : (2)

As the two cars (say A and B) are moving with same velocity, the relative velocity of one (say B) with respect to the other A,

$$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$$

$$= v - v = 0$$

So the relative separation between them (= 5 km) always remains the same.

Now if the velocity of car (say C) moving in opposite direction to A and B, is $\vec{v}_C$ relative to ground then the velocity of car C relative to A and B will be $\vec{v}_{rel.} = \vec{v}_C - \vec{v}$

But as $\vec{v}$ is opposite to v_C ,

$$v_{rel} = v_C - (-30)$$

$$= (v_C + 30) \text{ km/hr}$$

So, the time taken by it to cross the cars A and B is

$$t = \frac{d}{v_{rel.}}$$

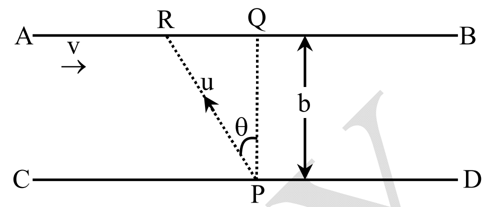
$$\Rightarrow \quad \frac{4}{60} = \frac{5}{v_C + 30}$$

$$\Rightarrow \quad v_C = 45 \text{ km/hr}$$

Hence correct answer is (2)

Some useful hints for solving problems regarding the motion of object across a river :

AB and CD → two banks of river, v → velocity of river, b → width of river



A swimmer wants to cross the river starting from a point P to reach a point directly opposite to P on the bank CD in a given time t, then

(1) $t = \frac{b}{u\cos\theta} \Rightarrow t = \frac{b}{\sqrt{u^2 - v^2}}$

(2) Resultant velocity of swimmer

$$V = \sqrt{u^2 - v^2}$$

(3) The distance travelled by swimmer

$$s = b$$

(4) For crossing the river in **minimum time**

$\theta = 0$, so $\quad t_{min} = \frac{b}{u}$

(5) distance covered in the direction of flow

$$= v = b$$

$$s = \left(\frac{b}{u}\right)v = b\left(\frac{v}{u}\right)$$

Example-51

A stream boat goes across a lake and comes back (1) On a quite day when the water is still and (2) On a rough day when there is uniform current so as to help the journey onward and to impede the journey back. If the speed of the launch on both days was same, in which case it will complete the journey in lesser time-

(1) case (1)

(2) case (2)

(3) same in both

(4) Nothing can be predicted

Solution : (2)

If the breadth of the lake is L and velocity of boat is V. Time in going and coming back on a quite day

$$t_Q = \frac{L}{V} + \frac{L}{V} = \frac{2L}{V} \quad ....(1)$$

Now if v is the velocity of air-current then time taken in going across the lake,

$$t_1 = \frac{L}{V+v}$$

[as current helps the motion]

and time taken in coming back

$$t_2 = \frac{L}{V+v}$$

[as current opposes the motion]

So $t_R = t_1 + t_2 = \frac{2L}{V[1-(v/V)^2]}$ ....(2)

From eq. (1) & (2)

$$\frac{t_R}{t_Q} = \frac{1}{[1-(v/V)^2]} > 1$$

[as $1 - \frac{v^2}{V^2} < 1$] i.e. $t_R > t_Q$

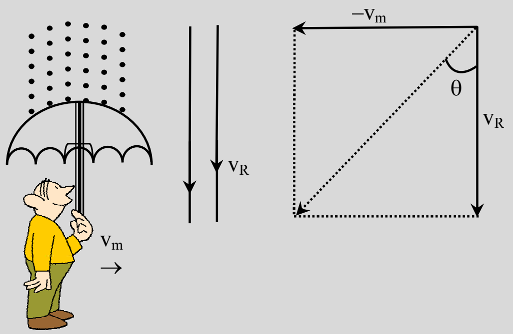
i.e. time taken to complete the journey on quite day is lesser than that on rough day

Hence correct answer is (2)

Note:

It is common-misconception that on a rough day in time decreases due to helping currents will be equal to increase in time due to opposition and so the time of journey on rough and quite day will be same.

If rain is falling vertically with a velocity $\vec{v}_R$ and an observer is moving horizontally with speed $\vec{v}_m$, the velocity of rain relative to observer :



$$\vec{v}_{RM} = \vec{v}_R - \vec{v}_m$$

which by law of vector addition has magnitude

$$v_{RM} = \sqrt{v_R^2 + v_M^2}$$

and direction $\theta = \tan^{-1}\left(\frac{v_M}{v_R}\right)$ with vertical.

Example-52

A man standing on a road holds his umbrella at 30º with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/h. He finds that rain drops are hitting his head vertically, the speed of raindrop with respect to the road will be-

(1) 10 km/h **(2) 20 km/h**

(3) 30 km/h **(4) 40 km/h**

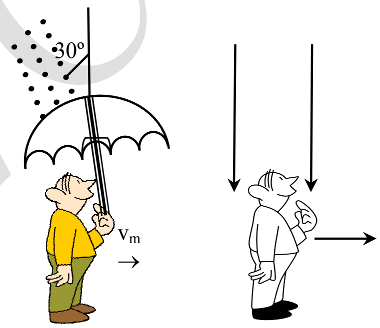
Solution : (2)

When the man is at rest w.r.t. the ground, the rain comes to him at an angle 30º with the vertical. This is the direction of the velocity of rain drops with respect to the ground.

Here $\vec{v}_{r,g}$ = velocity of rain with respect to the ground

$\vec{v}_{m,g}$ = velocity of the man with respect to the ground.

and $\vec{v}_{r,m}$ = velocity of the rain with respect to the man,



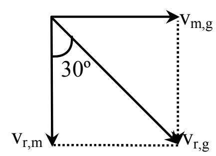
We have $\vec{v}_{r,g} = \vec{v}_{r,m} + \vec{v}_{m,g}$ ....(1)

Taking horizontal components eq. (1) gives

$v_{r,g} \sin 30^o = v_{m,g} = 10$ km/h

or $v_{r,g} = \frac{10}{\sin 30^o} = 20$ km/h

Hence correct answer is (2)



Example-53

In the above example, the speed of raindrops w.r.t. the moving man, will be-

(1) $10/\sqrt{3}$ km/h **(2) 5 km/h**

(3) $10\sqrt{3}$ km/h **(4) $5/\sqrt{3}$ km/h**

Solution : (3)

Taking vertical components eq. (1) gives

$v_{r,g} \cos 30^{o} = v_{r,m}$

or $v_{r,m} = 20 \frac{\sqrt{3}}{2} = 10\sqrt{3}$ km/hr

Hence correct answer is (3)

Special Note :

If speeds are comparable to the velocity of light c, according to theory of relativity, velocity of B relative to A (When both are moving along the same line in opposite directions) is given by

$v_{BA} = \frac{v_B + v_A}{\left[1 + \frac{v_A v_B}{c^2}\right]}$, from this it is clear that

if v_A or v_B is equal to c , $v_{BA} = \frac{v + c}{1 + v/c} = c$

i.e. speed of light is independent of relative motion between source and observer, the basic postulate of special theory of relativity

NOTE : 'Effect of Medium on Motion Under

Gravity' IS NOT IN SYLLABUS :

POINTS TO REMEMBER

1. If body starts from rest or falls freely or is dropped then, u = 0
2. If the body is thrown upwards then it will rise until its vertical velocity becomes zero. Maximum height attained is $h = u^2/2g$.
3. If air resistance is negligible then the time of the rise is equal to time of fall and each is equal to
   $t = u/g$.
4. The body returns to the starting point with the same speed with which it was thrown.
5. The straight line inclined to time axis in x-t graph represents constant velocity.
6. In x-t graph the straight line inclined to time axis at an angle greater than 90º shows negative velocity.
7. No line in x – t graph can be perpendicular to time axis because it will represent infinite velocity.
8. If the x – t graph is a curve whose slope decreases continuously with time, then the velocity of the body goes on decreasing continuously and the motion of the body is retarded.
9. If the v – t graph is a straight line parallel to time axis, then the acceleration of the body is zero.
10. If the graph is a straight line inclined to time axis with positive slope, then that body is moving with constant acceleration.
11. If v – t graph is a straight line inclined to time axis with negative slope, then the body is retarded.
12. Velocity and acceleration of a body need not be zero simultaneously.
13. A body in equilibrium has zero acceleration only. All other quantities need not be zero.
14. If a body travels with a uniform acceleration a_1 for a time interval t_1 and with uniform acceleration a_2 for a time interval t_2, then the average acceleration $a = \frac{a_1 t_1 + a_2 t_2}{t_1 + t_2}$
15. For a body moving with uniform acceleration, the average velocity (u + v)/2, where u is the initial velocity and v is the final velocity.
16. The distance travelled by the body in successive second in the ratio 1 : 3 : 5 : 7 ....etc.
17. When the body is starting from rest, the distances travelled by the body in the first second, first two seconds, first three seconds, etc. are in the ratio of 1 : 4 : 9 : 16 : 25........etc.
18. When a body is dropped freely from the top of the tower and another body is projected horizontally from the same point, both will reach the ground at the same time.

19. If the v – t graph is a curve whose slope decreases with time then the acceleration goes on decreasing.

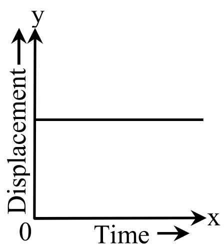
20. If the v-t graph is a curve whose slope increases with time then the acceleration of the body goes on increasing.

21. The v-t graph normal to time axis is not a practical possibility because it means that the acceleration of the body is infinite.

