SOLVED EXAMPLES

Ex.1 At t = 0, a particle is at rest at origin. Its acceleration is 2 m/s^2 for first 2 sec. and – 2 m/s^2 for next 4 sec as shown in a versus t graph.

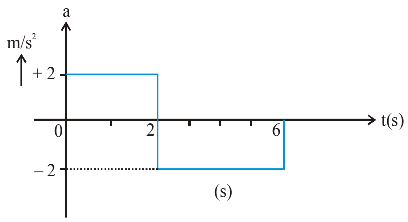
Plot graph for

(i) Velocity versus time

(ii) speed versus time

(iii) Displacement versus time

(iv) Distance versus time



Sol. **(i)** $V_2 - V_0$ = Area of a Vs t graph for t = 0 to t = 2 sec

$V_2 - 0 = 2 \times 2 \Rightarrow V_2 = 4$ m/s

Now $V_6 - V_2 = -2 \times 4 \Rightarrow V_6 = -4$ m/s

(ii) Since slope of a Vs t graph from t = 2 to 6 sec. is constant, we can observe its speed i.e. magnitude of its velocity is zero at = 4 sec. and after that magnitude of velocity increases in negative direction up to 4 m/s at the same rate.

(iii) Displacement (x) Vs t

$x_2 - x_0$ = area of v vs t graph for t = 0, t = 2 sec

$$x_2 - 0 = \frac{1}{2}(2)(4) \Rightarrow x_2 = +4 \text{ m}$$

$$x_4 - x_2 = \frac{1}{2}(4)(2) \Rightarrow x_4 = 8 \text{ m}$$

$$\text{also } x_6 - x_4 = \frac{1}{2}(-4)(2) = -4 \text{ m} \Rightarrow \therefore x_6 = +4 \text{ m}$$

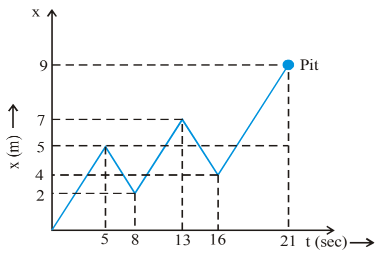
(iv) Distance **(d)** vs t

$$d_2 - d_0 = \frac{1}{2}(2)(4) \Rightarrow d_2 = 4\text{m}$$

$$d_4 - d_2 = \frac{1}{2}(2)(4) \Rightarrow d_4 = 8\text{m}$$

$$\text{Also } d_6 - d_4 = \left|\frac{1}{2}(2)(-4)\right| = 4 \Rightarrow d_6 = 12 \text{ m}$$

Ex.2 A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1s. Plot the x-t graph of his motion. Determine graphically or otherwise how long the drunkard takes to fall in a pit 9 m away from the start.



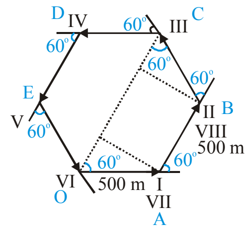
Sol. From x-t graph time taken = 21 s

or

(5m – 3m) + (5m – 3m) + 5m = 9m ⇒ total steps = 21 ⇒ time = 21 s

Ex.3 On an open ground a motorist follows a track that turns to his left by an angle of 60° after every 500 m. Starting from a given turn, specify the displacement of the motorist at the third, sixth and eight turn. Compare the magnitude of displacement with the total path length covered by the motorist in each case.

Sol.



At III turn :

Displacement = $\overrightarrow{OA} + \overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{OC}$ $= 500 \cos 60^o + 500 + 500 \cos 60^o$

$= 500 \times \frac{1}{2} + 500 + 500 \times \frac{1}{2}$ = 1000 m from O to C

Distance = $500 + 500 + 500 = 1500$ m So $\frac{\text{Displacement}}{\text{Distance}} = \frac{1000}{1500} = \frac{2}{3}$

At VI turn : $\because$ initial and final positions are same so displacement

= 0 and distance $= 500 \times 6 = 3000$ m $\therefore$ $\frac{\text{Displacement}}{\text{Distance}} = \frac{0}{3000} = 0$

At VIII turn : Displacement $= (500) \cos \left(\frac{60^o}{2}\right) = 1000 \times \cos 30^o = 1000 \times \frac{\sqrt{3}}{2} = 500\sqrt{3}$ m

Distance $= 500 \times 8\ 4000$ m $\therefore$ $\frac{\text{Displacement}}{\text{Distance}} = \frac{500\sqrt{3}}{4000} = \frac{\sqrt{3}}{8}$

Ex.4 A man walks on a straight road from his to a market 2.5 km away with a speed of 5 km/h. On reaching the market he initially turns and walks back with a speed of 7.5 km/h. What is the

(a) magnitude of average velocity and

(b) average speed of the man, over the interval of time **(i)** 0 to 30 min. **(ii)** 0 to 50 min **(iii)** 0 to 40 min

Sol. Time taken by man to go from his home to market, $t_1 = \frac{\text{distance}}{\text{speed}} = \frac{2.5}{5} = \frac{1}{2}$ h

Time taken by man to go from market to his home, $t_2 = \frac{2.5}{7.5} = \frac{1}{3}$ h

$\therefore$ Total time taken $= t_1 + t_2 = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}$ h = 50 min

(i) 0 to 30 min

Average velocity = $\frac{\text{displacement}}{\text{time interval}} = \frac{2.5}{\frac{30}{60}} = 5$ km/h towards market

Average speed = $\frac{\text{distance}}{\text{time interval}} = \frac{2.5}{\frac{30}{60}} = 5$ km/h

(ii) 0 to 50 min

Total displacement = zero So average velocity = 0

So, average speed $= \frac{5}{50/60} = 6$ km/h

Total distance travelled = 2.5 + 2.5 = 5 km

(iii) 0 to 40 min

Distance covered in 30 min (from home to market) = 2.5 km

Distance covered in 10 min (from market to home) with speed 7.5 km/h $= 7.5 \times \frac{10}{60} = 1.25$ km

So, displacement = 2.5 – 1.25 = 1.25 km (towards market)

Distance travelled = 2.5 + 1.25 = 3.75 km

Average velocity $= \frac{1.25}{\frac{40}{60}} = 1.875$ km/h. (towards market)

Average speed $= \frac{3.75}{\frac{40}{60}} = 5.625$ km/h.

Ex.5 If a body travels half its total path in the last second of its fall from rest, find :

(a) The time and

(b) heights of its fall.

Explain the physically unacceptable solution of the quadratic time equation. ($g = 9.8$ m/s^2)

Sol. If the body falls a height h in time t, then

$h = \frac{1}{2}gt^2$ [u = 0 as the body starts from rest] ....**(i)**

Now, as the distance covered in (t – 1) second in $h' = \frac{1}{2}g(t-1)^2$ ......**(ii)**

So from Equation **(i)** and **(ii)** distance travelled in the last second.

$h - h' = \frac{1}{2}gt^2 - \frac{1}{2}g(t-1)^2$ i.e., $h - h' = \frac{1}{2}g(2t-1)$

But according to given problem as $(h - h') = \frac{h}{2}$

$\Rightarrow \left(\frac{1}{2}\right)h = \left(\frac{1}{2}\right)g(2t-1)$ or $\left(\frac{1}{2}\right)gt^2 = g(2t-1)$ [as from equation **(i)** $h = \left(\frac{1}{2}\right)gt^2$]

$\Rightarrow t^2 - 4t + 2 = 0$ or $t = [4 \pm \sqrt{(4^2 - 4\times)}]/2 \Rightarrow t = 2 \pm \sqrt{2} \Rightarrow t = 0.59$ s or 3.41 s

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

so t = 3.41 s and $h = 1/2 \times (9.8) \times (3.41)^2 = 57$ m

Ex.6 A passenger is standing d distance away from a bus. The bus begins to move with constant acceleration a. To catch the bus, the passenger runs at a constant speed u towards the bus. What must be the minimum speed of the passenger so that he may catch the bus ?

Sol. Let the passenger catch the bus after time t

The distance travelled by the bus, $s_1 = 0 + \frac{1}{2}at^2$ ...(i)

and the distance travelled by the passenger $s^2 = ut + 0$ ...(ii)

Now the passenger will catch the bus if $d + s_1 + s_2$ ...(iii)

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

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

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

Ex.7 A driver takes 0.20 s to apply the brakes after he see a need for it. This is called the reaction time of the driver. If he is driving a car at a speed of 54 km/h and the brakes cause a deceleration of 6.0 m/s2, find the distance travelled by the car after he sees the need to put the brakes on ?

Sol. Distance covered by the car after during the application of brakes by driver

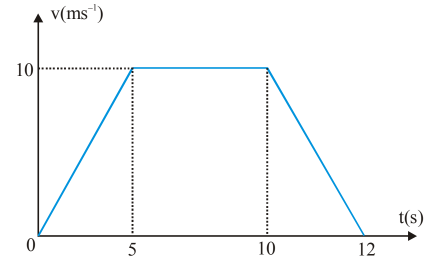
$s_1 = ut = \left(54 \times \frac{5}{18}\right)(0.2) = 15 \times 0.2 = 3.0\,m$

After applying the brakes ; $v = 0$, $u = 15$ m/s, $a = 6$ m/s^2 $s_2 = ?$

Using $V_2 = u_2 - 2as \Rightarrow 0 = (15)^2 - 2 \times 6 \times s_2 \Rightarrow 12\,s_2 = 255 \Rightarrow s_2 = \frac{255}{12} = 18.75$ m

Distance travelled by the car after driver sees the need for it $s = s_1 + s_2 = 3 + 18.75 = 21.75$ m

Ex.8 Draw displacement time and acceleration – time graph for the given velocity time - graph



Sol. For $0 \leq t \leq 5\; v \propto t^2$ and a_1 = constant $\frac{10}{5} = 2\ ms^{-2}$

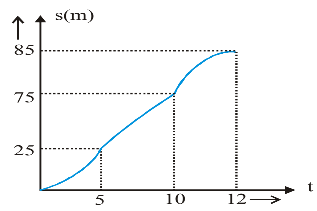
for whole intervals s1 = Area under the curve $= \frac{1}{2} \times 5 \times 10 = 25$ m

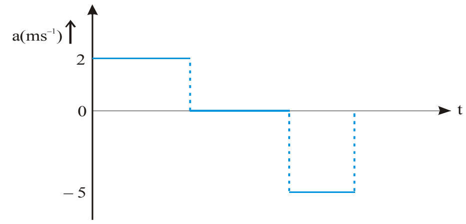
For $5 \leq t \leq 10$, $v = 10\ ms^{-1} \Rightarrow a = 0$

for whole interval s_2 = area under the curve $= 5 \times 10 = 50$ m

For $10 \leq t \leq 12$ v linearly decreases with time $\Rightarrow a_3 = -\frac{10}{2} = -5\ ms^{-2}$

for whole interval s_3 = Area under the curve $= \frac{1}{2} \times 2 \times 10 = 10$ m





Ex.9 A car accelerates from rest at a constat rate α for some time, after which it decelerates at a constant rate β, to come to rest. If total time elapsed is t evaluate **(a)** the maximum velocity attained and **(b)** the total distance travelled.

Sol. **(a)** Let the car accelerates for time t_1 and decelerates for time t_2 then $t = t_1 + t_2$ ...**(i)**

and corresponding velocity- time graph will be as shown in fig.

From the graph $a = \text{slope of line OA} = \dfrac{V_{max}}{t_1} \Rightarrow t_1 = \dfrac{V_{max}}{\alpha}$

and $b = -\text{slope of line AB} = \dfrac{V_{max}}{t_2} \Rightarrow t_2 = \dfrac{V_{max}}{\beta}$

$$\frac{V_{max}}{\alpha} + \frac{V_{max}}{\beta} = t \Rightarrow V_{max}\left(\frac{\alpha+\beta}{\alpha\beta}\right) = t \Rightarrow V_{max} = \frac{\alpha\beta t^2}{\alpha+\beta}$$

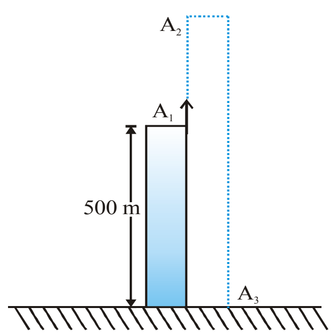
(b) Total distance $=$ area under v-t graph $= \dfrac{1}{2} \times t \times v_{max} = \dfrac{1}{2} \times t \times \dfrac{\alpha\beta t}{\alpha+\beta} = \dfrac{1}{2}\left(\dfrac{\alpha\beta t^2}{\alpha+\beta}\right)$

Note : This problem can also be solved by using equations of motion ($v = u + at$, etc).

Ex.10 At the height of 500m, a particle A is thrown up with $v = 75\ ms^{-1}$ and particle B is released from rest. Draw, acceleration - time, velocity- time, speed- time and displacement- time graph of each particle.

Sol.

For particle A:



Time of flight

$$-500 = +75t - \frac{1}{2} \times 10t^2$$

$\Rightarrow t^2 - 15t - 100 = 0$

$\Rightarrow t = 20\ s$

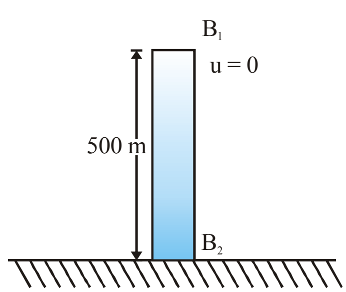
Time taken for A_1A_2

$v = 0 = 75 - 10t \Rightarrow t = 7.5\ s$

Velocity at A_3, $v = 75 - 10 \times 20 = -125$ ms–1

Height $A_2A_1 = 75 \times 7.5 - \dfrac{1}{2}(10)(7.5)^2 = 281.25$ m

For particle B



Time of flight

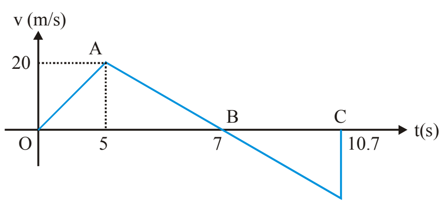
$$500 = \frac{1}{2}(10)t^2 \Rightarrow t = 10\ s$$

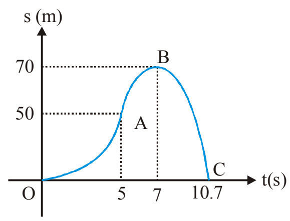
Velocity at B2

$v = 0 - (10)(10) = -100\ ms^{-1}$

Ex.11 A rocket is fired upwards vertically with a net acceleration of 4 m/s2 and initial velocity zero. After 5 second its fuel is finished and it decelerates with g. At the highest point its velocity becomes zero. Then it accelerates downwards with acceleration g return back to ground. Plot velocity-time and displacement graphs for the complete journey. Take $g = 10\ m/s^2$.

Sol.





In the graphs, $v_A = at_{OA} = (4)(5) = 20\ m/s$ $v_B = 0 = v_A - gt_{AB}$

$\therefore\ t_{AB} = \dfrac{v_A}{g} = \dfrac{20}{10} = 2s$ $\qquad \therefore\ t_{OAB} = (5+2)s = 7\ s$

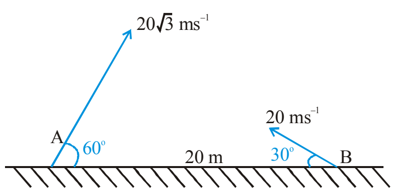
Now, s_{OAB} = area under v-t graph between 0 to 7 s $= \dfrac{1}{2}(7)(20) = 70\ m$

Now, $s_{OAB} = s_{BC} = \dfrac{1}{2}gt_{BC}^2$ $\qquad \therefore\ 70 = \dfrac{1}{2}(10)\,t_{BC}^2$

$\therefore\ \tau_{BX} = \sqrt{14} = 3.7\ s$ $\qquad \therefore\ t_{OABC} = 7 + 3.7 = 10.7\ s$

Also s_{OA} = area under v-t graph between OA $= \dfrac{1}{2}(5)(20) = 50\ m$

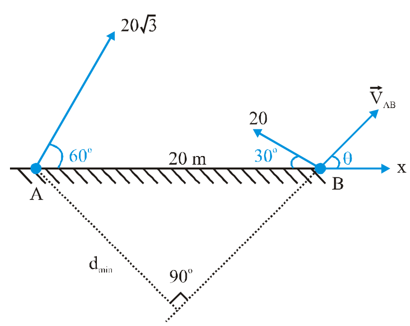
Ex.12 In the figure shown, the two projectile are fired simultaneously. Find the minimum distance between them during their flight.



Sol. Taking origin at A and x axis along AB

Velocity of A w.r.t B

$= 20\sqrt{3}\left(\cos 60\hat{i} + \sin 60\hat{j}\right) - 20\left(\cos 150\hat{i} + \sin 150\hat{j}\right)$



$= 20\sqrt{3}\left(\dfrac{1}{2}\hat{i} + \dfrac{\sqrt{3}}{2}\hat{j}\right) - 20\left(\dfrac{\sqrt{3}}{2}\hat{i} + \dfrac{1}{2}\hat{j}\right) = 20\sqrt{3}\hat{i} + 20\hat{j}$

$\tan\theta = \dfrac{20}{20\sqrt{3}} = \dfrac{1}{\sqrt{3}} \Rightarrow \theta = 30^\circ$

So $\dfrac{d_{min}}{20} = \sin\theta = \sin 30^\circ = \dfrac{1}{2} \Rightarrow d_{min} = 10m$

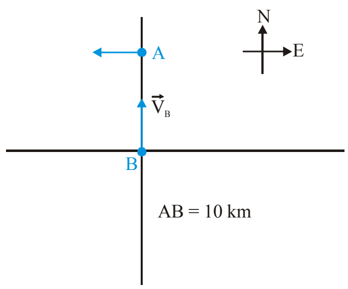
Ex.13 Two ships A and B are 10 km apart on a line running south to north. Ship A farther north is streaming west at 20 km/h and hip B is streaming north at 20 km/h. What is their distance of closest approach and how long do they take to reach it ?

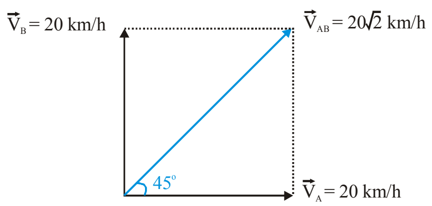
Sol. Ships A and B are moving with the same speed 20 km/h in the direction shown in figure. It is a two dimensional, two body problem with zero acceleration. Let us find $\vec{v}_{BA}$

Here $\left|\vec{V}_{BA}\right| = \sqrt{(20)^2 + (20)^2} = 20\sqrt{2}$ km/h

i.e., $\vec{V}_{BA}$ is 20 $\sqrt{2}$ km/h at an angle of 45° from east

towards north. Thus, the given problem can be simplified as :





A is at rest and B is moving with $\vec{V}_{BA}$ in the direction shown in figure.

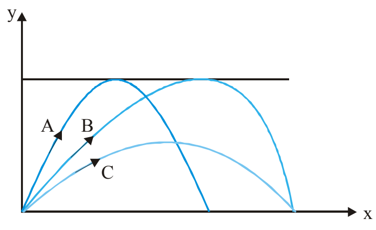
Therefore, the minimum distance between the two is

$$s_{min} = AC = AB\sin 45^\circ = 10\left(\frac{1}{\sqrt{2}}\right)\text{km} = 5\sqrt{2}\,\text{km}$$

and the desired time is $t = \dfrac{BC}{\left|\vec{V}_{BA}\right|} = \dfrac{5\sqrt{2}}{20\sqrt{2}} = \dfrac{1}{4}\text{h} = 15\,\text{min}$

Ex.14 Three particles are projected from same point and their paths are as shown. Compare their horizontal and vertical component of velocities of projection

Sol.



$H_A = H_B\ H_C \Rightarrow (u_y)_A = (u_y)_B > (u_y)_C$

$\therefore$ $R_B > R_A$

i.e., $(u_x u_y)_B > (u_x u_y)_A$ [$\because$ their u_x are equal]

$\therefore$ $(u_x)_B > (u_x)_A$

Also $R_B = R_C$

i.e., $(u_x u_y)_B = (u_x u_y)_C$

but $(u_y)_B > (u_y)_C$

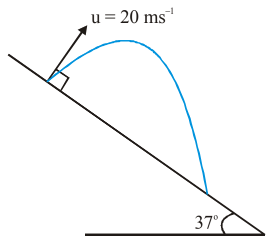
$\therefore$ $(u_x)_C > (u_x)_B > (u_x)_C$

Ex.15 Find range of projectile on the inclined plane which is projected perpendicular to the incline plane with velocity 20 m/s as shown in figure.

Sol. $\beta = 37^o$

$\alpha - \beta = 90^o$ & $\alpha = 90^o + \beta = 90^o + 37^o$

$\therefore$ Range , $R = \dfrac{2(20)^2 \sin(90^o)\cos(90^o + 37^o)}{10 \times \cos^2 37^o}$



$= \dfrac{2(400)}{10(4/5)^2} \times \left(-\dfrac{3}{5}\right)$ $\left[\because \cos(90^o + \theta) = -\sin\theta\right]$

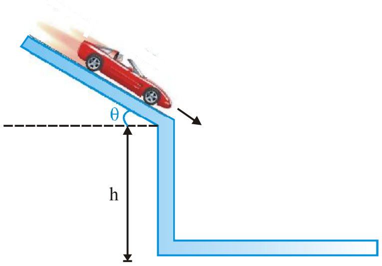
$\therefore$ $R = -75$ m

$\therefore$ $|R| = 75$ m

Here negative sign shown that particle strikes the plane along down the incline

Ex.16 A car goes out of control and slides off a steep embankment of height h at θ to the horizontal. It lands in a ditch at a distance T from the base. Find the speed at which the car leaves the slope.

(Take h = 12. 5 m; R = 10 m; θ = 45°)



Sol. $\Delta x = 10 = (u \cos 45^o)t \Rightarrow t = \dfrac{10\sqrt{2}}{u}$

$\Delta y = -(u \sin 45o)t - \dfrac{1}{2}gt^2 = -12.5$

$\Rightarrow$ $\left(\dfrac{u}{\sqrt{2}} \times \dfrac{10\sqrt{2}}{u}\right) + \dfrac{1}{2}(10)\left(\dfrac{10\sqrt{2}}{u}\right)^2 = 12.5$

Ex.17 A particle is dropped from the top of a high building of height 360 m. The distance travelled by the particle in ninth second is (g = 10 m/s^2)

(A) 85 m **(B)** 60 m

(C) 40 m **(D)** Can`t be determined

Sol. Total time taken by particle to reach the ground $T = \sqrt{\dfrac{2H}{g}} = \sqrt{\dfrac{2 \times 360}{10}} = 6\sqrt{2} = 8.4484\,s$

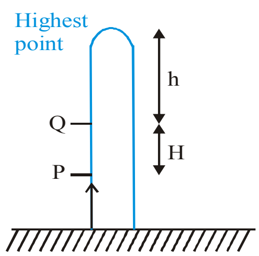
Distance travelled in 8 seconds = $\dfrac{1}{2}gt^2 = \dfrac{1}{2}(10)(8)^2 = 320\,m$

Therefore distance travelled in ninth second = 360 – 320 = 40 m

Ex.18 A particle is thrown vertically upward from the surface of the earth. Let T_P be the time taken by the particle to travel from a point P above the earth to its highest point and back to the point P. Similarly, let T_Q be the time taken by the particle to travel from another point Q above the earth to its highest point and back to the same point Q. If the distance between the point P and Q is H, the expression for acceleration due to gravity in terms of T_P , T_Q and H is

(A) $\dfrac{6H}{T_P^2 + T_Q^2}$ **(B)** $\dfrac{8H}{T_P^2 - T_Q^2}$ **(C)** $\dfrac{2H}{T_P^2 + T_Q^2}$ **(D)** $\dfrac{H}{T_P^2 - T_Q^2}$

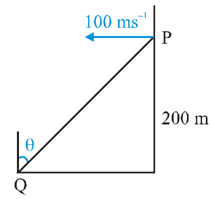
Sol. Time taken from point P to point P $T_P = 2\sqrt{\dfrac{2(h+H)}{g}}$



Time taken from point Q to point Q $T_Q = 2\sqrt{\dfrac{2h}{g}}$

$\Rightarrow$ $T_P^2 = \dfrac{8(h+H)}{g}$ and $T_Q^2 = \dfrac{8h}{g}$ $\Rightarrow T_P^2 = T_Q^2 + \dfrac{8H}{g}$ $\Rightarrow$ $g = \dfrac{8H}{T_P^2 - T_Q^2}$

Ex.19 An aeroplane is travelling horizontally at a height of 2000 m from ground. The aeroplane, when at a point P, drops a bomb to hit a stationary target Q on the ground. In order that the bomb hits the target, what angle q must the line PQ make with the vertical ? [$g = 10\ ms^{-2}$]

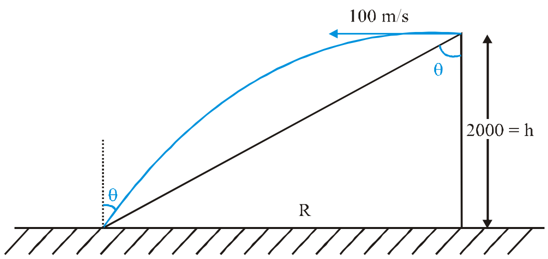


(A) 15° **(B)** 30° **(C)** 90° **(D)** 45°

Sol. Let t be the time taken by bomb to hit the target.

$h = 2000 = \dfrac{1}{2}gt^2 \Rightarrow t = 20$ sec

$R = ut = (100)(20) = 2000$ m



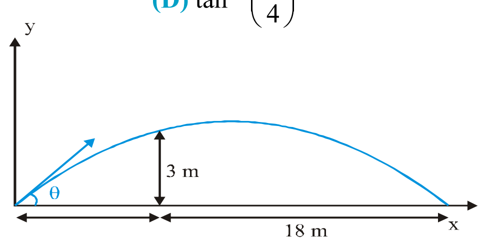
$\because$ $\tan\theta = \dfrac{R}{h} = \dfrac{2000}{2000} = 1 \Rightarrow \theta = 45°$

Ex.20 A ball is thrown from the ground to clear a wall 3 m high at a distance of 6 m and falls 18 m away from the wall, the angle of projection of ball is

(A) $\tan^{-1}\left(\dfrac{3}{2}\right)$ **(B)** $\tan^{-1}\left(\dfrac{2}{3}\right)$ **(C)** $\tan^{-1}\left(\dfrac{1}{2}\right)$ **(D)** $\tan^{-1}\left(\dfrac{3}{4}\right)$

Sol. From equation of trajectory $y = x\tan\theta$

$\left[1 - \dfrac{x}{R}\right] \Rightarrow 3 = 6\tan\theta\left[1 - \dfrac{1}{4}\right] \Rightarrow \tan\theta = \dfrac{2}{3}$



Ex.21 A particle moves in XY plane such that its position, velocity and acceleration are given by

$$\vec{r} = x\hat{i} + y\hat{j}\ ;\quad \vec{v} = v_x\hat{i} + v_y\hat{j}\ ;\quad \vec{a} = a_x\hat{i} + a_y\hat{j}$$

which of the following condition is correct if the particle is speeding down ?

(A) $xv_x + yv_y < 0$ **(B)** $xv_x + yv_y > 0$ **(C)** $a_xv_x + a_yv_y < 0$ **(D)** $a_xv_x + a_yv_y > 0$

Sol. For speeding down $\vec{a}.\vec{v} < 0 \Rightarrow a_xv_x + a_yv_y < 0$

Ex.22 A large number of particles are moving each with speed v having directions of motion randomly distributed. What is the average relative velocity between any two particles averaged over all the pairs ?