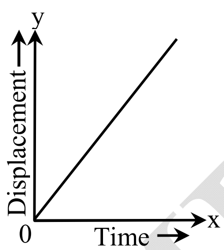
Various Graphs Related to Motion :

A. Displacement-Time Graph :

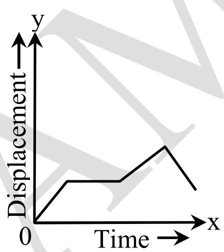
(1) For a stationary body



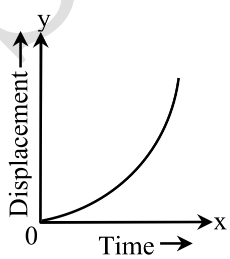
(2) For a body moving with constant velocity



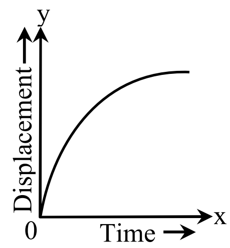
(3) For a body moving with non-uniform velocity



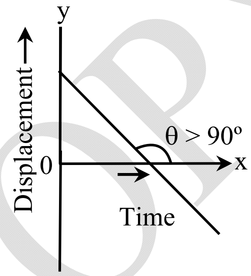
(4) For a body with accelerated motion



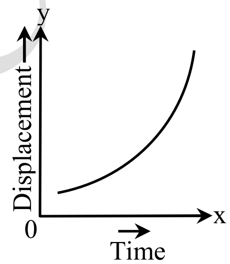
(5) For a body with decelerated motion



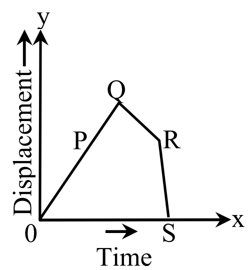
(6) For a body which returns towards the point of reference



(7) For a body whose velocity constantly changes

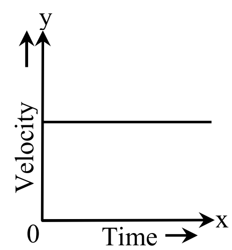


(8) For a body whose velocity changes after certain interval of time

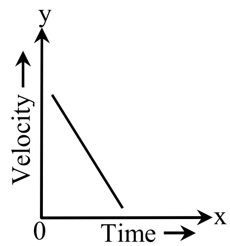


B. Velocity-Time Graph:

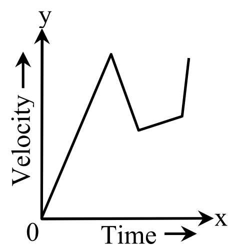
(1) For the body having constant velocity or zero acceleration



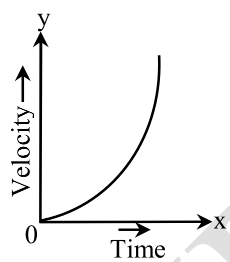
(2) When the body is moving with constant retardation and its initial velocity is not zero



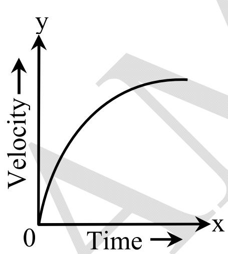
(3) When body moves with non-uniform acceleration and its initial velocity is zero.



(4) When the body is accelerated and its initial velocity is zero

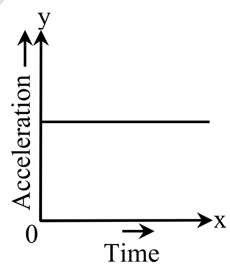


(5) When the body is decelerated.

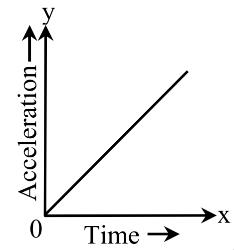


C. Acceleration-Time Graph :

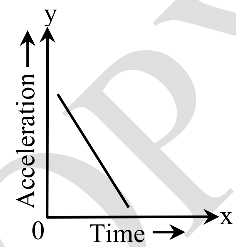
(1) When acceleration is constant



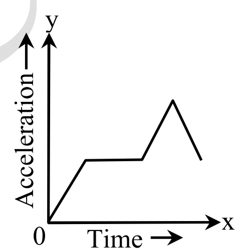
(2) When acceleration is increasing and is positive



(3) When acceleration is decreasing and is negative



(d) When initial acceleration is zero and rate of change of acceleration is non-uniform



EXERCISE # 1

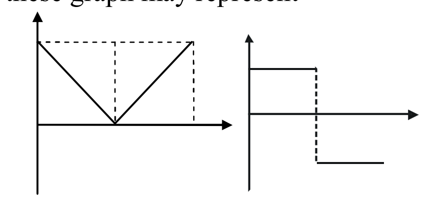
Based On | **Distance and Displacement**

1. A Body moves 6 *m* north. 8 *m* east and 10*m* vertically upwards, what is its resultant displacement from initial position

(1) $10\sqrt{2}$m (2) 10 m

(3) $\frac{10}{\sqrt{2}}$m (4) 10 × 2m

2. In the given figures, two graphs are shown. In each of them, time is represented on the abscissa but the quantity represented by the ordinate is not known. For rectilinear motion, these graph may represent



(A) position-time and velocity-time graphs respectively.

(B) velocity-time and acceleration-time graphs respectively.

(C) speed-time and acceleration-time graphs respectively.

(D) acceleration-time and velocity-time graphs respectively.

3. Mark the wrong statement -

(1) Nothing is in the state of absolute rest or state of absolute motion

(2) Magnitude of displacement is always equal to the distance travelled

(3) Magnitude of displacement can never be greater than the distance travelled

(4) Magnitude of displacement may be equal to the distance travelled

4. A car moving at a speed v is stopped in a certain distance when the brakes produce a deceleration a. If the speed of the car was no, what must be the deceleration of the car to stop it in the same distance and in the same time?

(1) $\sqrt{n}$ a (2) na (3) n^2a (4) n^3a

5. A car is moving at a certain speed. The minimum distance over which it can be stopped is x. If the speed of the car is doubled, what will be the minimum distance over which the car can be stopped during the same time?

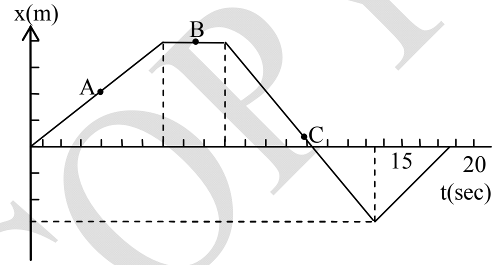
(1) 4x (2) 2x (3) x/2 (4) x/4

6. A body covered a distance of L m along a curved path of a quarter circle. The ratio of distance to displacement is-

(1) $\pi/2\sqrt{2}$ (2) $2\sqrt{2}/\pi$

(3) $\pi/\sqrt{2}$ (4) $\sqrt{2}/\pi$

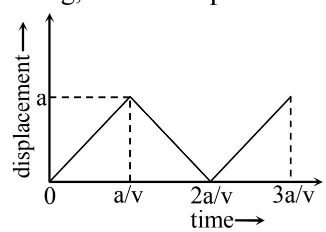
7. A person walks along an east-west street, and a graph of his displacement from home is shown in figure. His average velocity for the whole time interval is –

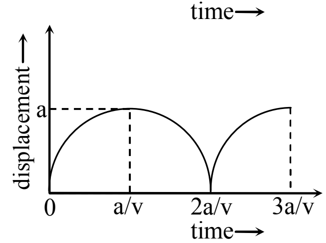


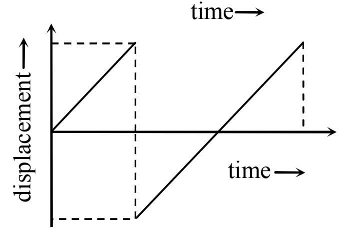
(1) 0 (2) 23 m/s

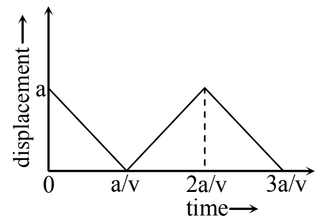
(3) 8.4 m/s (4) None of the above

8. A particle is confined to move along the x-axis between reflecting walls at x = 0 and x = a. Between these two limits it moves freely at constant velocity v. If the walls are perfectly reflecting, then its displacement time graph is -

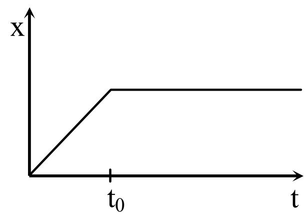
(1)


(2)


(3)


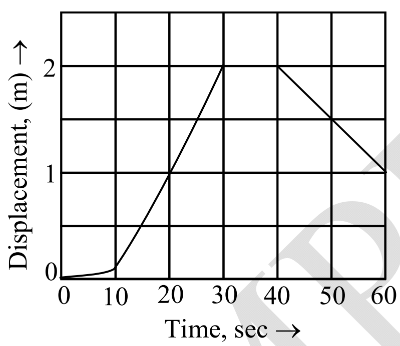
(4)


9. Figure shows the displacement time graph of a particle moving on the x-axis -



(1) the particle is continuously going in positive x direction
(2) the particle is at rest
(3) the velocity increases up to a time t_0,and then becomes constant
(4) the particle moves at a constant velocity up to a time t_0, and then stops

10. The displacement time graph for a one dimensional motion of a particle is shown in figure. Then the instantaneous velocity at t = 20 sec is –



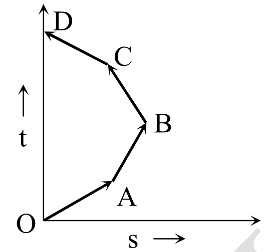
(1) 0.1 m/s (2) – 0.1 m/s
(3) – 0.05 m/s (4) 1.0 m/s

Based On **Uniform Motion**

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

(1) 5 km/h (2) $\frac{25}{4}$ km/h
(3) $\frac{30}{4}$ km/h (4) $\frac{45}{8}$ km/h

12. Which of the following options is correct for the object having a straight line motion represented by the following graph



(1) The object moves with constantly increasing velocity from O to A and then it moves with constant velocity.
(2) Velocity of the object increases uniformly
(3) Average velocity is zero
(4) The graph shown is impossible

13. Two boys are standing at the ends A and B of a ground where AB = a. The boy at B starts running in a direction perpendicular to AB with velocity v_1. The boy at A starts running simultaneously with velocity v and catches the other boy in a time t, where t is

(1) $a/\sqrt{v^2+v_1^2}$ (2) $\sqrt{a^2/(v^2-v_1^2)}$
(3) $a/(v-v_1)$ (4) $a/(v+v_1)$

14. The velocity acquired by a body moving with uniform acceleration is 20 meter/second in first 2 seconds and 40 m/sec in first 4 sec. The initial velocity will be -

(1) 0 m/sec (2) 40 m/sec
(3) 20 m/sec (4) None

15. A body moves along the sides AB, BC and CD of a square of side 10 meter with velocity of constant magnitude 3 meter/sec. Its average velocity will be-

(1) 3 m/sec (2) 0.87 m/sec
(3) 1.33 m/sec (4) None

16. A body covers half the distance with a velocity 10 m/s and remaining half with a velocity 15 m/s along a straight line. The average velocity will be-