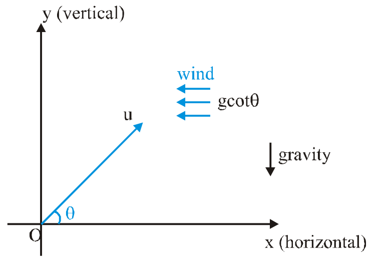
(A) v **(B)** $(\pi/4)v$ **(C)** $(4/\pi)v$ **(D)** Zero

Sol. Relative velocity, $v_r = |\vec{v}_1 - \vec{v}_2|$ where $v_1 = v_2 = v$

If angle between them be θ, then $v_r = \sqrt{v^2 + v^2 - 2v^2\cos\theta} = \sqrt{2v^2(1-\cos\theta)} = 2v\sin\left(\frac{\theta}{2}\right)$

Hence, average relative velocity $\vec{v}_r = \dfrac{\int_0^{2\pi} 2v\sin\frac{\theta}{2}d\theta}{\int_0^{2\pi} d\theta} = \dfrac{4v}{\pi}$

Ex.23 A ball is projected as shown in figure. The ball will return to point

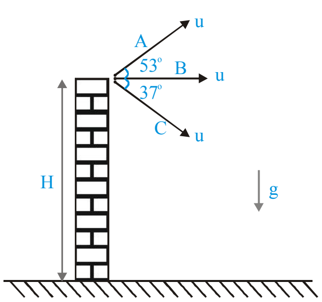


(A) O **(B)** left to point O **(C)** right to point O **(D)** none of these

Sol. Here $\frac{a_x}{a_y} = \frac{g\cot\theta}{g} = \frac{1}{\tan\theta} = \frac{u_x}{u_y} \Rightarrow$ Initial velocity & acceleration are opposite to each other.

$\Rightarrow$ Ball will return to point O.

Ex.24 Three point particles A, B and C are projected from same point with same speed at $t = 0$ as shown in figure. For this situation select correct statement(s).



(A) All of them reach the ground at same time.

(B) All of them reach the ground at different time.

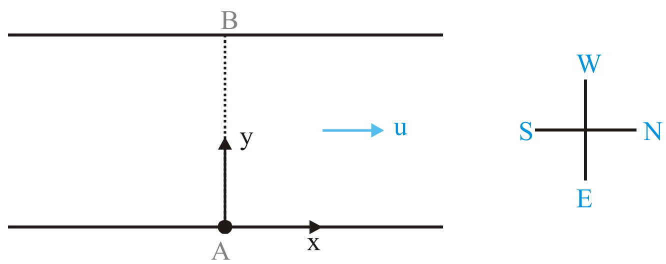
(C) All of them reach the ground with same speed.

(D) All of them have same horizontal displacement when they reach the ground.

Sol. Vertical component of initial velocities are different $\Rightarrow$ reach the ground at different time.

Ex.25 to 27

A river of which 'd' with straight parallel banks flows due to North with speed u. A boat, whose speed is v relative to water, starts from A and crosses the river. If the boat is steered due West and u varies with y as $u = \frac{y(d-y)v}{d^2}$ then answer the following questions.



Ex.25 The time taken by boat to cross the river is

(A) $\frac{d}{\sqrt{2}v}$ **(B)** $\frac{d}{v}$ **(C)** $\frac{d}{2v}$ **(D)** $\frac{2d}{v}$

Ex.26 Absolute velocity of boat when it reaches the opposite bank is

(A) $\frac{4}{3}$v ,towards East **(B)** v, towards West **(C)** $\frac{4}{3}$v, towards West **(D)** v, towards East

Ex.27 Equation of trajectory of the boat is

(A) $y = \frac{x^2}{2d}$ **(B)** $x = \frac{y^2}{2d}$ **(C)** $y = \frac{x^2}{2d} - \frac{x^2}{3d^2}$ **(D)** $x = \frac{y^2}{2d} - \frac{y^2}{3d^2}$

Sol. 25 to 27

25. **(B)**

Time taken $= \frac{d}{v_y} = \frac{d}{v}$

26. **(B)**

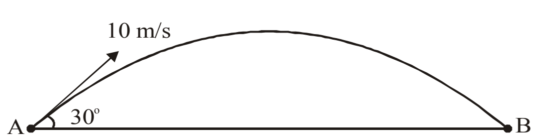
At y =d , u = 0 so absolute velocity of boat = v towards West.

27. **(D)**

For boat (w.r.t. ground) $v_y = v$, $v_x = u = \frac{y(d-y)}{d^2}v \Rightarrow \frac{dy}{dt} = v$ and $\frac{y(d-y)}{d^2}v \Rightarrow \frac{dx}{dt} = \frac{y(d-y)}{d^2}v$

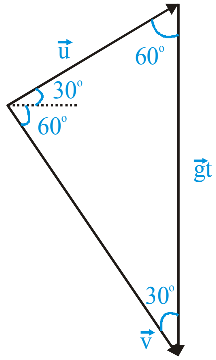
$$\frac{dx}{dy} = \frac{y(d-y)}{d^2} \Rightarrow \int_0^x dx = \int_0^y dx \frac{(yd-y^2)}{d^2}dy \Rightarrow x = \frac{y^2}{2d} - \frac{y^3}{3d^2}$$

Ex.28 As shown in the figure there is a particle of mass $\sqrt{3}$ kg, is projected with speed 10 m/s at an angle 30° with horizontal (take g = 10 m/s²) then match the following



	Column-I		Column-II
(A)	Average velocity (in m/s) during half of the time of flight, is	(P)	$\frac{1}{2}$
(B)	The time (in sec) after which the angle between velocity vector and initial velocity vector becomes $\pi/2$, is	(Q)	$\frac{5}{2}\sqrt{13}\ \frac{5}{2}\sqrt{13}$
(C)	Horizontal range (in m), is	(R)	$5\sqrt{3}$
(D)	Change in linear momentum (in N-s) when particle is at highest point, is	(S)	At an angle of tan–1 $\left(\frac{1}{2\sqrt{3}}\right)$ from horizontal
		(T)	2

Sol. **For (A) :** $v_{av} = \sqrt{(v_{avx})^2 + (v_{avy})^2} = \sqrt{(10\cos 30^\circ)^2 + \left(\frac{10\cos 30^\circ + 0}{2}\right)^2} = \sqrt{75 + \frac{25}{4}} = \frac{5}{2}\sqrt{13}$ m/s



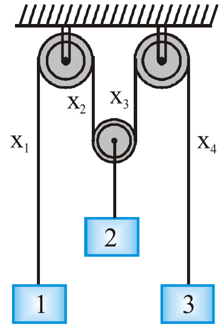
Angle with horizontal $\theta = \tan^{-1} = \left(\frac{v_{avy}}{v_{avx}}\right) = \tan^{-1}\left(\frac{5/2}{5\sqrt{3}}\right) = \tan^{-1}\left(\frac{1}{2\sqrt{3}}\right)$

For (B) : By using $\vec{v} = \vec{u} + \vec{a}t$ We have $\frac{u}{gt} = \sin 30^\circ \Rightarrow t = \frac{10}{(10)(1/2)} = 2$

For (C) : Horizontal range (R) $= \frac{u^2 \sin 2\theta}{g} = \frac{100 \times \sqrt{3}/2}{10} = 5\sqrt{3}$ m

For (D) : Change in linear momentum $= mu_y = \sqrt{3} \times 10 \sin 30^\circ = 5\sqrt{3}$ N-s

Ex.29 Find the reaction between acceleration of blocks a_1, a_2 and a_3.



Sol. $x_1 + x_2 + x_3 + x_4 = l$

$\Rightarrow \ddot{x}_1 + \ddot{x}_2 + \ddot{x}_3 + \ddot{x}_4 = 0$

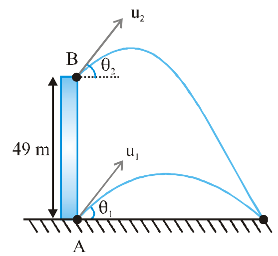
$\Rightarrow a_1 + a_2 + a_2 + a_3 = 0$

$\Rightarrow a_1 + 2a_2 + a_3 = 0$

$$\Rightarrow \left(\frac{u}{\sqrt{2}} \times \frac{10\sqrt{2}}{u}\right) + \frac{1}{2}(10)\left(\frac{10\sqrt{2}}{u}\right)^2 = 12.5$$

$$\Rightarrow \left(\frac{u}{\sqrt{2}} \times \frac{10\sqrt{2}}{u}\right) + \frac{1}{2}(10)\left(\frac{10\sqrt{2}}{u}\right)^2 = 12.5$$

Ex.30 Two stones A and B are projected simultaneously as shown in figure. It has been observed that both the stones reach the ground at the same place after 7 sec of their projection. Determine difference in their vertical components of initial velocities in m/g. ($g = 9.8\ m/s^2$)



Sol. In time of flight i.e., 7 s, the vertical displacement of A is zero and that of B is 49 m so for relative motion of B w.r.t. A

$(u_2 \sin\theta_2 - u_1 \sin\theta_1) \times 7 = 49 \Rightarrow u_2 \sin\theta_2 - u_1 \sin\theta_1 = 7\ \text{m/s}$

Ex.31 An aeroplane pilot wishes to fly due west. A wind of 100 km/h is blowing toward the south

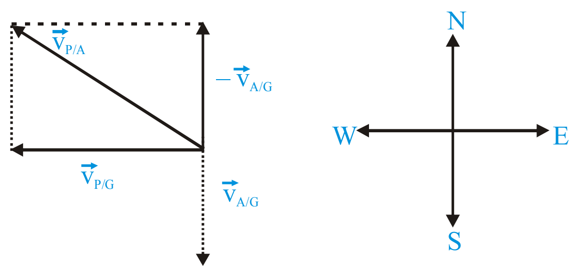
(A) What is the speed of the plane with respect to ground ?

(B) If the airspeed of the plane (its speed in still air) is 300 km/h, in which direction should the pilot head ?

Sol. **(A)** Given,

Velocity of air with respect of ground $\vec{V}_{A/G} = 100$ km/hr

Velocity of plane with respect to air $\vec{V}_{P/A} = 300$ km/hr

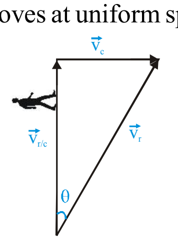


(B) As the plane is to move towards west, due to air in south direction, air will try drift the plane in south direction., air will try to drift the plane in south direction. Hence, the plane has to make an angle θ towards north-west, south west direction, in order to reach at point on west.

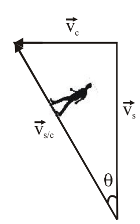
$\vec{V}_{P/A} = \vec{V}_{P/G} - \vec{V}_{A/G}$ and $\vec{V}_{P/A} = \sin\theta - V_{AG}$

Ex.32 Ram crossing a 2.5 m wide conveyor belt moves with a speed of 1.6 m/s. The conveyor belt moves at uniform speed of 1.2 m/s.

(A) If the Ram walks straight across the belt, determine the velocity of the Ram relative to an observer standing on ground.



(B) If Shayam has same speed on a still conveyor belt, and is to reach directly across the same moving conveyor belt. At what should he walk ?



Sol. (A) If you walk across a conveyor belt while the conveyor belt takes you along the length, you will not be able to move directly across the conveyor belt, but will end up down the length.

Here the velocity of the Ram will be net effect of his own motion of conveyor belt. The velocity of the Ram relative to the conveyor belt v_{rc}, is same as velocity of Ram if conveyor belt was still,

v_c is the velocity of the conveyor belt

we need to find v_r, the velocity of the Ram relative to the Earth.

Writing Equation of net motion $v_r = v_{rc} + vc$.

three vectors are shown in figure. The quantity v_{rc} is due y ; v_c is due x ; and the vector sum of the two v_r, is at an angle θ as defined in figure

the speed υ_r of the Ram relative to the Earth is $v_r = \sqrt{v_{s/c}^2 - v_c^2}$

(B) To go straight across the conveyor belt he has to walk at some angle.

Writing Equation of net motion $v_s = v_{s/c} + v_c$

three vectors are shown in figure

As in part , we know v_c and the magnitude of the vector $v_{s/c}$ and we want v_c to be directed across the conveyor belt

$\upsilon_s = \sqrt{v_{s/c}^2 - v_c^2}$

Ex.33 A river flows due to south with a speed of 2.0 m/s. A man steers a motorboat across the diver: his velocity relative to the water is 4 m/s due east. The river is 800 m wide.

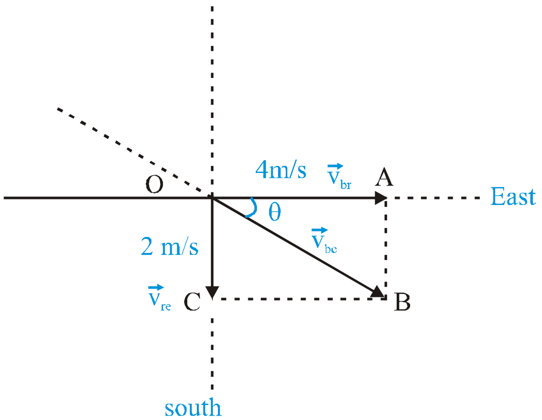
(A) What is his velocity (magnitude direction) relative to the earth ?

(B) How much time is required to cross the river ?

(C) How far south of his starting point will be reach the opposite bank ?

Sol. Velocity of river (i.e., speed of river w.r.t. earth) $\vec{\upsilon}_{rc} = 2$ m/s

Width of the river = 800 m



According to the given statement the diagram will be as given

(A) When two vectors are acting at an angle of 90o , their resultant can be obtained by phythagorous theorem,

$$\vec{v}_{be} = \sqrt{\upsilon_{br}^2 + \upsilon_{re}^2} = \sqrt{16+4} = \sqrt{20} = 4.6 \text{ m/s}$$

To find direction, we have

$$\tan\theta = \frac{\upsilon_{re}}{\upsilon_{br}} = \frac{2}{4} = \frac{1}{2} \quad \Rightarrow \quad \theta = \tan^{-1}\left(\frac{1}{2}\right)$$

(B) Time taken to cross the river $= \dfrac{\text{Displacement of boat w.r.t. river}}{\text{Velocity of boat w.r.t. river}} \Rightarrow \dfrac{800}{4} = 200\text{ s}$

(C) Desired position on other side is A, but due to current of river boat is drifted to position B. To find out this drift we need time taken in all to cross the river (200s) and speed of current (2 ms^{-1}).