(1) 12 m/s (2) 10 m/s
(3) 5 m/s (4) 12.5 m/s

17. A point travelling along a straight line traverse one third the distance with a velocity v_0. The remaining part of the distance was covered with velocity v_1 for half the time and with velocity v_2 for the other half of the time. The mean velocity of the point averaged over the whole time of motion will be-

(1) $\frac{v_0(v_1+v_2)}{3(v_1+v_2+v_3)}$ (2) $\frac{3v_0(v_1+v_2)}{v_1+v_2+v_3}$

(3) $\frac{v_0(v_1+v_2)}{v_1+v_2+4v_3}$ (4) $\frac{3v_0(v_1+v_2)}{v_1+v_2+4v_0}$

18. The position of a body with respect to time is given by $x = 4t^3 - 6t^2 + 20\,t + 12$. Acceleration at t = 0 will be-

(1) –12 units (2) 12 units

(3) 24 units (4) –24 units

19. A body travels 200 cm in the first two seconds and 220 cm in the next four second. The velocity at the end of the seventh second from the start will be-

(1) 10 cm/s (2) 5 cm/s

(3) 15 cm/s (4) 20 cm/s

20. An α particle travels along the inside of straight hollow tube, 2.0 metre long, of a particle accelerator. Under uniform acceleration, how long is the particle in the tube if it enters at a speed of 1000 m/s and leaves at 9000 m/s -

(1) 4×10^{-4} sec (2) 2×10^{-7} sec

(3) 40×10^{-4} sec (4) 20×10^{-7} sec

Based On | Non-uniform Motion

21. 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) $S_1 = S_2/4$

22. A body is moving from rest under constant acceleration and let S_1 be the displacement in the first (p – 1) sec and S_2 be the displacement in the first p sec. The displacement in $(p^2 - p + 1)^{th}$ sec. will be

(1) $S_1 + S_2$ (2) S_1S_2

(3) $S_1 - S_2$ (4) S_1/S_2

23. A body starts from the origin and moves along the X-axis such that the velocity at any instant is given by $(4t^3 - 2t)$, where t is in sec and velocity in m/s. What is the acceleration of the particle, when it is 2 m from the origin

(1) 28 m/s^2 (2) 22 m/s^2

(3) 12 m/s^2 (4) 10 m/s^2

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

(1) $2\alpha v^3$ (2) $2\beta v^3$

(3) $2\alpha\beta v^3$ (4) $2\beta^2 v^3$

25. A point moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3. Which of the following relations is correct

(1) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$

(2) $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$

(3) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$

(4) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

26. The initial velocity of a particle is u (at t = 0) and the acceleration n^{th} is given by at. Which of the following relation is valid

(1) $v = u + at^2$ (2) $v = u + a\frac{t^2}{2}$

(3) $v = u + at$ (4) $v = u$

27. The velocity of a body depends on time according to the equation $v = 20 + 0.1t^2$. The body is undergoing

(1) Uniform acceleration

(2) Uniform retardation

(3) Non-uniform acceleration

(4) Zero acceleration

28. The position of a particle moving in the xy-plane at any time t is given by $x = (3t^2 - 6t)$ metres, $y = (t^2 - 2t)$ metres. Select the correct statement about the moving particle from the following

(1) The acceleration of the particle is zero at t = 0 second

(2) The velocity of the particle is zero at t = 0 second

(3) The velocity of the particle is zero at t = 1 second

(4) The velocity and acceleration of the particle are never zero

29. Two trains travelling on the same track are approaching each other with equal speeds of 40 m/s. The drivers of the trains begin to decelerate simultaneously when they are just 2.0 km apart. Assuming the decelerations to be uniform and equal, the value of the deceleration to barely avoid collision should be

(1) $11.8\ m/s^2$ (2) $11.0\ m/s^2$

(3) $2.1\ m/s^2$ (4) $0.8\ m/s^2$

30. What is the relation between displacement, time and acceleration in case of a body having uniform acceleration

(1) $S = ut + \frac{1}{2}ft^2$ (2) $S = (u + f)t$

(3) $S = v^2 - 2fs$ (4) None of these

31. The position of a particle moving along the *x*-axis at certain times is given below :

t (s)	0	1	2	3
x (m)	–2	0	6	16

Which of the following describes the motion correctly

(1) Uniform, accelerated

(2) Uniform, decelerated

(3) Non-uniform, accelerated

(4) There is not enough data for generalization

32. A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 S, then

(1) $S = \frac{1}{2}ft^2$ (2) $S = \frac{1}{4}ft^2$

(3) $S = \frac{1}{72}ft^2$ (4) $S = \frac{1}{6}ft^2$

33. A truck starts from rest with an acceleration of $1.5\ m/s^2$ while a car 150 m behind starts from rest with an acceleration of $2\ m/s^2$. How long will it take before both the truck and car side by side, and how much distance is travelled by each ?

(1) 2.45 s, 500 m (truck), 650 m (car)

(2) 5 s, 450 m (truck), 600 m (car)

(3) 24.5 s, 450 m (truck), 600 m (car)

(4) 5.3 s, 500 m (truck), 650 m (car)

34. Two car travelling towards each other on a straight road at velocity 10 m/sec and 12 m/sec respectively. When they are 150 m apart, both drivers apply their brakes and each car decelerates at $2\ m/sec^2$ until it stops. How far apart will they be when they have both come to a stop?

(1) 8.9 m (2) 89 m

(3) 809 m (4) 890 m

35. The driver of a train travelling at 115 km/hour sees on the same track 100 m in front of him a slow train travelling in same direction at 25 km/hr. The least retardation that must be applied to the faster train to avoid a collision will be-

(1) $3.125\ m/s^2$ (2) $31.25\ m/s^2$

(3) $312.5\ m/s^2$ (4) $0.3125\ m/s^2$

36. A car is moving with a velocity of 20 m/sec. The driver sees a stationary truck at a distance of 100 m ahead. After some reaction time Δt he applies the brakes, produces a retardation of $4\ m/s^2$. The maximum reaction time to avoid collision will be –

(1) 5 sec (2) 2.5 sec

(3) 4 sec (4) 10 sec

37. An engine driver of a passenger train travelling at 40 m/s sees a goods train, whose last compartment is 250 m ahead on the same track. The goods train is travelling in the same direction as the passenger train, with a constant speed of 20 m/s. The passenger train driver has reaction time of 0.5 sec. He applies the brakes which causes the train to decelerate at the rate of 1 m/sec^2, while the goods train continues with its constant speed. Can the driver save a crash ?

(1) Yes, if the distance between the trains before application of brakes is more than 200 m

(2) Yes, if the distance between the trains before application of brakes is more than 250 m

(3) No, if the distance between the trains before application of brakes is more than 200 m

(4) No, if the distance between the trains before application of brakes is more than 250 m

Based On | Motion Under Gravity

38. A stone is dropped into water from a bridge 44.1 m above the water. Another stone is thrown vertically downward 1 *sec* later. Both strike the water simultaneously. What was the initial speed of the second stone

(1) 12.25 m/s (2) 14.75 m/s
(3) 16.23 m/s (4) 17.15 m/s

39. An iron ball and a wooden ball of the same radius are released from the same height in vacuum. They take the same time to reach the ground. The reason for this is

(1) Acceleration due to gravity in vacuum is same irrespective of the size and mass of the body

(2) Acceleration due to gravity in vacuum depends upon the mass of the body

(3) There is no acceleration due to gravity in vacuum

(4) In vacuum there is a resistance offered to the motion of the body and this resistance depends upon the mass of the body

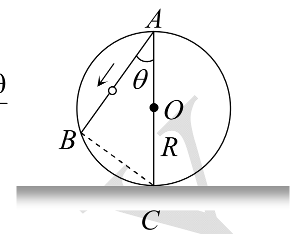
40. A frictionless wire *AB* is fixed on a sphere of radius *R*. A very small spherical ball slips on this wire. The time taken by this ball to slip from *A* to *B* is

(1) $\frac{2\sqrt{gR}}{g\cos\theta}$

(2) $2\sqrt{gR}.\frac{\cos\theta}{g}$

(3) $2\sqrt{\frac{R}{g}}$

(4) $\frac{gR}{\sqrt{g\cos\theta}}$



41. A stone is dropped from a certain height which can reach the ground in 5 second. If the stone is stopped after 3 second of its fall and then allowed to fall again, then the time taken by the stone to reach the ground for the remaining distance is

(1) 2 sec (2) 3 sec
(3) 4 sec (4) None of these

42. An aeroplane is moving with horizontal velocity u at height h. The velocity of a packet dropped from it on the earth's surface will be (g is acceleration due to gravity)

(1) $\sqrt{u^2+2gh}$ (2) $\sqrt{2gh}$
(3) 2gh (4) $\sqrt{u^2-2gh}$

43. A body dropped from a height h with an initial speed zero, strikes the ground with a velocity 3 km/h. Another body of same mass is dropped from the same height h with an initial speed $-u' = 4$km/h. Find the final velocity of second body with which it strikes the ground

(1) 3 km/h (2) 4 km/h
(3) 5 km/h (4) 12 km/h

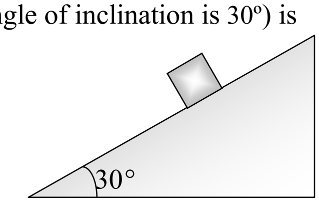
44. The time taken by a block of wood (initially at rest) to slide down a smooth inclined plane 9.8 m long (angle of inclination is 30º) is

(1) $\frac{1}{2}$sec

(2) 2 sec

(3) 4 sec

(4) 1 sec



45. A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball in T/3 seconds

(1) h/9 meters from the ground

(2) 7h/9 meters from the ground

(3) 8h/9 meters from the ground

(4) 17h/18 meters from the ground

46. When a ball is thrown up vertically with velocity V_0, it reaches a maximum height of *'h'*. If one wishes to triple the maximum height then the ball should be thrown with velocity

(1) $\sqrt{3}V_0$ (2) $3V_0$

(3) $9V_0$ (4) $3/2V_0$

47. A ball is thrown from the ground with a velocity of 80 ft/sec. Then the ball will be at a height of 96 feet above the ground after time -

(1) 2 and 3sec (2) only 3 sec

(3) only 2sec (4) 1 and 2 sec

48. A balloon going upward with a velocity of 12 m/sec is at a height of 65 m from the earth at any instant. Exactly at this instant a packet drops from it. How much time will the packet take in reaching the earth? ($g = 10\ m/sec^2$)

(1) 7.5 sec (2) 10 sec

(3) 5 sec (4) None

49. A body is falling from a height 'h'. It takes t_1 sec to reach the ground, the time taken to reach the half of the height will be-

(1) $\sqrt{2}\ t_1$ (2) $\frac{t_1}{2}$

(3) $\frac{t_1}{\sqrt{2}}$ (4) $2t_1$

50. A body thrown up with a velocity reaches a maximum height of 100 m. Another body with double the mass thrown up with double the initial velocity will reach a maximum height of-

(1) 400 m (2) 200 m

(3) 100 m (4) 250 m

51. A ball dropped from the top of a building takes 0.5 sec to clear the window of 4.9 m height. What is the height of building above the window?

(1) 2.75 m (2) 5.0 m

(3) 5.5 m (4) 4.9 m

52. A ball is thrown from ground vertically upward, reaches the roof of a house 100 meters high. At the moment this ball was thrown vertically upward, another ball is dropped from rest vertically downward from the roof of the house. At which height from the ground do the balls pass each other and after what time?

(1) $t = \frac{100}{\sqrt{1960}}$ sec, h = 25 m

(2) $t = \frac{100}{\sqrt{1690}}$ sec; h = 25 m

(3) $t = \frac{200}{\sqrt{1690}}$, h = 75 m

(4) $\frac{100}{\sqrt{1960}}$ sec; h = 75 m

53. From the foot of a tower 90 m high a stone is thrown up so as to reach the top of the tower. Two second later another stone is dropped from the top of the tower. When and where two stones meet ?

(1) $\frac{22}{7}$ sec later, at 83.6 m

(2) $\frac{22}{7}$ sec later, at 86.6 m

(3) $\frac{2.2}{7}$ sec later, at 86.6 m

(4) $\frac{2.2}{7}$ sec later, at 83.6 m

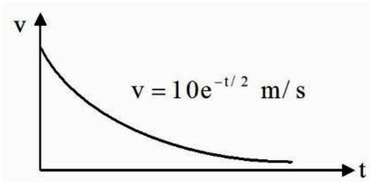
54. A motor boat covers the distance between two spots on the river in t_1 = 8 hr and t_2 = 12 hr downstream and upstream respectively. The time required for the boat to cover this distance in still water will be-

(1) 6.9 hr (2) 9.6 hr

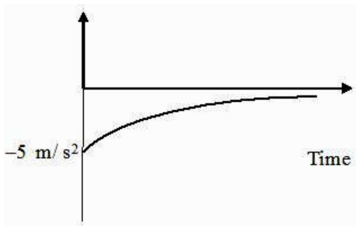
(3) 69 sec (4) 96 sec

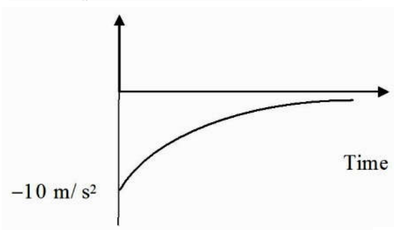
EXERCISE # 2

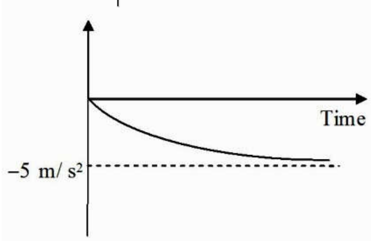
1. Velocity-time (v-t) graph of a particle moving in straight line is shown in the given figure.

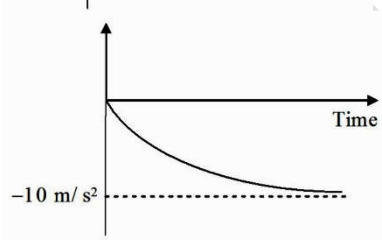


Which of the following graphs shows variation in acceleration of the particle with time?

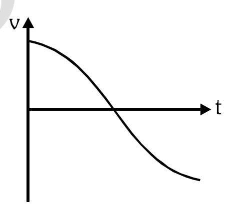
(1) 

(2) 

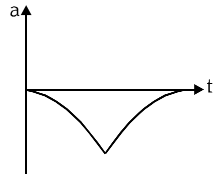
(3) 

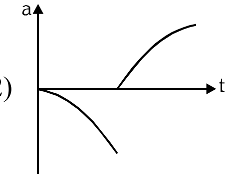
(4) 

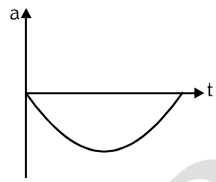
2. The graph shows the variation with time t of velocity v of an object moving along a straight line.

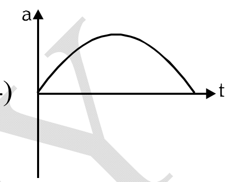


Which of the following graph best shows the variation with time t of the acceleration 'a' of the object?

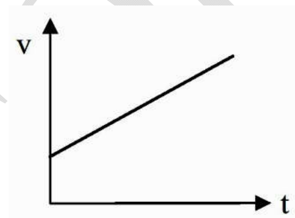
(1) 

(2) 

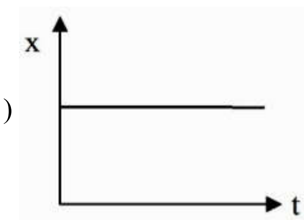
(3) 

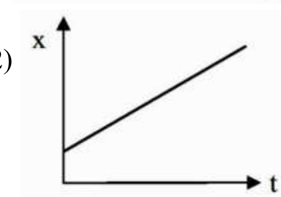
(4) 

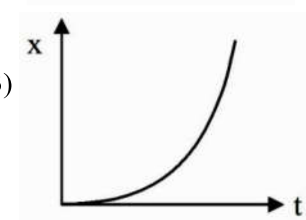
3. Velocity-time (v-t) graph of a particle moving in straight line is shown in the given figure.

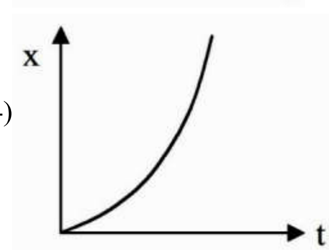


Which of the following pairs of graphs represent position-time (x-t) graph of the particle?

(1) 

(2) 

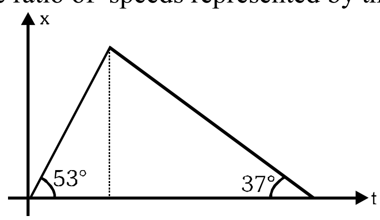
(3) 

(4) 

4. If a particle moves in a straight line according to the law $x = t^3 - 6t^2 - 15t$, the time interval during which velocity is negative and acceleration is positive, is

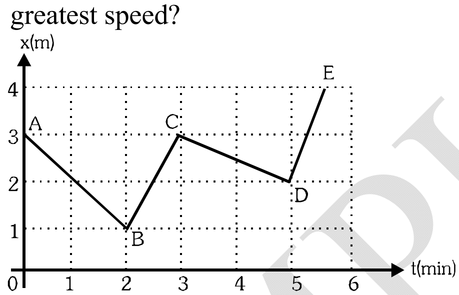
(1) $t < 2$ and $t > 5$ (2) $2 < t < 5$
(3) $-1 < t < 5$ (4) $-1 < t < 2$

5. On the position–time graph, two straight lines make angles 53° and 37° with time axis as shown in figure. If both axes have equal scales, the ratio of speeds represented by them, is



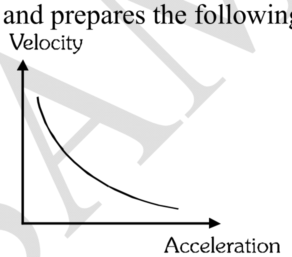
(1) $\frac{4}{3}$ (2) $\frac{3}{4}$ (3) $\frac{16}{9}$ (4) $\frac{9}{16}$

6. A child rides her tricycle back and forth along a sidewalk, producing the position versus time graph as shown in figure. Indicate on which of the following segment, the child has the greatest speed?



(1) AB (2) BC (3) CD (4) DE

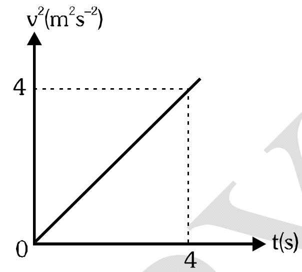
7. A physics student studies rectilinear motion of a body and prepares the following graph.



Which of the following conclusions best suits the above graph?

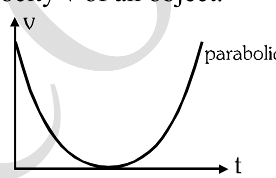
(1) The body is speeding up and its acceleration is decreasing.
(2) The body is slowing down and its acceleration is increasing.
(3) The body is speeding up and its acceleration is increasing.
(4) The given graph cannot describe any physically realizable motion.

8. A particle is moving along a straight line such that square of its velocity varies with time as shown in the figure. What is the acceleration of the particle at t = 4 s?

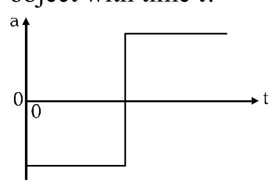


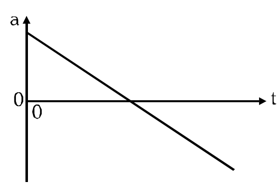
(1) 4 m/s^2 (2) 1/4 m/s^2
(3) 1/2 m/s^2 (4) zero

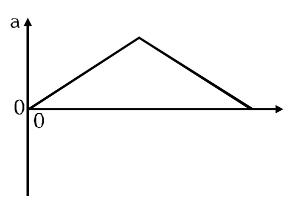
9. The graph shows the variation with time t of the velocity v of an object.

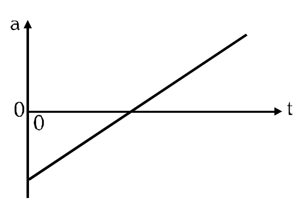


Which one of the following graphs best represents the variation of acceleration ' a' of the object with time t?

(1)


(2)


(3)


(4)


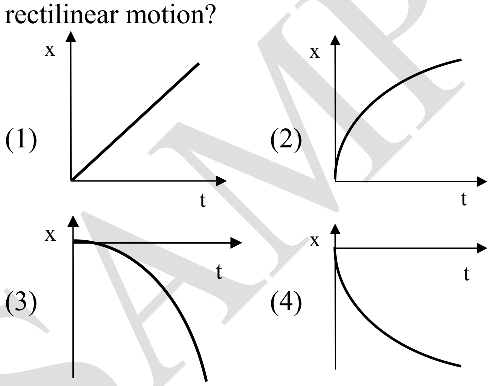
10. Velocity of an object in rectilinear motion is given as function of time by $v = 4t - 3t^2$, where v is in m/s and t is in seconds. Its average velocity over the time interval from t = 0 s to t = 2 s is
(1) 0 m/s
(2) –2 m/s
(3) 2 m/s
(4) determinable, if initial position is known.