So distance AB = Time taken × speed of current = 200 × 2 = 400 m.

Hence, the boat is drifted but 400 m away from position A.

Ex.34 A person standing on a road has to hold his umbrella at 60º with the vertical to keep the rain away. He throws the umbrella and starts running at 20 ms^{-1}. He finds that rain drops are falling on him vertically. Find the speed of the rain drops with respect to

(A) the road, and

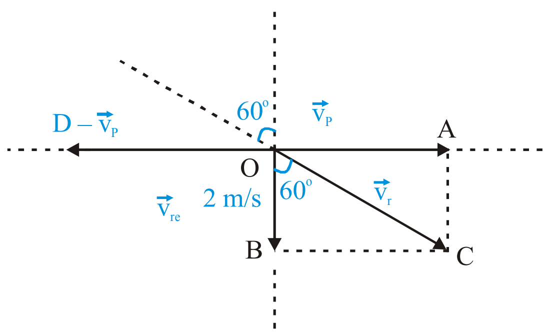
(B) the moving person.

Sol. Given $\theta = 60^{o}$ and velocity person

$\vec{v}_P = \overrightarrow{OA} = 20\text{ ms}^{-1}$

This velocity is the same as the velocity of person w.r.t. ground. First of all let`s see how the diagram works out.

$\vec{\upsilon}_{rP} = \overrightarrow{OB} =$ velocity of rain w.r.t. the person



$\vec{\upsilon}_r = \overrightarrow{OC} =$ velocity of rain w.r.t. earth $\vec{\upsilon}_{rP}$ is along $\overrightarrow{OB}$ as a person has to hold umbrella at an angle with vertical which is the angle between velocity of rain and velocity of rain w.r.t. the person .

Values of $\vec{\upsilon}_r$ and $\vec{\upsilon}_{rP}$ can be obtained by using simple trigonometric relations.

(A) Speed of rain drops w.r.t. earth $= \vec{\upsilon}_r = \overrightarrow{OC}$

From ΔOCM, $\dfrac{CB}{OC} = \sin 60^{o} \Rightarrow OC = \dfrac{CB}{\sin 60^{o}}$

$$= \frac{20}{\sqrt{3}/2} = \frac{40}{\sqrt{3}} = \frac{40\sqrt{3}}{3}\ \text{ms}^{-1}$$

(B) Speed of rain w.r.t. the person $\vec{\upsilon}_{rP} = \overrightarrow{OB}$

From ΔOCM, $\dfrac{OB}{CB} = \cot 60^{o}$

$$\Rightarrow \quad OB = CB\ \cot 60^{o} = \frac{20}{\sqrt{3}} = \frac{20\sqrt{3}}{3}\ \text{ms}^{-1}$$

Ex.35 A person walk up a stationary escalator in t1 second. If he remains stationary on the escalator, then it can take him up t2 second. If the length of the escalators is L, then

(A) Determine the speed of man with respect to the escalator.

(B) Determine the speed of the escalator

(C) How much time would it take him to walk up the moving escalators ?

Sol.

(A) As the escalators is stationary, so the distance covered in t_1 second is L which is the length of the escalator.

Speed of the man w.r.t. the escalator $\upsilon_e = \frac{L}{t_1}$

(B) When the man is stationary, by taking man as reference point the distance covered b y the escalator is L in time t_2.

Speed of escalator $\upsilon_e = \frac{L}{t_2}$

(C) Speed of man w.r.t. the ground

$$v_m = v_{me} + v_e$$

$$\Rightarrow \quad v_m = \frac{L}{t_1} + \frac{L}{t_2} = L\left[\frac{1}{t_2} + \frac{1}{t_2}\right] = L\left[\frac{t_1 + t_2}{t_1 t_2}\right] \quad \Rightarrow \quad L = \upsilon_m \left[\frac{t_1 t_2}{t_1 + t_2}\right]$$

$\left[\frac{t_1 t_2}{t_1 + t_2}\right]$ is the time taken by the man to walk up the moving escalator.

Ex.36 A man wants to cross a river 500 m wide. Rowing speed of the man relative to water is 3 km/hr and river flows at the speed of 2 km/hr. If man`s walking speed on the shore is 5 km/hr, then in which direction he should starts rowing in order to reach the directly opposite point on the bank in shortest time.

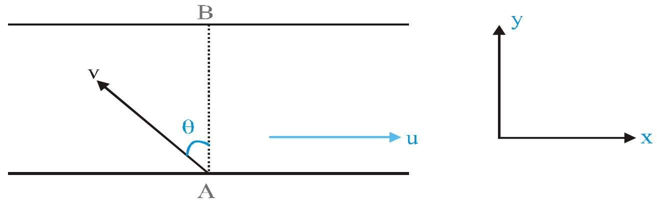
Sol. Let he should starts at an angle θ with normal

hence

$$\vec{v}_m = (u - v\sin\theta)\hat{i} + v\cos\theta\hat{j}$$

Here $\vec{v}_m$ = velocity of the man relative to water

u = velocity of water



Hence time taken by the man to cross the river is $t_1 = \frac{0.5}{v\cos\theta}$

∴ Drift of the man to cross the river is

$x = (u - v \sin\theta)\, t1$

$$x = (u - v\sin\theta)\frac{0.5}{v\cos\theta}$$

Time taken by the man to cover this distance is

$$t_2 = \frac{0.5\left(\frac{u\sec\theta}{v}\tan\theta\right)}{5} = 0.1\left(\frac{u}{v}\sec\theta - \tan\theta\right)$$

Therefore,

total time $T = t_1 + t_2$

$$\Rightarrow \qquad T = \frac{0.5}{v}\sec\theta + \frac{0.1u}{v}\sec\theta - 0.1\tan\theta$$

Putting the value of u and v, we get

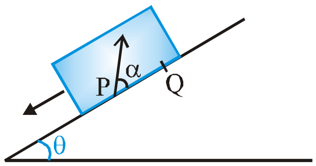
$$T = \frac{0.5}{3}\sec\theta + \frac{0.1\times 2}{3}\sec\theta - 0.1\tan\theta$$

$$= \frac{0.7}{3}\sec\theta - 0.1\tan\theta \qquad \Rightarrow \qquad \frac{dt}{d\theta} = \frac{0.7}{3}\sec\theta\tan\theta - 0.1\sec^2\theta$$

for T to be minimum

$$\frac{dt}{d\theta} = 0 \quad \Rightarrow \qquad \sin\theta = (3/7) \qquad \Rightarrow \qquad \theta = \sin^{-1}(3/7)$$

Ex.37 A large heavy box is sliding without friction down a smooth plane of inclination θ. From a point P on the bottom of a box, a particle is projected inside the box. The initial speed of the particle with respect to box. The initial speed of the particle with respect to box is u and the direction of projection makes an angle α with the bottom as shown in figure.



(a) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands. (Assume that the particle does not hit any other surface of the box. Neglect air resistance).

(b) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected.

Sol. **(a)** u is the relative velocity of the particle with respect to the box. Resolve u.

u_x is the relative velocity of the particle with respect to the box in x- direction.

uy is the relative velocity with respect to the box in y- direction, therefore this is the vertical velocity of the particle with respect to ground also.

Y- direction motion (Taking relative terms w.r.t. box)

$u_y = +u\sin\alpha$

$a_y = -g\cos\theta$

$s_y = 0$

$$s_y = u_y t + \frac{1}{2}a_y t^2 \;\Rightarrow\; 0 = (u\sin\alpha)t - \frac{1}{2}g\cos\theta\times t^2 \;\Rightarrow\; t = \frac{2u\sin\alpha}{g\cos\theta}$$

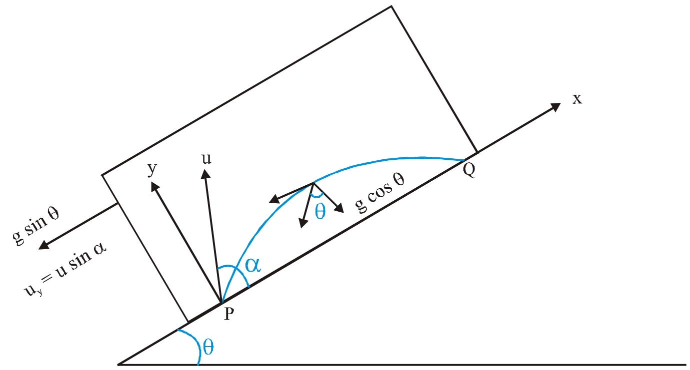
x-direction motion (Taking relative terms w.r.t. box)

$u_x = +\cos\alpha\ ;\ a_x = 0$

$$s_x = u_y t + \frac{1}{2}a_y t^2 \;\Rightarrow\; s_x = u\cos\alpha\times\frac{2u\sin\alpha}{g\cos\theta} = \frac{u^2\sin 2\alpha}{g\cos\theta}$$

(b) For the observer (on ground) to see the horizontal displacement to be zero, the distance travelled by the box in time $\left(\frac{2u\sin 2\alpha}{g\cos\theta}\right)$ should be equal to the range of the particle w.r.t. box.

Let the speed of the box at the time projection of particle be U. Then for the motion of box with respect to ground.



$u_x = -U; a_x = -g\sin\theta; t = \frac{2u\sin\alpha}{g\cos\theta}; s_x = \frac{-u^2\sin 2\alpha}{g\cos\theta}$ $\Rightarrow$ $s_x = u_x t + \frac{1}{2}a_x t^2$

$$\frac{-u^2\sin 2\alpha}{g\cos\theta} = -U\left(\frac{2u\sin\alpha}{g\cos\theta}\right) - \frac{1}{2}g\sin\theta\left(\frac{2u\sin\alpha}{g\cos\theta}\right)^2$$

on solving we get

$$U = \frac{u\cos(\alpha+\theta)}{\cos\theta}$$

Exercise # 1

[Single Correct Choice Type Questions]

1. A particle moves in straight line in same direction for 20 seconds with velocity 3 m/s and then moves with velocity 4 m/s for another 20 sec and finally moves with velocity 5 m/s for next 20 seconds. What is the average velocity of the particle?

(A) 3 m/s **(B)** 4 m/s **(C)** 5 m/s **(D)** Zero

2. A bird moves from point $(1, -2, 3)$ to $(4, 2, 3)$. If the speed of the bird is 10 m/s, then the velocity vector of the bird is :-

(A) $5\left(\hat{i} - 2\hat{j} + 3\hat{k}\right)$ **(B)** $5\left(4\hat{i} + 2\hat{j} + 3\hat{k}\right)$

(C) $0.6\hat{i} + 0.8\hat{j}$ **(D)** $6\hat{i} + 8\hat{j}$

3. A particle is moving in x–y–plane at 2 m/s along x–axis. 2 seconds later, its velocity is 4 m/s in a direction making 60° with positive x–axis. Its average acceleration for this period of motion is:-

(A) $\sqrt{5}$ m/s^2, along y–axis **(B)** $\sqrt{3}$ m/s^2, along y–axis

(C) $\sqrt{5}$ m/s^2, along at 60° with positive x–axis **(D)** 3m/s^2, at 60° with positive x–axis.

4. The coordinates of a moving particle at time t are given by $x = ct^2$ and $y = bt^2$. The speed of the particle is given by :–

(A) $2t(c+b)$ **(B)** $2t\sqrt{c^2 - b^2}$ **(C)** $t\sqrt{c^2 + b^2}$ **(D)** $2t\sqrt{c^2 + b^2}$

5. The velocity of a particle moving along x–axis is given as $v = x^2 - 5x + 4$ (in m/s) where x denotes the x–coordinate of the particle in metres. Find the magnitude of acceleration of the particle when the velocity of particle is zero?

(A) 0 m/s^2 **(B)** 2 m/s^2 **(C)** 3 m/s^2 **(D)** None of these

6. A, B, C and D are points in a vertical line such that AB = BC = CD. If a body falls from rest from A, then the times of descend through AB, BC and CD are in the ratio :-

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

(C) $\sqrt{3} : 1 : \sqrt{2}$ **(D)** $1 : (\sqrt{2} - 1) : (\sqrt{3} - \sqrt{2})$

7. A body starts from rest and is uniformly accelerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then $x_1 : x_2 : x_3$ is the same as:-

(A) 1 : 2 : 4 **(B)** 1 : 2 : 5 **(C)** 1 : 3 : 5 **(D)** 1 : 3 : 9

8. A particle has an initial velocity of $(3\hat{i} + 4\hat{j})$ m/s and a constant acceleration of $(4\hat{i} - 3\hat{j})$ m/s^2. Its speed after one second will be equal to :-

(A) 0 **(B)** 10 m/s **(C)** $5\sqrt{2}$ m/s **(D)** 25 m/s

9. A particle is projected vertically upwards and it reaches the maximum height H in T seconds . The height of the particle at any time t will be :-

(A) $H - g(t-T)^2$ **(B)** $g(t-T)^2$ **(C)** $H - \frac{1}{2}g(t-T)^2$ **(D)** $\frac{g}{2}(t-T)^2$

10. A particle is projected vertically upwards from a point A on the ground. It takes t_1 time to reach a point B but it still continues to move up. If it takes further t_2 time to reach the ground from point B then height of point B from the ground is :-

(A) $\frac{1}{2}g\left(t_1 + t_2\right)^2$ **(B)** gt_1t_2 **(C)** $\frac{1}{8}g\left(t_1 + t_2\right)^2$ **(D)** $\frac{1}{2}gt_1t_2$

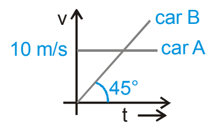
11. A parachutist drops freely from an aeroplane for 10 s before the parachute opens out. Then he descends with a net retardation of $2.5\ m/s^2$. If he bails out of the plane at a height of 2495 m and $g = 10\ m/s^2$, hit velocity on reaching the ground will be :-

(A) 5 m/s **(B)** 10 m/s **(C)** 15 m/s **(D)** 20 m/s

12. With what speed should a body be thrown upwards so that the distances traversed in 5th second and 6th second are equal ?