11. An object starts from rest at the origin and moves along the x-axis with constant acceleration of 4 m/s^2. Its average velocity as it goes from x = 2m to x = 8m is
(1) 3 m/s (2) 4 m/s (3) 5 m/s (4) 6 m/s

12. At time t = 0 s a car passes a point with velocity of 16 m/s and thereafter slows down with acceleration a = – 0.5 t m/s^2, where t is in seconds. It stops at the instant t =
(1) 32 s (2) 16 s (3) 8.0 s (4) 4.0 s

13. A body is thrown vertically upwards from the top of a tower. It reaches the ground in 5 seconds. If it is thrown vertically downwards from the top of the tower with the same speed, it reaches the ground in 3.2 seconds. Height of the tower above the ground is closest to [g = 10 m/s^2]
(1) 125 m (2) 80 m (3) 50 m (4) 16 m

14. Which of the following position–time (x–t) graphs represents positive acceleration in rectilinear motion?

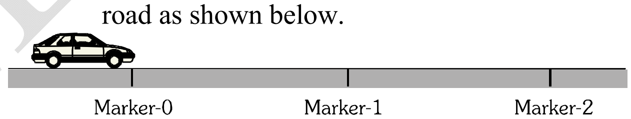


15. A stone falls freely from a point A. It passes through the points B_1, B_2, B_3.... such that AB_1, AB_2, AB_3.... are in geometric progression. Then magnitude of velocities of stone at B_1, B_2, B_3.... are in
(1) arithmetic progression
(2) geometric progression
(3) harmonic progression
(4) none of these

16. A train moving with a speed of 60 km/hr is slowed down uniformly to 30 km/hr for repair purposes during running. After this it was accelerated uniformly to reach to its original speed. If the distance covered during constant retardation be 2 km and that covered during constant acceleration be 1 km, find the time lost in the above journey
(1) 1 min (2) 2 min
(3) 4 min (4) 5 min

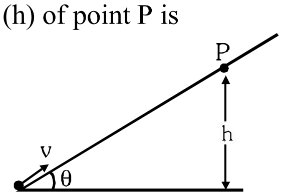
17. A horse is galloping forward with an acceleration of 3 m/s^2. Which of the following statement is necessarily true?
(1) The horse is increasing its speed by 3 m/s every second i.e. from 0 to 3 m/s to 6 m/s to 9 m/s.
(2) The speed of the horse will triple every second i.e. from 0 to 3 m/s to 9 m/s to 27 m/s.
(3) Starting from rest, the horse will cover 3 m of ground in the first second.
(4) In the third second the horse will cover 9 m of ground.

18. A car moving at 160 km/h when crosses the marker-0, driver applies brake and reduces its speed uniformly to 40 km/h at marker-2. The markers are spaced at equal distances along the road as shown below.



At which part of the track would the car have been traveling at instantaneous speed of 100 km/h?
(1) At marker-1
(2) Between marker-0 and marker-1
(3) Between marker-1 and marker-2
(4) More information required to decide.

19. A particle is thrown up with initial velocity v along a smooth fixed wedge as shown in figure. The particle reaches upto P and returns. The height (h) of point P is



(1) $\frac{v^2}{2g}$ (2) $\frac{v^2}{2g\sin\theta}$

(3) $\frac{v^2}{2g}\sin^2\theta$ (4) $\frac{v^2}{2g}\cos\theta$

20. The position of a particle moving in a straight line is described by the relation, $x = 5 + 16t - 4t^2$. Here x is in meters and t in minutes. The distance covered by particle in first 5 minute is

(1) 52 m (2) 57 m
(3) 15 m (4) 21 m

21. A particle moving on the x-axis with constant acceleration has displacements of 6 m from t = 4 s to t = 7 s and 3 m from t = 5 s to t = 8 s. The distance covered from t = 6 s to t = 9 s is

(1) 1.75 m (2) 2.25 m
(3) 3.0 m (4) 3.5 m

22. A rectangular farm-house has a 1 km difference between its sides. Two farmers simultaneously leave one vertex of the rectangle for a point at the opposite vertex. One farmer crosses the farmhouse along its diagonal and other walks along the bank. The speed of each farmer is 4km/hr. If one of them arrives half an hour earlier than the other then the size of farmhouse is-

(1) 12 km × 13km (2) 4 km × 5km
(3) 3 km × 4km (4) None of these

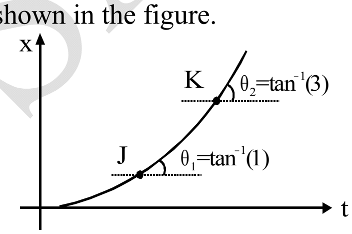
23. If the velocity of a particle is varying as $v = \frac{1}{4}at$, where a is the acceleration and t is the time. At t = 1 sec, v = 1 m/s, then acceleration is proportional to -

(1) t^0 (2) t^1
(3) t^2 (4) t^3

24. One of the apollo astronauts drops a hammer on the Moon where the acceleration due to gravity is 1.7 m/s^2. If it took one second for the hammer to hit the surface of the Moon, what was its average speed during that second ?

(1) 0.85 m/s (2) 1.7 m/s
(3) 3.4 m/s (4) 4.9 m/s

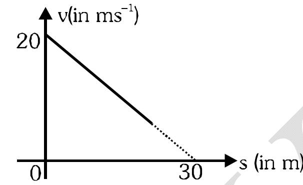
25. x–t graph for a uniformly accelerated motion is as shown in the figure.



Then find the average velocity between points J and K

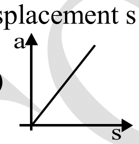
(1) 3m/s (2) 2m/s
(3) 4 m/s (4) 1.5 m/s

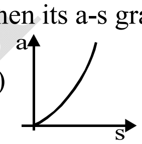
26. If the velocity v of a particle moving along a straight line decreases linearly with its displacement s from 20 ms^{-1} to a value approaching zero at s = 30 m, then acceleration of the particle at s = 15 m is

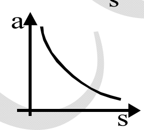


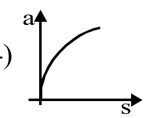
(1) $\frac{2}{3}$ ms^{-2} (2) $-\frac{2}{3}$ ms^{-2}
(3) $\frac{20}{3}$ ms^{-2} (4) $-\frac{20}{3}$ ms^{-2}

27. If the velocity 'v' of a particle depends upon displacement s as v = ks then its a-s graph is-

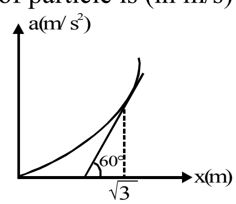
(1) 

(2) 

(3) 

(4) 

28. A particle starts moving with initial velocity 3m/s always along x-axis from origin. Its acceleration is varying with position x in parabolic nature as shown. A tangent to the graph is drawn at $x = \sqrt{3}$ m. The tangent makes an angle of 60° with x-axis. At this position velocity of particle is (in m/s)



(1) $\sqrt{\sqrt{3}+9}$ (2) $\sqrt{\sqrt{3}+6}$
(3) $\sqrt{3}$ (4) $\sqrt{6}$

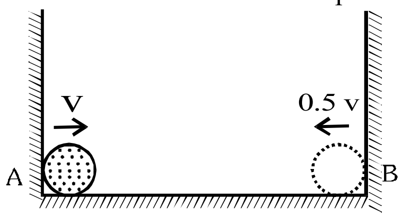
29. A particle starting from rest has a constant acceleration of 4ms^{-2} for 4s. It then retards uniformly for next 8s and comes to rest. Average speed of the particle during the motion is

(1) 16 ms^{-1} (2) 8 ms^{-1}
(3) 24 ms^{-1} (4) None of these

30. If an object is moving eastward and slowing down, then the direction of its velocity vector is

(1) Eastward
(2) Westward
(3) Neither
(4) Not enough information to tell

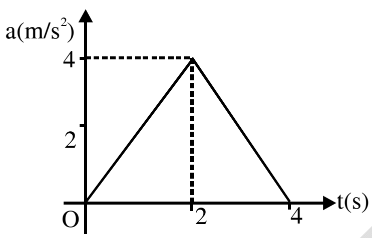
31. A small glass ball is pushed with a speed v from A. It moves on a smooth surface and collides with wall at B. If it loses half of its speed during the collision, what will be the average speed of the ball till it reaches at its initial position :-



(A) Zero (B) $\frac{v}{3}$

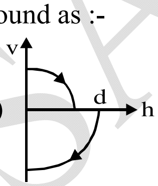
(C) $\frac{2v}{3}$ (D) $\frac{v}{2}$

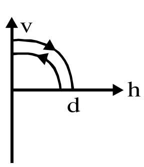
32. Acceleration-time graph of a particle moving in a straight line is shown in fig. Velocity of particle at time t = 0 is 2 m/s, velocity at the end of fourth second is :-

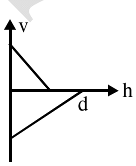


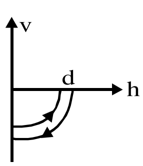
(1) 8 m/s (2) 16 m/s
(3) 10 m/s (4) 18 m/s

33. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height $\frac{d}{2}$. Neglecting subsequent motion and air resistance, its velocity v varies with height h above the ground as :-

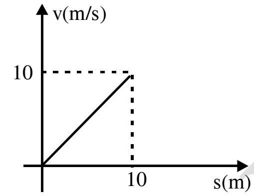
(1) 

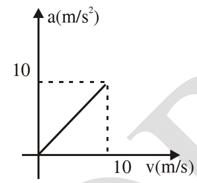
(2) 

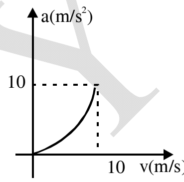
(3) 

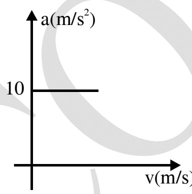
(4) 

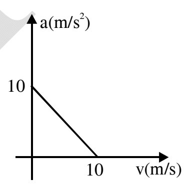
34. Velocity versus displacement graph of a particle moving in a straight line is shown in figure. Corresponding acceleration versus velocity graph will be :-