(A) 58.4 m/s **(B)** 49 m/s **(C)** $\sqrt{98}$ m/s **(D)** 98 m/s

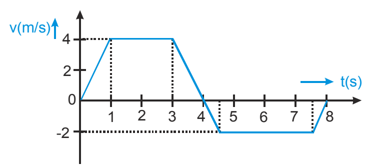
13. Initially car A is 10.5 m ahead of car B. Both start moving at time t=0 in the same direction along a straight line. The velocity time graph of two cars is shown in figure. The time when the car B will catch the car A, will be:-



(A) t = 21 sec **(B)** $t = 2\sqrt{5}$ sec

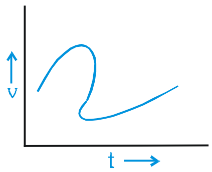
(C) 20 sec **(D)** None of these

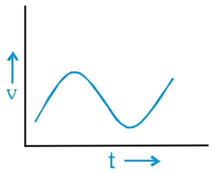
14. The velocity – time graph of a linear motion is shown in figure. The displacement & distance from the origin after 8 sec. is :-

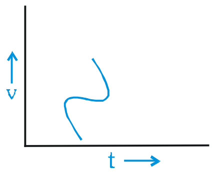


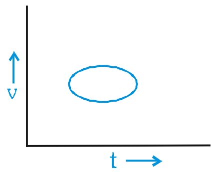
(A) 5 m, 19m **(B)** 16 m,22m **(C)** 8 m,19m **(D)** 6 m, 5m

15. Which of the following velocity–time graph shows a realistic situation for a body in motion :–

(A)


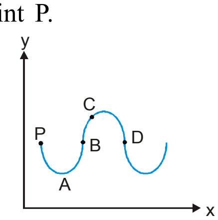
(B)


(C)


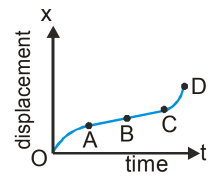
(D)


16. A man moves in x–y plane along the path shown. At what point is his average velocity vector in the same direction as his instaneous velocity vector. The man starts from point P.

(A) A
(B) B
(C) C
(D) D

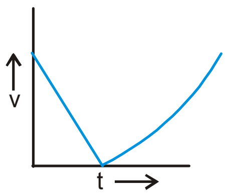


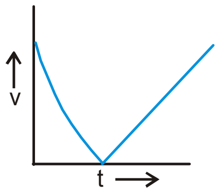
17. The graph between the displacement x and time t for a particle moving in a straight line is shown in figure. During the interval OA, AB, BC and CD, the acceleration of the particle is :

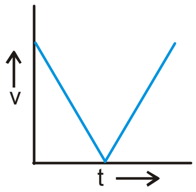


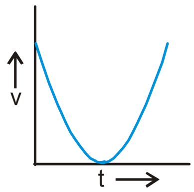
	OA,	AB,	BC,	CD
(A)	+	0	+	+
(B)	–	0	+	0
(C)	+	0	–	+
(D)	–	0	0	+

18. A ball is thrown vertically upwards. Which of the following plots represents the speed–time graph of the ball during its flight if the air resistance is ignored :–

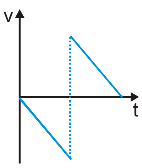
(A) 

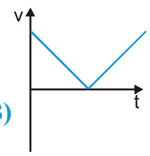
(B) 

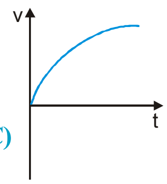
(C) 

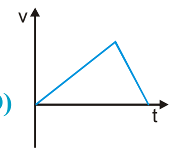
(D) 

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

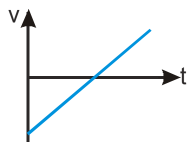
(A) 

(B) 

(C) 

(D) 

20. Which of the following situation is represented by the velocity–time graph as shown in the diagram :–



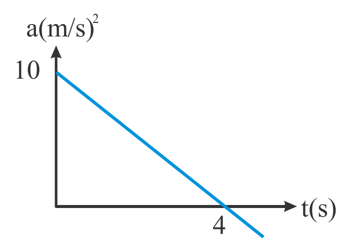
(A) A stone thrown up vertically, returning back to the ground

(B) A car decelerating at constant rate and then accelerating at the same rate

(C) A ball falling from a height and then bouncing back

(D) None of the above

21. 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?



(A) 12 sec

(B) 5 sec

(C) 8 sec

(D) 16 sec

22. A river is flowing from west to east at a speed of 5 meters per minute. A man on the south bank of the river, capable of swimming at 10 meters per minute in still water, wants to swim across the river in the shortest time. He should swim in a direction :-

(A) Due north **(B)** 30° east of north **(C)** 30° north of west **(D)** 60° east of north

23. A man starts running along a straight road with uniform velocity $\vec{u} = u\hat{i}$ feels that the rain is falling vertically down along $\hat{j}$. If he doubles his speed he finds that the rain is coming at an angle θ to the vertical. The velocity of rain with respect to the ground is :-

(A) $u\hat{i} - u\tan\theta\,\hat{j}$ **(B)** $u\hat{i} - \dfrac{u}{\tan\theta}\hat{j}$ **(C)** $u\tan\theta\,\hat{i} - u\hat{j}$ **(D)** $\dfrac{u}{\tan\theta}\hat{i} - u\hat{j}$

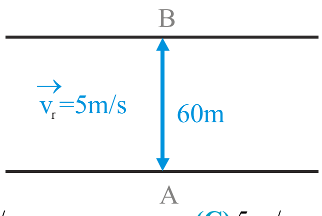
24. Raindrops are falling vertically with a velocity 10m/s. To a cyclist moving on a straight road the rain drops appear to be coming with a velocity of 20m/s. The velocity of cyclist is :-

(A) 10m/s **(B)** $10\sqrt{3}$ m/s **(C)** 20 m/s **(D)** $20\sqrt{3}$ m/s

25. A boat moving towards east with velocity 4 m/s with respect to still water and river is flowing towards north with velocity 2 m/s and the wind is blowing towards north with velocity 6 m/s. The direction of the flag blown over by the wind hoisted on the boat is :-

(A) North–west (B) South–east (C) $\tan^{-1}(1/2)$ with east (D) North

26. A man is crossing a river flowing with velocity of 5m/s. He reaches a point directly across at distance of 60 m in 5s. His velocity in still water should be :–



(A) 12 m/s (B) 13 m/s (C) 5 m/s (D) 10 m/s

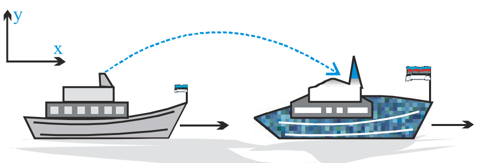
27. A river is flowing from east to west at a speed of 5 m/min. A man on south bank of river, capable of swimming 10 m/min in still water, wants to swim across the river in shorter time; he should swim :–

(A) Due north
(B) Due north–east
(C) Due north–east with double the speed of river
(D) None of the above

28. A boat which has a speed of 5km per hour in still water crosses a river of width 1km along the shortest possible path in fifteen minutes. The velocity of the river water in km per hour is :-

(A) 1 (B) 2 (C) 3 (D) $\sqrt{41}$

29. From a motorboat moving downstream with a velocity 2 m/s with respect to river, a stone is thrown. The stone falls on an ordinary boat at the instant when the motorboat collides with the ordinary boat. The velocity of the ordinary boat with respect to the river is equal to zero. The river flow velocity is given to be 1 m/s. The initial velocity vector of the stone with respect to earth is :-



Take the value of g = 10 m/s^2
Initial separation between the two boats is 20m.

(A) $2i + 20j$ (B) $3i + 40j$ (C) $3i + 50j$ (D) $2i + 50j$

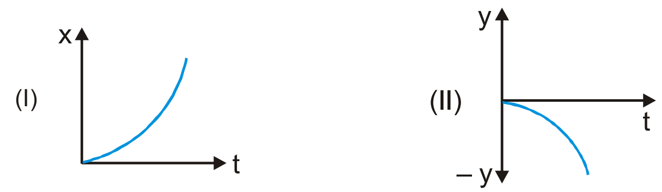
30. Two particles P and Q are moving with velocities of $(\hat{i} + \hat{j})$ and $(-\hat{i} + 2\hat{j})$ respectively. At time t = 0, P is at origin and Q is at a point with position vector $(2\hat{i} + \hat{j})$. Then the shortest distance between P & Q is :-

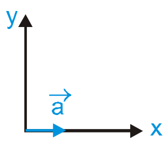
(A) $\frac{2\sqrt{5}}{5}$ (B) $\frac{4\sqrt{5}}{5}$ (C) $\sqrt{5}$ (D) $\frac{3\sqrt{5}}{5}$

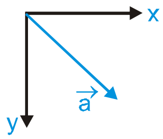
31. The total speed of a projectile at its greatest height is $\sqrt{\frac{6}{7}}$ of its speed when it is at half of its greatest height The angle of projection will be :-

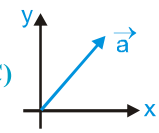
(A) 60° (B) 45° (C) 30° (D) 50°

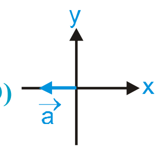
32. Graphs I and II give coordinates x(t) and y(t) of a particle moving in the x–y plane. Acceleration of the particle is constant and the graphs are drawn to the same scale. Which of the vector shown in options best represents the acceleration of the particle :-



(A) 

(B) 

(C) 

(D) 

33. Particle is dropped from the height of 20m on horizontal ground. There is wind blowing due to which horizontal acceleration of the particle becomes 6 ms^{-2}. Find the horizontal displacement of the particle till it reaches ground.

(A) 6m **(B)** 10 m **(C)** 12m **(D)** 24 m

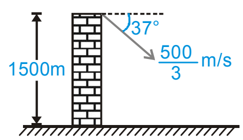
34. A particle is projected from a horizontal plane (x–z plane) such that its velocity vector at time t is given by $\vec{v} = a\hat{i} + (b - ct)\hat{j}$. Its range on the horizontal plane is given by :-

(A) $\frac{ba}{c}$ **(B)** $\frac{2ba}{c}$ **(C)** $\frac{3ba}{c}$ **(D)** None

35. A projectile is projected at an angle (α>45°) with an initial velocity u. The time t, at which its magnitude of horizontal velocity will equal the magnitude of vertical velocity is :-

(A) $t = \frac{u}{g}(\cos\alpha - \sin\alpha)$ **(B)** $t = \frac{u}{g}(\cos\alpha + \sin\alpha)$ **(C)** $t = \frac{u}{g}(\sin\alpha - \cos\alpha)$ **(D)** $t = \frac{u}{g}(\sin^2\alpha - \cos^2\alpha)$.

36. A particle is projected from a tower as shown in figure, then the distance from the foot of the tower where it will strike the ground will be :- (take g = 10 m/s^2)

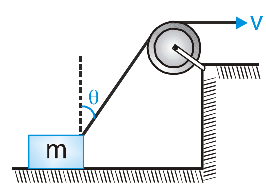


(A) 4000/3 m **(B)** 5000/3 m **(C)** 2000 m **(D)** 3000 m

37. A particle is dropped from a height h . Another particle which was initially at a horizontal distance 'd' from the first, is simultaneously projected with a horizontal velocity 'u' and the two particles just collide on the ground. The three quantities h. d and u are related to :-

(A) $d^2 = \frac{u^2 h}{2g}$ **(B)** $d^2 = \frac{2u^2 h}{g}$ **(C)** $d = h$ **(D)** $gd^2 = u^2h$

38. A block is dragged on a smooth plane with the help of a rope which moves with a velocity v as shown in figure. The horizontal velocity of the block is :



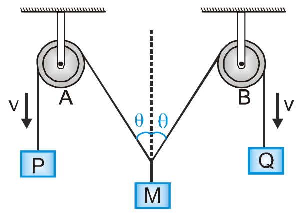
(A) v

(B) $\frac{v}{\sin\theta}$

(C) v sinθ

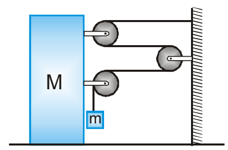
(D) $\frac{v}{\cos\theta}$

39. In the figure, the ends P and Q of an unstrechable string move downwards with uniform speed v. Mass M moves upward with speed



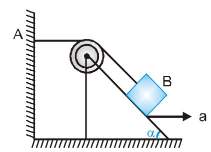
(A) v cosθ (B) $\frac{v}{\cos\theta}$ (C) 2v cos θ (D) $\frac{2}{v\cos\theta}$

40. If acceleration of M is a then acceleration of m is



(A) 3a (B) $\frac{a}{3}$ (C) a (D) $\sqrt{10}$ a

41. A weightless inextensible rope rest on a stationary wedge forming an angle α with the horizontal. One end of the rope is fixed on the wall at point A. A small load is attached to the rope at point B. The wedge starts moving to the right with a constant acceleration a. The acceleration of the load is given by:

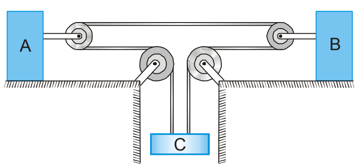


(A) a (B) 2a sinα (C) 2a sin $\frac{\alpha}{2}$ (D) gsinα

42. If angular velocity of a disc depends an angle rotated θ as $\omega = \theta^2 + 2\theta$, then its angular acceleration α at $\theta = 1$ rad is :

(A) 8 rad/s^2 (B) 10rad/s^2 (C) 12 rad/s^2 (D) None of these

43. If acceleration of A is 2 m/s^2 towards left and acceleration of B is 1 m/s^2 towards left, then acceleration of C is :–



(A) 1 m/s^2 downwards (B) 1 m/s^2 upwards (C) 2 m/s^2 downwards (D) 2 m/s^2 upwards

44. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, the magnitude of acceleration is :

(A) 20 ms^{-2} (B) 12 m/s^2 (C) 9.9 ms^{-2} (D) 8 ms^{-2}

45. If the radii of circular path of two particles are in the ratio of 1 : 2, then in order to have same centripetal acceleration, their speeds should be in the ratio of :

(A) 1 : 4 (B) 4 : 1 (C) $1 : \sqrt{2}$ (D) $\sqrt{2} : 1$

46. For a body in circular motion with a constant angular velocity, the magnitude of the average acceleration over a period of half a revolution is.... times the magnitude of its instantaneous acceleration.