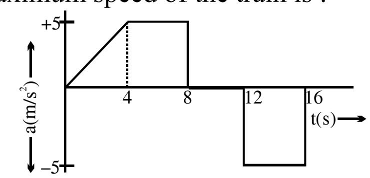
(1) 

(2) 

(3) 

(4) 

35. The acceleration of a train between two stations 2km apart is shown in the figure. The maximum speed of the train is :

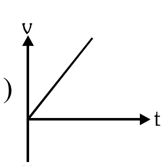


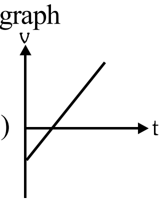
(1) 60 m/s (2) 30 m/s (3) 120 m/s(4) 90 m/s

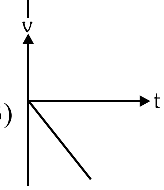
36. If a particle moves along a straight line according to the law v = 2 (x sin x + cos x) then find its acceleration at x= π/2:–

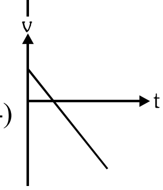
(1) $\frac{\pi}{2}$ (2) $\frac{\pi}{2\sqrt{2}}$ (3) $\frac{\pi}{4\sqrt{2}}$ (4) zero

37. A particle moves along x-axis in such a way that its x-coordinate varies with time t according to the equation $x = (8 - 4t + 6t^2)$ m where t is in seconds. The velocity of the particle will vary with time according to the graph

(1) 

(2) 

(3) 

(4) 

38. A ball is thrown downwards with velocity v from the top of a tower and it reaches the ground with speed 3v. What is the height of the tower?

(1) $\frac{v^2}{g}$ (2) $\frac{2v^2}{g}$

(3) $\frac{4v^2}{g}$ (4) $\frac{8v^2}{g}$

39. A stone is dropped from a certain height which can reach the ground in 5 sec. It is stopped after three seconds of its fall and then is again released. The total time taken by the stone to reach the ground will be

(1) 6 s (2) 6.5 s (3) 7 s (4) 7.5 s

40. If the velocity of a particle is given by $v = (180 - 16x)^{1/2}$ m/s then its acceleration will be

(1) zero (2) 8 m/s^2

(3) – 8 m/s^2 (4) 4 m/s^2

41. The engine of a vehicle can produce a maximum acceleration of 4 ms^{-2}. Its brakes can produce a maximum retardation of 6 ms^{-2}. The minimum time in which it can cover a distance of 3 km is

(1) 30 s (2) 40 s (3) 50 s (4) 60 s

42. A ball is thrown vertically upwards from the ground. It crosses a point at the height of 25 m twice at an interval of 4 secs. The ball was thrown with the velocity of

(1) 20m/sec. (2) 25 m/sec.

(3) 30m/sec. (4) 35 m/sec.

43. The Displacement (x) of a particle starting from rest is given by $x = 6t^2 - t^3$. The time at which the particle will attain zero velocity again, is

(1) 2 (2) 4 (3) 6 (4) 8

44. A train stopping at two stations 5 km apart takes 5 min on the journey from one of the station to the other. Assuming that its first accelerates with a uniform acceleration α and then that of uniform retardation β. If units of mass, length, and time are kg, km and min respectively then

(1) $\frac{1}{\alpha}+\frac{1}{\beta}=2$ (2) $\frac{1}{\alpha}+\frac{1}{\beta}=\frac{2}{5}$

(3) $\frac{1}{\alpha}+\frac{1}{\beta}=\frac{5}{2}$ (4) $\frac{1}{\alpha}+\frac{1}{\beta}=\frac{1}{2}$

45. A particle moves in a straight line with retardation inversely proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

(1) x^2 (2) e^x (3) x (4) $\log_e x$

46. A particle is moving on a circular path of radius $\frac{100}{\sqrt{19}}$ m in such a way that magnitude of its velocity varies with time as, where v is velocity in m/s and t is time in s. The acceleration of the particle at t = 2 s is

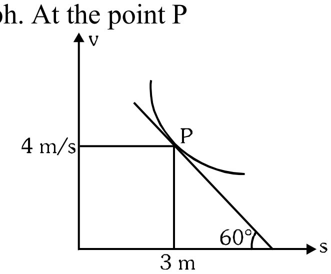
(1) 21 m/s^2 (2) 9 m/s^2

(3) 10 m/s^2 (4) 13.5 m/s^2

47. A particle moves from A to B in a straight line with constant speed and then moves from B to C with same speed where C is the middle point of the line joining A and B. If the average velocity of the particle from A to C through B is v_0, the average speed of the particle for the same motion is

(1) $3v_0$ (2) $\frac{2v_0}{3}$ (3) $\frac{v_0}{3}$ (4) v_0

48. A particle is moving along a straight line whose velocity-displacement graph is as shown in figure : A tangent is drawn at point P on the graph. At the point P



(1) the particle is speeding up

(2) numerical value of velocity and acceleration of the particle are equal

(3) numerical value of velocity is more than the numerical value of acceleration of the particle

(4) numerical value of acceleration is more than the numerical value of velocity of the particle

49. A point moves in a straight line so that its distance r from a fixed point at any time t is proportional to t^n. If v and a be the velocity and acceleration at time t then

(1) $v^2 = \left(\frac{n-1}{n}\right)ar$ (2) $v^2 = \left(\frac{n}{n-1}\right)ar$

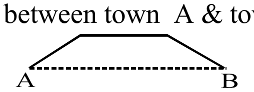
(3) $v^2 = \left(\frac{n+1}{n}\right)ar$ (4) $v^2 = \left(\frac{n-1}{n-2}\right)ar$

50. The velocity of a particle that moves in the positive x-direction varies with its position as shown in figure. The acceleration of the particle when x = 5.5 m is-
(1) Zero (2) 5 ms^{-2}
(3) 10 ms^{-2} (4) 20 ms^{-2}

51. If sound of thunder is heard after 7 sec the lightening then find the height of the clouds. Given speed of light is 3×10^8 m/s & speed of sound is 340 m/s.
(1) 2.1×10^6 km (2) 7.2 km
(3) 2.38 km (4) Can't be determined

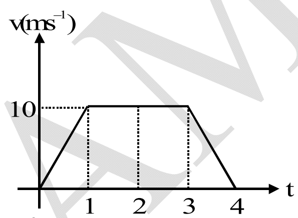
52. A particle moving on a straight line ultimately comes to rest. What is the angle between in initial velocity and acceleration?
(1) zero (2) $\pi/4$ (3) $\pi/2$ (4) π

53. A boy travels from town A to town B such that his speed is 2km/hr, 3km/hr and 6km/hr in uphill, plane and down hill respectively. When he goes from A to B, he takes 4hrs and in return journey he takes 6hrs, What is road distance between town A & town B ?



(1) 30 km
(2) 24 km
(3) 15 km
(4) Can't be determined

54. Find the average acceleration of the block from time t = 2 sec to t = 4 sec.



(1) 5 m/s^2 (2) 10 m/s^2
(3) –5 m/s^2 (4) 10 m/s^2

55. While sitting on a tree branch 20m above the ground, you drop a chestnut. When the chestnut has fallen 5m, you throws a second chestnut straight down. What initial speed must you give the second chestnut if they are both to reach the ground at the same time ? ($g = 10ms^{-2}$)
(1) 5 ms^{-1} (2) 10 ms^{-1}
(3) 15 ms^{-1} (4) None of these

56. A bird flies with a speed u over a train which moves with a speed v. The average speed of the bird w.r.t. train is travelling to and fro along the train (end to end) is
(1) $\frac{2uv}{u+v}$ (2) $\sqrt{u^2+v^2}$
(3) $\sqrt{uv}$ (4) $\frac{u^2-v^2}{u}$

57. A particle starts moving from origin along x–axis with a constant acceleration of 5 ms^{-2}. At a time 10 s after the beginning of motion, the acceleration changes sign, remaining the same in magnitude. Determine the time from the beginning of motion in which the particle returns to the origin.
(1) $10(1+\sqrt{2})s$ (2) $10(2+\sqrt{2})s$
(3) $10(2-\sqrt{2})s$ (4) $10(\sqrt{2}-1)s$

58. A point mass moves with velocity $v = (5t - t^2)\ ms^{-1}$ in a straight line. Find the distance travelled (i.e. $\int vdt$) in fourth second.
(1) $\frac{31}{6}$ m (2) $\frac{29}{6}$ m
(3) $\frac{37}{6}$ m (4) None of these

59. The motion of a body is given by the equation $\frac{dv}{dt} = 6 - 3v$. Where v is velocity is m/s and t in sec. If body was at rest at t = 0, then–
(1) Velocity varies with time exponentially
(2) Velocity varies with time linearly
(3) Velocity varies with time parabolically
(4) None of these

60. A particle has initial velocity 9 m/sec due east and a constant acceleration of 2ms^{-2} due west. The distance covered by the particle in 5th second of its motion is -
(1) 0 m (2) 0.5 m
(3) 2 m (4) 2.5 m

61. A bus is beginning to move with an acceleration of 1 m/sec^2. A boy who is 48 m behind the bus starts running at 10 m/sec. The times at which the boy can catch the bus will be-
(1) 8 sec (2) 10 sec
(3) 12 sec (4) 14 sec

62. A boy standing at a corner noticed a thief on bike moving with 54 km/hr and after some time a police jeep crosses him with speed 72 km/hr. If jeep catches the thief at a distance of 1 km from the boy then the time gap between bike & jeep will be when they cross the boy-

(1) 3.33 sec (2) 16.67 sec

(3) 20 sec (4) 27.5 sec

63. Given that x = displacement at time t and p,q,r are non zero constants. Which of the following represents the motion with constant non-zero acceleration ?