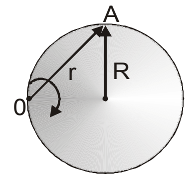
(A) $\frac{2}{\pi}$ (B) $\frac{\pi}{2}$ (C) π (D) 2

47. A particle starts moving along a circle of radius $(20/\pi)$m with constant tangential acceleration. If the velocity of the particle is 50 m/s at the end of the second revolution after motion has began, the tangential acceleration in m/s^2 is :
(A) 1.6 **(B)** 4 **(C)** 15.6 **(D)** 13.2

48. A particle is kept fixed on a turntable rotating uniformly. As seen from the ground, the particle goes in a circle, its speed is 20 cm/s and acceleration is 20 cm/s^2. The particle is now shifted to a new position to make the radius half of the original value. The new values of the speed and acceleration will be
(A) 10 cm/s, 10 cm/s^2 **(B)** 10 cm/s, 80 cm/s^2 **(C)** 40 cm/s, 10 cm/s^2 **(D)** 40 cm/s, 40 cm/s^2

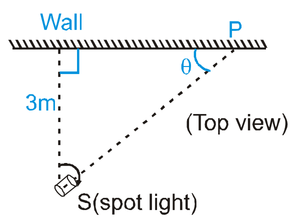
49. The second's hand of a watch has length 6 cm. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be
(A) 2π & 0 mm/s **(B)** $2\sqrt{2}\pi$ & 4.44 mm/s
(C) $2\sqrt{2}\pi$ & 2π mm/s **(D)** 2π & $2\sqrt{2}\pi$ mm/s

50. A particle A moves along a circle of radius R=50 cm so that its radius vector r relative to the point O (figure) rotates with the constant angular velocity ω=0.40 rad/s. Then modulus of the velocity of the particle, and the modulus of its total acceleration will be



(A) v= 0.4 m/s, a = 0.4 m/s^2 **(B)** v = 0.32 m/s, a = 0.32 m/s^2
(C) v = 0.32 m/s, a = 0.4 m/s^2 **(D)** v = 0.4 m/s, a = 0.32 m/s^2

51. A spot light S rotates in a horizontal plane with a constant angular velocity of 0.1 rad/s. The spot of light P moves along the wall at a distance 3m. What is the velocity of the spot P when θ=45°?



(A) 0.6 m/s **(B)** 0.5 m/s **(C)** 0.4 m/s **(D)** 0.3 m/s

Exercise # 2 — Part # I [Multiple Correct Choice Type Questions]

1. A point moves in a straight line under the retardation av^2. If the initial velocity is u, the distance covered in 't' seconds is :-

(A) aut **(B)** $\frac{1}{a}\ell n(aut)$ **(C)** $\frac{1}{a}\ell n(1+aut)$ **(D)** $a\ell n(aut)$

2. A particle is moving in a plane with velocity given by $\vec{u} = u_0\hat{i} + (a\omega\cos\omega t)\hat{j}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axes respectively. If particle is at the origin at t = 0. Calculate the trajectory of the particle:-

(A) $y = a\sin\left(\frac{u_0}{\omega x}\right)$ **(B)** $y = a\sin\left(\frac{\omega x}{u_0}\right)$ **(C)** $y = \frac{1}{a}.\sin\left(\frac{u_0}{\omega x}\right)$ **(D)** $y = \frac{1}{a}.\sin\left(\frac{\omega x}{u_0}\right)$

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

(A) $2\alpha v^3$ **(B)** $2\beta v^2$ **(C)** $2\alpha\beta v^2$ **(D)** $2\beta^2 v^3$

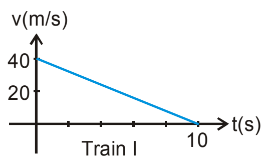
4. A, B & C are three objects each moving with constant velocity . A's speed is 10 m/s in a direction $\overrightarrow{PQ}$. The velocity of B relative to A is 6 m/s at an angle of, $\cos^{-1}(15/24)$ to PQ . The velocity of C relative to B is 12 m/s in a direction $\overrightarrow{QP}$. Then the magnitude of the velocity of C is :-

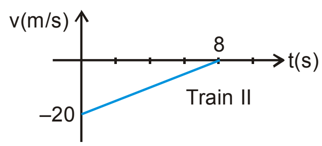
(A) 5 m/s **(B)** $2\sqrt{10}$ m/s **(C)** 3 m/s **(D)** 4 m/s

5. A particle is moving with uniform acceleration along a straight line . Its velocities at A & B are respectively 7 m/s & 17 m/s . M is mid point of AB . If t_1 is the time taken to go from A to M and t_2 the time taken to go from M to B, the ratio $\frac{t_1}{t_2}$ is equal to :-

(A) 3 : 2 **(B)** 3 : 1 **(C)** 2 : 1 **(D)** 2 : 3

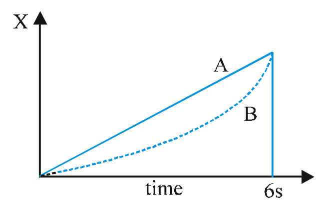
6. Two trains, which are moving along different tracks in opposite directions, are put on the same track due to a mistake. Their drivers, on noticing the mistake, start slowing down the trains when the trains are 300 m apart. Given graphs show their velocities as function of time as the trains slow down. The separation between the trains when both have stopped,, is :-





(A) 120 m **(B)** 280 m **(C)** 60 m **(D)** 20 m

7. In the diagram shown, the displacement of particles is given as a function of time. The particle A is moving under constant velocity of 9 m/s. The particle B is moving under variable acceleration. From time t = 0 s. to t = 6 s., the average velocity of the particle B will be equal to :-



(A) 2.5 m/s **(B)** 4 m/s **(C)** 9 m/s **(D)** None

8. A person drops a stone from a building of height 20 m . At the same instant the front end of a truck passes below the building moving with constant acceleration of 1 m/s^2 and velocity of 2 m/s at that instant. Length of the truck if the stone just misses to hit its rear part is :-

(A) 6 m **(B)** 4 m **(C)** 5 m **(D)** 2 m

9. The position vector of a particle is given as $\vec{r} = (t^2 - 4t + 6)\hat{i} + (t^2)\hat{j}$. The time after which the velocity vector and acceleration vector becomes perpendicular to each other is equal to :-

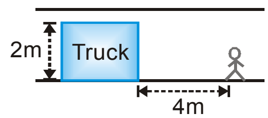
(A) 1 sec **(B)** 2 sec **(C)** 1.5 sec **(D)** Not possible

10. A particle 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 ?

(A) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$ **(B)** $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$

(C) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$ **(D)** $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

11. A 2m wide truck is moving with a uniform speed of 8 m/s along a straight horizontal road. A pedestrian starts crossing the road at an instant when the truck is 4 m away from him. The minimum constant velocity with which
he should run to avoid an accident is :-



(A) $1.6\sqrt{5}$ m/s **(B)** $1.2\sqrt{5}$ m/s **(C)** $1.2\sqrt{7}$ m/s **(D)** $1.6\sqrt{7}$ m/s

12. If some function say x varies linearly with time and we want to find its average value in a given time interval we can directly find it by $\frac{x_i + x_f}{2}$. Here, x_i is the initial value of x and x_f its final value.

x and y co–ordinates of a particle moving in x–y plane at some instant are : $x = 2t^2$ and $y = 3/2\, t^2$. The average velocity of particle in at time interval from t = 1 s to t = 2s is :-

(A) $(8\hat{i} + 5\hat{j})$ m/s **(B)** $(12\hat{i} + 9\hat{j})$ m/s **(C)** $(6\hat{i} + 4.5\hat{j})$ m/s **(D)** $(10\hat{i} + 6\hat{j})$ m/s

13. A particle moves along a straight line OX. At a time t (in seconds) the distance x (in metres) of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest ?

(A) 24 m **(B)** 40 m **(C)** 56 m **(D)** 16 m

14. A particle starts from rest with constant acceleration. The ratio of space–average velocity to the time average velocity is :–

(A) 1/2 **(B)** 3/4 **(C)** 4/3 **(D)** 3/2

15. A particle is thrown upwards from ground. It experiences a constant resistance force which can produce retardation 2 m/s^2. The ratio of time of ascent to the time of descent is :- [g = 10 m/s^2]

(A) 1 : 1 **(B)** $\sqrt{\frac{2}{3}}$ **(C)** $\frac{2}{3}$ **(D)** $\sqrt{\frac{3}{2}}$

16. A ball is dropped from the top of a building. The ball takes 0.5 s to fall the 3m length of a window some distance from the top of the building. If the velocities of the ball at the top and at the bottom of the window are v_T and v_B respectively, then (take g = 10 m/s^2) :-

(A) $v_T + v_B = 12\ ms^{-1}$ **(B)** $v_B - v_T = 4.9\ ms^{-1}$ **(C)** $v_B v_T = 1\ ms^{-1}$ **(D)** $\frac{v_B}{v_T} = 1\ ms^{-1}$

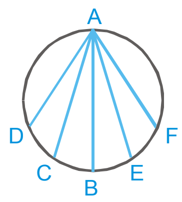
17. Drops of water fall from the roof of a building 9m. high at regular intervals of time, the first drop reaching the ground at the same instant fourth drop starts to fall. What are the distances of the second and third drops from the roof ?

(A) 6 m and 2 m **(B)** 6 m and 3 m **(C)** 4 m and 1 m **(D)** 4 m and 2 m

18. Two boats A and B are moving along perpendicular paths in a still lake at night. Boat A move with a speed of 3 m/s and boat B moves with a speed of 4 m/s in the direction such that they collide after sometime. At t = 0, the boats are 300 m apart. The ratio of distance travelled by boat A to the distance travelled by boat B at the instant of collision is:-

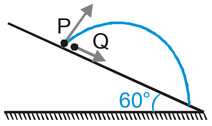
(A) 1 **(B)** 1/2 **(C)** 3/4 **(D)** 4/3

19. A disc in which several grooves are cut along the chord drawn from a point 'A', is arranged in a vertical plane, several particles starts slipping from 'A' along the grooves simultaneously. Assuming friction and resistance negligible, the time taken in reaching the edge of disc will be :-



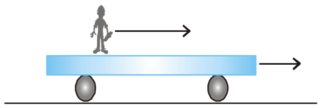
(A) Maximum in groove AB
(B) Maximum in groove AD
(C) Same in all groove
(D) According to the heights of B, C, D, E, F

20. A particle P is projected from a point on the surface of smooth inclined plane (see figure). Simultaneously another particle Q is released on the smooth inclined plane from the same position. P and Q collide after t = 4 second. The speed of projection of P is :-



(A) 5 m/s **(B)** 10 m/s **(C)** 15 m/s **(D)** 20 m/s

21. A trolley is moving horizontally with a constant velocity of v m/s w.r.t. earth. A man starts running from one end of the trolley with a velocity 1.5v m/s w.r.t. to trolley. After reaching the opposite end, the man return back and continues running with a velocity of 1.5 v m/s w.r.t. the trolley in the backward direction. If the length of the trolley is L then the displacement of the man with respect to earth during the process will be :-



(A) 2.5L **(B)** 1.5 L **(C)** $\frac{5L}{3}$ **(D)** $\frac{4L}{3}$

22. A body is thrown horizontally with a velocity $\sqrt{2gh}$ from the top of a tower of height h. It strikes the level ground through the foot of the tower at a distance x from the tower. The value of x is :-
(A) h **(B)** h/2 **(C)** 2h **(D)** 2h/3

23. A particle is projected from a point P(2,0,0)m with a velocity 10m/s making an angle 45° with the horizontal. The plane of projectile motion passes through a horizontal line PQ which makes an angle of 37° with positive x–axis, xy plane is horizontal. The coordinates of the point where the particle will strike the line PQ is :- (take g = 10 m/s^2)
(A) (10,6,0)m **(B)** (8,6,0)m **(C)** (10,8,0)m **(D)** (6,10,0)m

24. A ball is projected from a certain point on the surface of a planet at a certain angle with the horizontal surface. The horizontal and vertical displacements x and y vary with time t in second as : $x = 10\sqrt{3}\,t$; $y = 10t - t^2$ the maximum height attained by the ball is :-
(A) 100m **(B)** 75m **(C)** 50 m **(D)** 25m

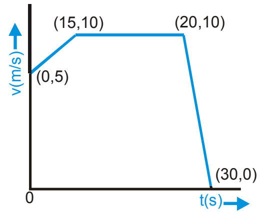
25. A particle A is projected with speed v_A from a point making an angle 60° with the horizontal. At the same instant, a second particle B is thrown vertically upward from a point directly below the maximum height point of parabolic path of A with velocity v_B. If the two particles collide then the ratio of v_A/v_B should be :-

(A) 1 **(B)** $\frac{2}{\sqrt{3}}$ **(C)** $\frac{\sqrt{3}}{2}$ **(D)** $\sqrt{3}$

26. A particle moves in the xy plane and at time t is at the point $(t^2, t^3 - 2t)$. Then :-
(A) At t = 2/3 s, directions of velocity and acceleration are perpendicular
(B) At t = 0, directions of velocity and acceleration are perpendicular
(C) At $t = \sqrt{\frac{2}{3}}$ s, particle is moving parallel to x–axis
(D) Acceleration of the particle when it is at point (4, 4) is $2\hat{i} + 24\hat{j}$

27. An object may have :-
(A) Varying speed without having varying acceleration
(B) Varying velocity without having varying speed
(C) Non–zero acceleration without having varying velocity
(D) Non–zero acceleration without having varying speed .

28. The figure shows the velocity time graph of a particle which moves along a straight line starting with velocity at 5 m/sec and coming to rest at t = 30s . Then :-



(A) Distance travelled by the particle is 212.5 m
(B) Distance covered by the particle when it moves with constant velocity is 100 m
(C) Velocity of the particle at t = 25s is 5 m/sec
(D) Velocity of the particle at t = 9s is 8 m/sec .