(1) $x = pt^{-1} + qt^2$ (2) $x = qt$

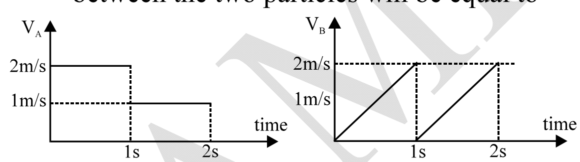
(3) $x = pt + qt^2$ (4) $x = pt + qt^2 + rt^3$

64. A particle retards from v_0 with an acceleration $a = -kt$, where k is a positive constant. The total distance covered by the particle is –

(1) $\sqrt{\frac{2v_0^3}{3k}}$ (2) $\sqrt{\frac{8v_0^3}{9k}}$

(3) $\sqrt{\frac{8v_0^3}{3k}}$ (4) $\sqrt{\frac{2v_0^3}{9k}}$

65. Two particles A and B start moving from the same point on the X-axis. The velocity versus time graph of the particles is as shown in the figure. The maximum relative separation between the two particles will be equal to



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

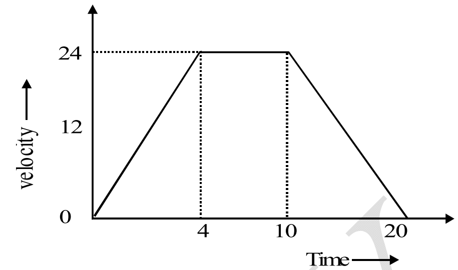
(3) 5/4 m (4) 1m

66. A train accelerates from rest at a constant rate α for distance x_1 and time t_1. After that retards at constant rate β for distance x_2 in time t_2 and comes to the rest, which of the following relation is correct :–

(1) $\frac{x_1}{x_2} = \frac{\alpha}{\beta} = \frac{t_1}{t_2}$ (2) $\frac{x_1}{x_2} = \frac{\beta}{\alpha} = \frac{t_1}{t_2}$

(3) $\frac{x_1}{x_2} = \frac{\alpha}{\beta} = \frac{t_2}{t_1}$ (4) $\frac{x_1}{x_2} = \frac{\beta}{\alpha} = \frac{t_2}{t_1}$

67. Figure shows the velocity–time plot of a body moving in a straight line.



How much distance does it travel in the last 10s?

(1) 24 m (2) 240 m

(3) 120 m (4) 180m

68. A body dropped from the top of a tower falls through 40 m during the last 2 s of its fall. The height of the tower is ($g = 10\ m/s^2$)

(1) 60 m (2) 45 m

(3) 80 m (4) 50 m

69. A bus travels the first $\frac{1}{3}$ distance at a speed of 10 km/hr, the next $\frac{1}{3}$ at 20 km/hr and the last $\frac{1}{3}$ at 60 km/hr. The average speed of the bus is

(1) 9 km/hr (2) 16 km/hr

(3) 18 km/hr (4) 48 km/hr

70. A particle moves along a straight line such that its displacement at any time t is given by $s = (t^3 - 6t^2 + 4)$ m. The velocity when the acceleration is zero, will be

(1) 3m/s (2) –12 m/s

(3) 42 m/s (4) – 9 m/s

71. A ball is dropped from height h. After 1 s another ball is dropped from the same point. What is the distance between them after 3s ?

(1) 25 m (2) 20 m

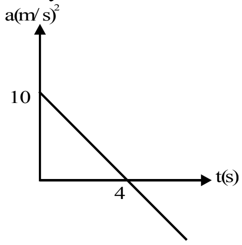
(3) 50 m (4) 9.8 m

72. A lift ascends with a constant acceleration of $4 m/s^2$, then with a constant velocity v and finally stops under a constant retardation of $4 m/s^2$. If the total height ascended is 20 m and the total time taken is 6 s then the time during which the lift was moving with a velocity v is

(1) 2 s (2) 3 s

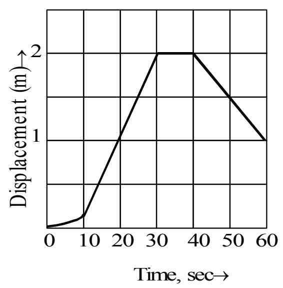
(3) 4 s (4) 5 s

73. The acceleration time graph of a particle moving along a straight line is as shown in figure. At what time the particle acquires its initial velocity?



(1) 12 s (2) 8s (3) 5s (4) 16 s

74. The displacement time graph for a one dimensional motion of a particle is shown in figure. Then the instantaneous velocity at t = 20 s is



(1) 0.1 m/s (2) – 0.1 m/s
(3) – 0.05 m/s (4) 1.0 m/s

75. A car moves with uniform acceleration along a straight line PQR. Its speeds at P and R are 5 m/s and 25 m/s respectively. If PQ : QR = 1 : 2, the ratio of the times taken by car to travel distance PQ and QR is

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

76. Water is dropped from the tap at a height h from the ground at regular interval T_0. They reach the ground at interval T_1. Then T_1 is equal to

(1) T_0 (2) $T_0 + \sqrt{\frac{2h}{g}}$

(3) $T_0 - \sqrt{\frac{2h}{g}}$ (4) $T_0 + 2\sqrt{\frac{2h}{g}}$

EXERCISE # 3

Questions | **Assertion and Reason**

Read the assertion and **reason** carefully to mark the correct option out of the options given below:

(a) *If both assertion and* ***reason*** *are true and the* ***reason*** *is the correct explanation of the assertion.*
(b) *If both assertion and* ***reason*** *are true but* ***reason*** *is not the correct explanation of the assertion.*
(c) *If assertion is true but* ***reason*** *is false.*
(d) *If the assertion and* ***reason*** *both are false.*

1. **Assertion :** A body can have acceleration even if its velocity is zero at a given instant of time.
Reason : A body is momentarily at rest when it reverses its direction of motion.
(1) a (2) b (3) c (4) d

2. **Assertion :** Two balls of different masses are thrown vertically upward with same speed. They will pass through their point of projection in the downward direction with the same speed.
Reason : The maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.
(1) a (2) b (3) c (4) d

3. **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.
(1) a (2) b (3) c (4) d

4. **Assertion :** The average velocity of the object over an interval of time is either smaller than or equal to the average speed of the object over the same interval.
Reason : Velocity is a vector quantity and speed is a scalar quantity.
(1) a (2) b (3) c (4) d

5. **Assertion :** An object can have constant speed but variable velocity.
Reason : Speed is a scalar but velocity is a vector quantity.
(1) a (2) b (3) c (4) d

6. **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.
(1) a (2) b (3) c (4) d

7. **Assertion :** The position-time graph of a uniform motion in one dimension of a body can have negative slope.
Reason : When the speed of body decreases with time, the position-time graph of the moving body has negative slope.
(1) a (2) b (3) c (4) d

8. **Assertion :** A positive acceleration of a body can be associated with a '*slowing down*' of the body.
Reason : Acceleration is a vector quantity.
(1) a (2) b (3) c (4) d

9. **Assertion :** A negative acceleration of a body can be associated with a '*speeding up*' of the body.
Reason : Increase in speed of a moving body is independent of its direction of motion.
(1) a (2) b (3) c (4) d

10. **Assertion :** When a body is subjected to a uniform acceleration, it always move in a straight line.
Reason : Straight line motion is the natural tendency of the body.
(1) a (2) b (3) c (4) d

11. **Assertion :** Rocket in flight is not an illustration of projectile.
Reason : Rocket takes flight due to combustion of fuel and does not move under the gravity effect alone.
(1) a (2) b (3) c (4) d

12. **Assertion :** The average speed of a body over a given interval of time is equal to the average velocity of the body in the same interval of time if a body moves in a straight line in one direction.
Reason : Because in this case distance travelled by a body is equal to the displacement of the body.
(1) a (2) b (3) c (4) d

13. **Assertion :** Position-time graph of a stationary object is a straight line parallel to time axis.
Reason : For a stationary object, position does not change with time.
(1) a (2) b (3) c (4) d

14. **Assertion :** The slope of displacement-time graph of a body moving with high velocity is steeper than the slope of displacement-time graph of a body with low velocity.
Reason : Slope of displacement-time graph = Velocity of the body.
(1) a (2) b (3) c (4) d

15. **Assertion :** Distance-time graph of the motion of a body having uniformly accelerated motion is a straight line inclined to the time axis.
Reason : Distance travelled by a body having uniformly accelerated motion is directly proportional to the square of the time taken.
(1) a (2) b (3) c (4) d

16. **Assertion :** A body having non-zero acceleration can have a constant velocity.
Reason : Acceleration is the rate of change of velocity.
(1) a (2) b (3) c (4) d

17. **Assertion :** A body, whatever its motion is always at rest in a frame of reference which is fixed to the body itself.
Reason : The relative velocity of a body with respect to itself is zero.
(1) a (2) b (3) c (4) d

18. **Assertion :** Displacement of a body may be zero when distance travelled by it is not zero.
Reason : The displacement is the longest distance between initial and final position.
(1) a (2) b (3) c (4) d

19. **Assertion :** The equation of motion can be applied only if acceleration is along the direction of velocity and is constant.
Reason : If the acceleration of a body is constant then its motion is known as uniform motion.
(1) a (2) b (3) c (4) d

20. **Assertion :** A bus moving due north takes a turn and starts moving towards east with same speed. There will be no change in the velocity of bus.
Reason : Velocity is a vector-quantity.
(1) a (2) b (3) c (4) d

21. **Assertion :** The relative velocity between any two bodies moving in opposite direction is equal to sum of the velocities of two bodies.
Reason : Sometimes relative velocity between two bodies is equal to difference in velocities of the two.
(1) a (2) b (3) c (4) d

22. **Assertion :** The displacement-time graph of a body moving with uniform acceleration is a straight line.
Reason : The displacement is proportional to time for uniformly accelerated motion.
(1) a (2) b (3) c (4) d

23. **Assertion :** Velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to the time axis.
Reason : In uniform motion of an object velocity increases as the square of time elapsed.
(1) a (2) b (3) c (4) d

24. **Assertion :** A body may be accelerated even when it is moving uniformly.
Reason : When direction of motion of the body is changing then body may have acceleration.
(1) a (2) b (3) c (4) d

25. **Assertion :** A body falling freely may do so with constant velocity.
Reason: The body falls freely, when acceleration of a body is equal to acceleration due to gravity.
(1) a (2) b (3) c (4) d

26. **Assertion :** Displacement of a body is vector sum of the area under velocity-time graph.
Reason : Displacement is a vector quantity.
(1) a (2) b (3) c (4) d

27. **Assertion :** The position-time graph of a body moving uniformly is a straight line parallel to position-axis.

Reason : The slope of position-time graph in a uniform motion gives the velocity of an object.

(1) a (2) b (3) c (4) d

28. **Assertion :** The average speed of an object may be equal to arithmetic mean of individual speed.

Reason : Average speed is equal to total distance travelled per total time taken.

(1) a (2) b (3) c (4) d

29. **Assertion :** The average and instantaneous velocities have same value in a uniform motion.

Reason : In uniform motion, the velocity of an object increases uniformly.