29. A particle moves along x–axis according to the law $x = (t^3 - 3t^2 - 9t + 5)$m. Then :-
(A) In the interval $3 < t < 5$, the particle is moving in +x direction
(B) The particle reverses its direction of motion twice in entire motion if it starts at t=0
(C) The average acceleration from $1 \le t \le 2$ seconds is $6 m/s^2$.
(D) In the interval $5 \le t \le 6$ seconds, the distance travelled is equal to the displacement.

30. A particle moves with constant speed v along a regular hexagon ABCDEF in the same order . Then the magnitude of the average velocity for its motion from A to :-

(A) F is $\frac{v}{5}$ (B) D is $\frac{v}{3}$ (C) C is $\frac{v\sqrt{3}}{2}$ (D) B is v .

31. The co–ordinate of the particle in x–y plane are given as $x = 2 + 2t + 4t^2$ and $y = 4t + 8t^2$:-
The motion of the particle is :-
(A) Along a straight line (B) Uniformly accelerated
(C) Along a parabolic path (D) Non-uniformly accelerated

32. A particle moving along a straight line with uniform acceleration has velocities 7m/s at A and 17m/s at C. B is the mid point of AC. Then :-
(A) The velocity at B is 12m/s
(B) The average velocity between A and B is 10m/s
(C) The ratio of the time to go from A to B to that from B to C is 3 : 2
(D) The average velocity between B and C is 15m/s

33. A particle moves along the X–axis as $x = u(t - 2s) + a(t - 2s)^2$:-
(A) The initial velocity of the particle is u (B) The acceleration of the particle is a
(C) The acceleration of the particle is 2a (D) At t = 2s particle is at the origin.

34. Pick the correct statements :-

(A) Average speed of a particle in a given time is never less than the magnitude of the average velocity.

(B) It is possible to have a situation in which $\left|\frac{d\vec{u}}{dt}\right| \neq 0$ but $\frac{d}{dt}|\vec{u}| = 0$.

(C) The average velocity of a particle is zero in a time interval. It is possible that the instantaneous velocity is never zero in the interval.

(D) The average velocity of a particle moving on a straight line is zero in a time interval. It is possible that the instantaneous velocity is never zero in the interval. (infinite acceleration is not allowed)

35. A particle leaves the origin with an initial velocity $\vec{u} = 3\hat{i}$ m/s and a constant acceleration $\vec{a} = (-1.0\hat{i} - 0.5\hat{j})\ m/s^2$. Its velocity $\vec{v}$ and position vector $\vec{r}$ when it reaches its maximum x–co–ordinate are :-

(A) $\vec{v} = -2\hat{j}$ **(B)** $\vec{v} = -1.5\hat{j}\ m/s$

(C) $\vec{r} = (4.5\hat{i} - 2.25\hat{j})$ m **(D)** $\vec{r} = (3\hat{i} - 2\hat{j})$ m

36. If velocity of the particle is given by v = $\sqrt{x}$, where x denotes the position of the particle and initially particle was at x = 4m, then which of the following are correct.

(A) At t = 2 s, the position of the particle is at x = 9m

(B) Particle acceleration at t = 2 s. is 1 m/s^2

(C) Particle acceleration is 1/2 m/s^2 through out the motion

(D) Particle will never go in negative direction from it's starting position

37. Which of the following statements are true for a moving body ?

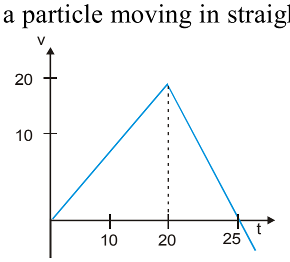
(A) If its speed changes, its velocity must change and it must have some acceleration

(B) If its velocity changes, its speeds must change and it must have some acceleration

(C) If its velocity changes, its speed may or may not change, and it must have some acceleration

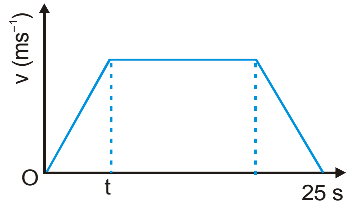
(D) If its speed changes but direction of motion does not change, its velocity may remain constant

38. The figure shows the v–t graph of a particle moving in straight line. Find the time when particle returns to the starting point.



(A) 30 sec **(B)** 34.5 sec **(C)** 36.2 sec **(D)** 35.4 sec

39. The velocity – time graph of the particle moving along a straight line is shown. The rate of acceleration and deceleration is constant and it is equal to 5 ms^{-2}. If the average velocity during the motion is 20 ms^{-1}, then the value of t is

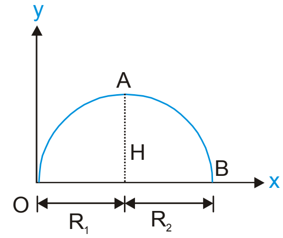


(A) 3 sec **(B)** 5 sec **(C)** 10 sec **(D)** 12 sec

40. A particle is projected from a point P with a velocity v at an angle θ with horizontal. At a certain point Q it moves at right angle to its initial direction. Then :-

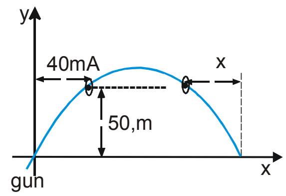
(A) Velocity of particle at Q is vsinθ
(B) Velocity of particle at Q is vcotθ
(C) Time of flight from P to Q is (v/g)cosecθ
(D) Time of flight from P to Q is (v/g)secθ

41. In a projectile motion assuming no air drag let $t_{0A} = t_1$ and $t_{AB} = t_2$. The horizontal displacement from O to A is R_1 and from A to B is R_2. Maximum height is H and time of flight is T. Now if air drag is to be considered, then choose the correct alternative(s).



(A) t_1 will decrease while t_2 will increase
(B) H will increase
(C) R_1 will decrease while R_2 will increase
(D) T may increase or decrease

42. A gun is set up in such a way that the muzzle is at ground level as in figure. The hoop A is located at a horizontal distance 40m from the muzzle and is 50m above the ground level. Shell is fired with initial horizontal component of velocity as 40m/s. Which of the following is/are correct?



(A) The vertical component of velocity of the shell just after it is fired is 55m/s, if the shell has to pass through the hoop A.
(B) The shell will pass through both the hoops if x=40m.
(C) The shell will pass through both the hoops if x=20m.
(D) The vertical component of velocity of the shell just after it is fired is 45m/s, if the shell is to pass through both the hoops.

43. If T is the total time of flight, H the maximum height and R is the horizontal range of a projectile. Then x and y co–ordinates at any time t are related as :-

(A) $y = 4H\left(\frac{t}{T}\right)\left(1-\frac{t}{T}\right)$
(B) $y = 4H\left(\frac{T}{t}\right)\left(1-\frac{T}{t}\right)$
(C) $y = 4H\left(\frac{x}{R}\right)\left(1-\frac{x}{R}\right)$
(D) $y = 4H\left(\frac{R}{x}\right)\left(1-\frac{R}{x}\right)$

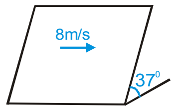
44. Two particles P & Q are projected simultaneously from a point O on a level ground in the same vertical plane with the same speed in directions making angle of 30^0 and 60^0 respectively with the horizontal.

(A) Both reach the ground simultaneously
(B) P reaches the ground earlier than Q
(C) Both strike the same point on the level ground
(D) The maximum height attained by Q is thrice that attained by P

45. Two particles A & B projected along different directions from the same point P on the ground with the same velocity of 70 m/s in the same vertical plane . They hit the ground at the same point Q such that PQ = 480m. Then :- ($g = 9.8 m/s^2$]

(A) Ratio of their times of flight is 4 : 5
(B) Ratio of their maximum heights is 9 : 16
(C) Ratio of their minimum speeds during flights is 4 : 3
(D) The bisector of the angle between their directions of projection makes 45^0 with horizontal

46. A ball is projected on smooth inclined plane in direction perpendicular to line of greatest slope with velocity of 8m/s. Find it's speed after 1 sec.



(A) 10 m/s **(B)** 12 m/s **(C)** 15 m/s **(D)** 20 m/s

47. A particle of mass m moves along a curve $y = x^2$. When particle has x – co–ordinate as 1/2 and x–component of velocity as 4m/s. Then :-

(A) The position coordinate of particle are (1/2, 1/4)

(B) The velocity of particle will be along the line $4x - 4y - 1 = 0$

(C) The magnitude of velocity at that instant is $4\sqrt{2}$ m/s

(D) The magnitude of angular momentum of particle about origin at that position is 0.

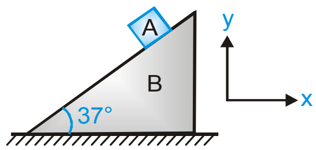
48. Balls are thrown vertically upward in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute will be :-

(A) 40 **(B)** 50 **(C)** 60 **(D)** 120

49. The horizontal range of a projectile is R and the maximum height attained by it is H. A strong wind now begins to blow in the direction of motion of the projectile, giving it a constant horizontal acceleration = g/2. Under the same conditions of projection. Find the horizontal range of the projectile.

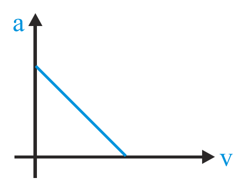
(A) R +H **(B)** R + 2H **(C)** R **(D)** R +H/2

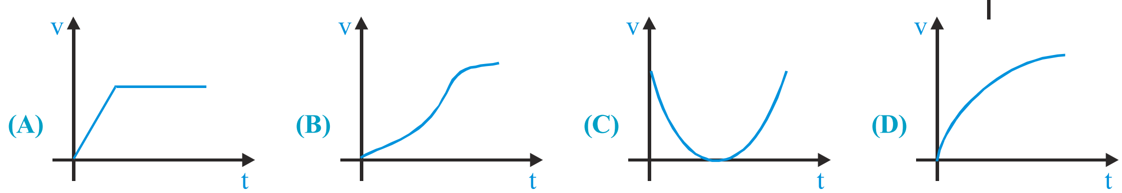
50. In the figure shown the acceleration of A is, $\vec{a}_A = 15\hat{i} + 15\hat{j}$ then the acceleration of B is (A remains in contact with B)



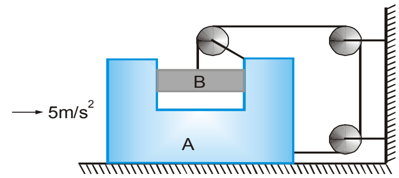
(A) $6\hat{i}$ **(B)** $-15\hat{i}$ **(C)** $-10\hat{i}$ **(D)** $-5\hat{i}$

51. Acceleration versus velocity graph of a particle moving in a straight line starting from rest is as shown in figure. The corresponding velocity – time graph would be:-



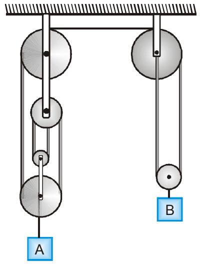


52. If block A is moving with an acceleration of 5 m/s², the acceleration of B w.r.t. ground is



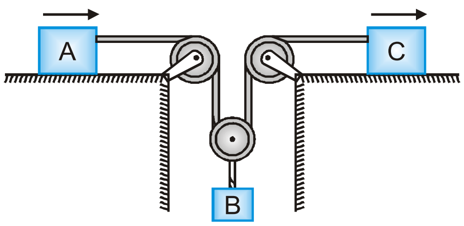
(A) 5 m/s² **(B)** $5\sqrt{2}$ m/s² **(C)** $5\sqrt{5}$ m/s² **(D)** 10 m/s²

53. Block B has a downward velocity in m/s and given by $v_B = \frac{t^2}{2} + \frac{t^3}{6}$, where t is in s. Acceleration of A at t = 2 second is



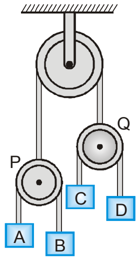
(A) 2 m/s^2 **(B)** 4 m/s^2 **(C)** 6 m/s^2 **(D)** None of these

54. Block A and C start from rest and move to the right with acceleration a_A=12t m/s^2 and a_C=3 m/s^2 . Here t is in seconds. The time when block B again comes to rest is



(A) 2s **(B)** 1s **(C)** $\frac{3}{2}$ s **(D)** $\frac{1}{2}$ s

55. In the figure acceleration of A is 1 m/s^2 upwards, acceleration of B is 7 m/s^2 upwards and acceleration of C is 2m/s^2 upwards. Then acceleration of D will be



(A) 7 m/s^2 downwards **(B)** 2 m/s^2 downwards
(C) 10 m/s^2 downwards **(D)** 8 m/s^2 downwards

56. A particle moves along an arc of a circle of radius R. Its velocity depends on the distance covered as $v=a\sqrt{s}$, where a is a constant then the angle α between the vector of the total acceleration and the vector of velocity as a function of s will be

(A) $\tan\alpha = \frac{R}{2s}$ **(B)** $\tan\alpha = \frac{2s}{R}$ **(C)** $\tan\alpha = \frac{2R}{s}$ **(D)** $\tan\alpha = \frac{s}{2R}$

57. A particle moves with deceleration along the circle of radius R so that at any moment of time its tangential and normal accelerations are equal in moduli. At the initial moment t =0 the speed of the particle equals v_0, then the speed of the particle as a function of the distance covered S will be

(A) $v = v_0\, e^{-S/R}$ **(B)** $v = v_0 e^{S/R}$ **(C)** $v=v_0\, e^{-R/S}$ **(D)** $v=v_0\, e^{R/S}$

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement 2 (reason).

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

(E) Statement- I is false, Statement-II is false.

1. **Statement–I** : Path of a projectile is a parabola irrespective of its velocity of projection.

Statement–II : Trajectory of a projectile is a parabola when variation of g, (acceleration due to gravity) can be neglected.

2. **Statement–I** : A projectile is thrown with an initial velocity of $\left(a\tilde{i} + b\tilde{j}\right)$ m/s. If range of projectile is maximum then a = b.

Statement–II : In projectile motion, angle of projection is equal to 45° for maximum range condition.

3. **Statement I** : When velocity of a particle is zero then acceleration of particle is zero.

Statement II : Acceleration is equal to rate of change of velocity.

4. **Statement–I** : If two particles, moving with constant velocities are to meet, the relative velocity must be along the line joining the two particles.