(1) a (2) b (3) c (4) d

30. **Assertion :** The speedometer of an automobile measure the average speed of the automobile.

Reason : Average velocity is equal to total displacement per total time taken.

(1) a (2) b (3) c (4) d

EXERCISE # 4

Questions **Previous Year (NEET)**

1. A stone is thrown vertically upwards. When stone is at a height half of its maximum height, its speed is 10 m/s, then the maximum height attained by the stone is ($g = 10\ m/s^2$) **[AIPMT-2001]**

(1) 8 m (2) 10 m
(3) 15 m (4) 20 m

2. If a ball is thrown vertically upwards with speed u, the distance covered during the last 't' seconds of its ascent is- **[AIPMT-2003]**

(1) ut (2) $\frac{1}{2}gt^2$
(3) $ut - \frac{1}{2}gt^2$ (4) $(u + g t)t$

3. A man throws ball with the same speed vertically upwards one after the other at an interval of 2 seconds. What should be the speed of the throw so that more than two balls are in the sky at any time ? (Given $g = 9.8\ m/s^2$) **[AIPMT-2003]**

(1) More than 19.6 m/s
(2) At least 9.8 m/s
(3) Any speed less than 19.6 m/s
(4) Only with speed 19.6 m/s

4. The displacement x of a particle varies with time t as $x = ae^{-\alpha t+} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will **[AIPMT-2005]**

(1) decrease with time
(2) be independent of α and β
(3) drop to zero when $\alpha = \beta$
(4) increase with time

5. A particle moves along a straight line OX. At a time t (in second), the distance x (in metre) of the particle from O is given by

$$x = 40 + 12\,t - t^3$$

How long would the particle travel before coming to rest ? **[AIPMT-2006]**

(1) 24 m (2) 40 m
(3) 56 m (4) 16 m

6. Two bodies A (of mass 1 kg) and b (of mass 3 kg) are dropped from heights of 16 m and 25 m, respectively. The ratio of the time taken by them to reach the ground is - **[AIPMT-2006]**

(1) –5/4 (2) 12/5
(3) 5/12 (4) 4/5

7. The position x of a particle w.r.t. time t along x-axis is given by $x = 9t^2 - t^3$, where x is in metre and t in sec. What will be the position of this particle when it achieves maximum speed along the +x direction ? **[AIPMT-2007]**

(1) 32 m (2) 54 m
(3) 81 m (4) 24 m

8. A car moves from X to Y with a uniform speed vu and returns to X with a uniform speed v_d. The average speed for this round trip is – **[AIPMT-2007]**

(1) $\frac{2v_d v_u}{v_d + v_u}$ (2) $\sqrt{v_u v_d}$
(3) $\frac{v_d v_u}{v_d + v_u}$ (4) $\frac{v_u + v_d}{2}$

9. A particle moving along x-axis has acceleration f, at time t, given by $f = f_0\left(1 - \frac{t}{T}\right)$, where f_0 and T are constants. The particle at t = 0 has zero velocity. In the time interval between t = 0 and the instant when f = 0, the particle's velocity (v_x) is - **[AIPMT-2007]**

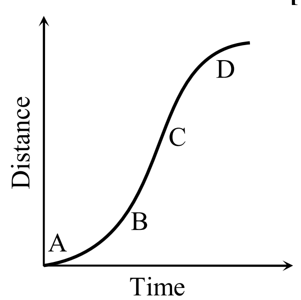
(1) $f_0 T$ (2) $\frac{1}{2} f_0 T^2$
(3) $f_0 T^2$ (4) $\frac{1}{2} f_0 T$

10. The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}ms^{-2}$, in the third-second is - **[AIPMT-2008]**

(1) 6 m (2) 4 m

(3) $\frac{10}{3}$ m (4) $\frac{19}{3}$ m

11. A particle shows distance-time curve as given in this figure. The maximum instantaneous velocity of the particle is around the point **[AIPMT-2008]**



(1) B (2) C (3) D (4) A

12. A particle moves in a straight line with a constant acceleration. It changes its velocity from 10 ms^{-1} to 20 ms^{-1} while passing through a distance 135 m in t sec. The value of t is - **[AIPMT-2008]**

(1) 10 (2) 1.8

(3) 12 (4) 9

13. A bus is moving with a speed of 10 ms^{-1} on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what speed should the scooterist chase the bust ? **[AIPMT-2009]**

(1) 20 ms^{-1} (2) 40 ms^{-1}

(3) 25 ms^{-1} (4) 10 ms^{-1}

14. A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 s is s_1 and that covered in the first 20 s is s_2, then - **[AIPMT-2009]**

(1) $s_2 = 2\ s_1$ (2) $s_2 = 3\ s_1$

(3) $s_2 = 4\ s_1$ (4) $s_2 = s_1$

15. A particle moves a distance x in time t according to the equation $x = (t + 5)^{-1}$. The acceleration of particle is proportional to - **[AIPMT-2010]**

(1) $(\text{velocity})^{3/2}$ (2) $(\text{distance})^{2}$

(3) $(\text{distance})^{-2}$ (4) $(\text{velocity})^{2/3}$

16. A ball is dropped from a high rise platform at t = 0 starting from rest. After 6 s, another ball is thrown downwards from the same platform with a speed v. The two balls meet at t = 18 s. What is the value of v ? (Take g = 10 ms^{-2}) **[AIPMT-2010]**

(1) 74 ms^{-1} (2) 55 ms^{-1}

(3) 40 ms^{-1} (4) 60 ms^{-1}

17. A body is moving with velocity 30 m/s towards East. After 10 s, its velocity becomes 40 m/s towards North. The average acceleration of the body is - **[AIPMT-2011]**

(1) 7 m/s^2 (2) $\sqrt{7}$ m/s^2

(3) 5 m/s^2 (4) 1 m/s^2

18. A body standing at the top of a tower of 20 m height drops a stone. Assuming, g = 10 ms^{-2}, the velocity with which its hits the ground is - **[AIPMT-2011]**

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

(3) 5 m/s (4) 10 m/s

19. The motion of a particle along a straight line is described by equation

$$x = 8 + 12t - t^3$$

where, x is in metre and t in sec. The retardation of the particle when its velocity becomes zero, is - **[AIPMT-2012]**

(1) 24 ms^{-2} (2) zero

(3) 6 ms^{-2} (4) 12 ms^{-2}

20. A stone falls freely under gravity. It covers distance h_1, h_2 and h_3 in the first 5s, the next 5s and the next 5s respectively. The relation between h_1, h_2 and h_3 is - **[NEET-2103]**

(1) $h_1 = 2h_2 = 3h_3$

(2) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$

(3) $h_2 = 3h_1$ and $h_3 = 3h_2$

(4) $h_1 = h_2 = h_3$

21. If vectors $\mathbf{A} = \cos\omega t\ \hat{i} + \sin\omega t\ \hat{j}$ and $\mathbf{B} = \cos\frac{\omega t}{2}\hat{i} + \sin\frac{\omega t}{2}\hat{j}$ are functions of time, then the value of t at which they are orthogonal to each other, is - **[AIPMT-2015]**

(1) $t = \frac{\pi}{4\omega}$ (2) $t = \frac{\pi}{2\omega}$

(3) $t = \frac{\pi}{\omega}$ (4) $t = 0$

22. A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-2n}$ where, β and n are constants and x is the position of the particle. The acceleration of the particle as a function of x, is given by **[AIPMT-2015]**

(1) $-2n\beta x^{-2n-1}$ (2) $-2n\beta^2 x^{-4n-1}$

(3) $-2\beta^2 x^{-2n+1}$ (4) $-2n\beta^2 e^{-4n+1}$

23. Two cars P and start from appoint at the same time in a straight line and their positions are represented by $X_P(t) = at + bt^2$ and $X_Q(t) = ft - t^2$. At what time do the cars have the same velocity ? **[NEET-2016]**

(1) $\frac{a-f}{1+b}$ (2) $\frac{a+f}{2(b-1)}$

(3) $\frac{a+f}{2(1+b)}$ (4) $\frac{f-a}{2(1+b)}$

24. If the velocity of a particle is $v = At + Bt^2$, where A and B are constant, then the distance travelled by it between 1s and 2s is - **[NEET-2016]**

(1) $3A + 7B$ (2) $\frac{3}{2}A + \frac{7}{3}B$

(3) $\frac{A}{2} + \frac{B}{3}$ (4) $\frac{3}{2}A + 4B$

25. Preeti reached the metro station and found that the escalator was not working. She walked up to stationary escalator in time t_1. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2. The time taken by her to walk up on the moving escalator will be - **[NEET-2017]**

(1) $\frac{t_1 + t_2}{2}$ (2) $\frac{t_1 t_2}{t_2 - t_1}$

(3) $\frac{t_1 t_2}{t_2 + t_1}$ (4) $t_1 - t_2$

26. The x and y coordinates of the particle at any time are $x = 5t - 2t^2$ and $y = 10t$ respectively, where x and y are in meters and t in seconds. The acceleration of the particle at t = 2s is : **[NEET-2017]**

(1) $-8\ m/s^2$ (2) 0

(3) $5\ m/s^2$ (4) $-4\ m/s^2$

ANSWER KEY & SOLUTIONS

EXERCISE-1

Qus.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	3	2	3	1	1	1	1	3	1	4	3	2	1	4	1	4	1	1	1
Qus.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	2	1	2	2	3	3	4	1	3	3	3	2	1	2	1	1	1	3
Qus.	41	42	43	44	45	46	47	48	49	50	51	52	53	54						
Ans.	3	1	3	2	3	1	1	3	3	1	1	4	1	2						

EXERCISE-2

Qus.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	3	2	3	4	1	2	4	1	4	3	2	4	2	1	1	3	1	1
Qus.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	3	4	1	2	4	1	1	2	1	3	3	1	1	2	4	2	3	3	3
Qus.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	3	2	3	4	3	1	4	2	3	3	4	3	3	3	4	2	1	1	2
Qus.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76				
Ans.	1	2	3	2	3	2	3	2	3	2	1	3	2	1	3	1				

EXERCISE-3

Qus.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	1	1	4	3	2	2	4	1	1	1	1	4	4	1	3	4	4
Qus.	21	22	23	24	25	26	27	28	29	30										
Ans.	2	4	3	4	4	1	4	2	3	4										

EXERCISE-4

Qus.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	2	1	4	3	4	2	1	4	3	2	4	1	3	1	1	3	1	4	2
Qus.	21	22	23	24	25	26														
Ans.	3	2	4	2	3	4														