Statement–II : Relative velocity means motion of one particle as viewed from the other.

5. **Statement I** : A particle moves in a straight line with constant acceleration. The average velocity of this particle cannot be zero in any time interval.

Statement II : For a particle moving in straight line with constant acceleration, the average velocity in a time interval is $\frac{u+v}{2}$, where u and v are initial and final velocity of the particle of the given time interval.

6. **Statement–I** : When a body is dropped or thrown horizontally from the same height, it reaches the ground at the same time.

Statement–II : They have same acceleration and same initial speed in vertical direction.

7. **Statement–I** : A man can cross river of width d in minimum time t. On increasing river velocity, minimum time to cross the river by man will remain unchanged.

Statement–II : Velocity of river is perpendicular to width of river. So time to cross the river is independent of velocity of river.

8. **Statement–I** : Two balls are dropped one after the other from a tall tower. The distance between them increases linearly with time (elapsed after the second ball is dropped and before the first hits ground).

Statement–II : Relative acceleration is zero, whereas relative velocity is non–zero in the above situation.

9. **Statement–I** : The maximum range along the inclined plane, when thrown downward is greater than that when thrown upward along the same inclined plane with same velocity.

Statement–II : The maximum range along inclined plane is independent of angle of inclination.

10. Statement–I : A positive acceleration can be associated with a 'slowing down' of the body.

Statement–II : The origin and the positive direction of an axis are a matter of choice.

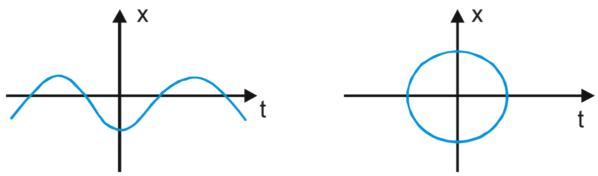
11. Statement–I : Two particles of different mass, are projected with same velocity at same angles. The maximum height attained by both the particles will be same.

Statement–II : The maximum height of projectile is independent of particle mass

12. Statement–I : The speed of a body can be negative.

Statement–II : If the body is moving in the opposite direction of positive motion, then its speed is negative.

13. Statement–I : Graph (1) represent one dimensional motion of a particle. While graph (2) can not represent 1–D motion of the particle. (here x is position and t is time)



(1) (2)

Statement–II : Particle can have only one position at an instant.

14. Statement–I : In a free fall, the initial velocity of a body may or may not be zero.

Statement–II : A heavy body falls at a faster rate as compared to a lighter body.

15. Statement–I : When the direction of motion of a particle moving in a circular path is reversed the direction of radial acceleration still remains the same (at the given point).

Statement–II : Particle revolves on circular path in any direction such as clockwise or anticlockwise the direction of radial acceleration is always towards the centre of the circular path.

16. Statement–I : When a body is dropped or thrown horizontally from the same height, it would reach the ground at the same time.

Statement–II : Horizontal velocity has no effect on the vertical direction.

17. Statement–I : A cyclist must adopt a zig–zag path while ascending a steep hill.

Statement–II : The zig–zag path prevent the cyclist to slip down.

18. Statement–I : When a particle is thrown obliquely from the surface of the Earth, it always moves in a parabolic path, provided the air resistance is negligible.

Statement–II : A projectile motion is a two dimensional motion.

19. Statement–I : Mountain roads rarely go straight up the slope.

Statement–II : Slope of mountains are large therefore more chances of vehicle to slip from roads.

Exercise # 3

Part # I [Matrix Match Type Questions]

Following question contains statements given in two columns, which have to be matched. The statements in Column-I are labelled as A, B, C and D while the statements in Column-II are labelled as p, q, r and s. Any given statement in Column-I can have correct matching with one or more statement(S) in Column-II.

1. **Column I**

(A) Zero acceleration

(B) Infinite acceleration

(C) Constant positive acceleration, with zero initial velocity

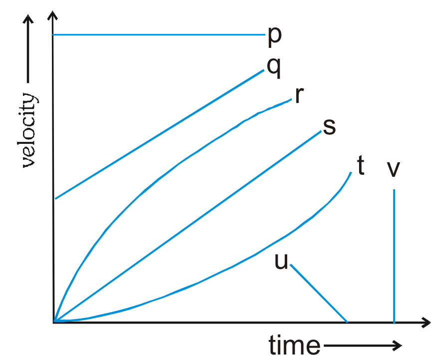
(D) Constant positive acceleration, with non–zero initial velocity

(E) Constant Negative acceleration

(F) Increasing acceleration

(G) Decreasing acceleration

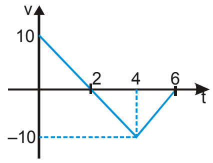
Column II



2. The equation of one dimensional motion of the particle is described in column I. At t= 0, particle is at origin and at rest. Match the column I with the statements in Column II.

	Column I		**Column II**
(A)	$x = (3t^2 + 2)$m	**(P)**	Velocity of particle at t = 1s is 8 m/s
(B)	v = 8t m/s	**(Q)**	Particle moves with uniform acceleration
(C)	a = 16 t	**(R)**	Particle moves with variable acceleration
(D)	$v = 6t - 3t^2$	**(S)**	Particle will change its direction some time.

3. For the velocity–time graph shown in figure, in a time interval from t = 0 to t = 6 s, match the following:



	Column I		**Column II**
(A)	Change in velocity	**(P)**	– 5/3 SI unit
(B)	Average acceleration	**(Q)**	– 20 SI unit
(C)	Total displacement	**(R)**	– 10 SI unit
(D)	Acceleration at t=3s	**(S)**	– 5 SI unit

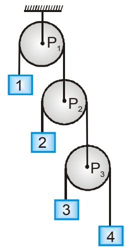
4. A balloon rises up with constant net acceleration of $10 m/s^2$. After 2 s a particle drops from the balloon. After further 2 s match the following : (Take $g = 10 m/s^2$)

	Column I		**Column II**
(A)	Height of particle from ground	**(P)**	Zero
(B)	Speed of particle	**(Q)**	10 SI units
(C)	Displacement of Particle	**(R)**	40 SI units
(D)	Acceleration of particle	**(S)**	20 SI units

5. A particle is rotating in a circle of radius 1m with constant speed 4 m/s. In time 1 s, match the following (in SI units)

	Column I		Column II
(A)	Displacement	**(P)**	8 sin 2
(B)	Distance	**(Q)**	4
(C)	Average velocity	**(R)**	2 sin 2
(D)	Average acceleration	**(S)**	4 sin 2

6. In the figure shown, acceleration of 1 is x (upwards). Acceleration of pulley P_3, w.r.t. pulley P_2 is y (downwards) and acceleration of 4 w.r.t. to pulley P_3 is z (upwards). Taking upward +ve and downward –ve then

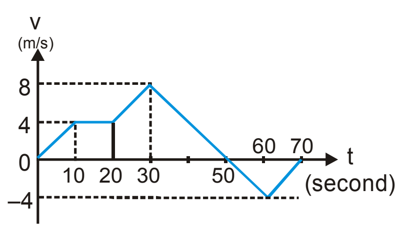


	Column I		Column II
(A)	Absolute acceleration of 2	**(P)**	(y–x) downwards
(B)	Absolute acceleration of 3	**(Q)**	(z–x–y) upwards
(C)	Absolute acceleration of 4	**(R)**	(x+y+z) downwards
		(S)	None

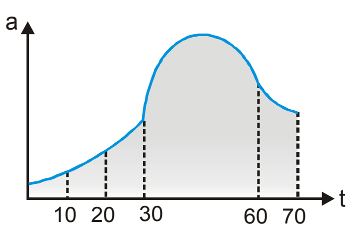
Part # II [Comprehension Type Questions]

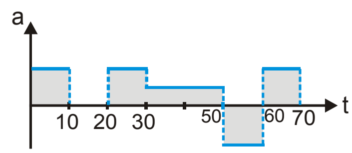
Comprehension # 1

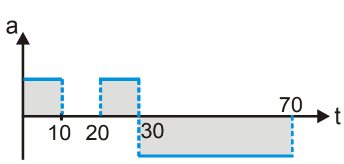
A car is moving on a straight road. The velocity of the car varies with time as shown in the figure. Initially (at t = 0), the car was at x = 0, where, x is the position of the car at any time 't'.

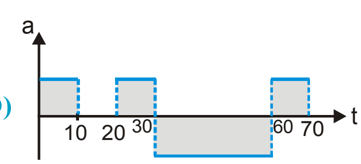


1. The variation of acceleration **(A)** with time **(T)** will be best represented by :-

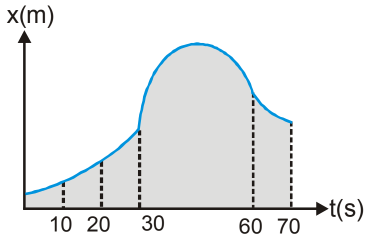
(A)


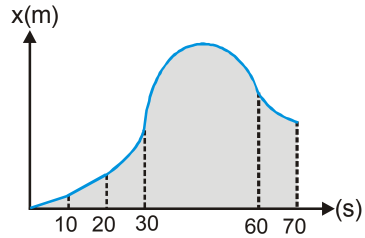
(B)


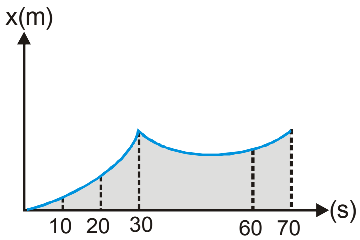
(C)


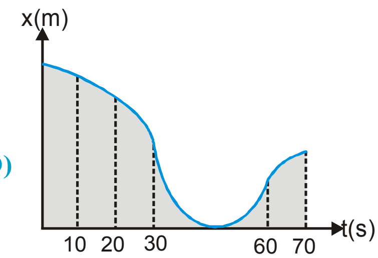
(D)


2. The displacement time graph will be best represented by :-

(A)


(B)


(C)


(D)


3. The maximum displacement from the starting position will be :-
(A) 200 m **(B)** 250 m **(C)** 160 m **(D)** 165 m

4. Average speed from t = 0 to t = 70 s will be :-

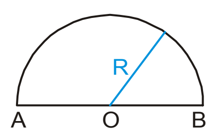
(A) $\frac{16}{7}$ m/s **(B)** $\frac{24}{7}$ m/s **(C)** $\frac{20}{7}$ m/s **(D)** zero

5. The time interval during which the car is retarding can be :-
(A) t = 50s to t = 70s **(B)** t = 30s to t = 50s
(C) t = 30s to t = 60s **(D)** t = 10s to t = 20s

Comprehension # 2

Distance is a scalar quantity. Displacement is a vector quantity. The magnitude of displacement is always less than or equal to distance. For a moving body displacement can be zero but distance cannot be zero. Same concept is applicable regarding velocity and speed. Acceleration is the rate of change of velocity. If acceleration is constant, then equations of kinematics are applicable for one dimensional motion under the gravity in which air resistance is considered, then the value of acceleration depends on the density of medium. Each motion is measured with respect of frame of reference. Relative velocity may be greater/smaller to the individual velocities.

1. A particle moves from A to B. Then the ratio of distance to displacement is :-



(A) $\frac{\pi}{2}$ **(B)** $\frac{2}{\pi}$ **(C)** $\frac{\pi}{4}$ **(D)** 1 : 1

2. A person is going 40m north, 30 m east and then $30\sqrt{2}$ m southwest. The net displacement will be :-

(A) 10 m towards east **(B)** 10 m towards west

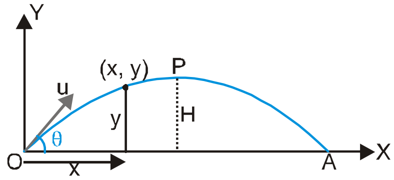
(C) 10 m towards south **(D)** 10 m towards north

3. A particle is moving along the path $y = 4x^2$. The distance and displacement from x = 1 to x = 2 is (nearly) :-

(A) $\sqrt{150}$, 12 **(B)** $\sqrt{160}$, 20 **(C)** $\sqrt{200}$, 30 **(D)** $\sqrt{150}$, 20

Comprehension # 3

The trajectory of a projectile in a vertical plane is $y=\sqrt{3}\,x-2x^2$. [$g = 10\ m/s^2$]



1. Angle of projection θ is :-

(A) 30° **(B)** 60° **(C)** 45° **(D)** $\sqrt{3}$ rad

2. Maximum height H is :-

(A) $\frac{8}{3}$ **(B)** $\frac{3}{8}$ **(C)** $\sqrt{3}$ **(D)** $\frac{2}{\sqrt{3}}$

3. Range OA is :-

(A) $\frac{\sqrt{3}}{2}$ **(B)** $\frac{\sqrt{3}}{4}$ **(C)** $\sqrt{3}$ **(D)** $\frac{3}{8}$

4. Time of flight of the projectile is :-

(A) $\sqrt{\frac{3}{10}}$s **(B)** $\sqrt{\frac{10}{3}}$s **(C)** 1s **(D)** 2s

5. Radius of curvature of the path of the projectile at the topmost point P is :-

(A) $\frac{1}{2}$m **(B)** 1m **(C)** 4m **(D)** $\frac{1}{4}$m

Comprehension # 4

A circus wishes to develop a new clown act. Fig. (1) shows a diagram of the proposed setup. A clown will be shot out of a cannon with velocity v_0 at a trajectory that makes an angle $\theta = 45°$ with the ground. At this angle, the clown will travel a maximum horizontal distance. The cannon will accelerate the clown by applying a constant force of 10,000N over a very short time of 0.24s. The height above the ground at which the clown begins his trajectory is 10m.

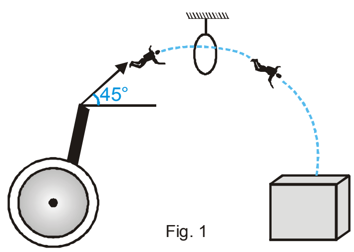


Fig. 1

A large hoop is to be suspended from the ceiling by a massless cable at just the right place so that the clown will be able to dive through it when he reaches a maximum height above the ground. After passing through the hoop he will then continue on his trajectory until arriving at the safety net. Fig. (2) shows a graph of the vertical component of the clown's velocity as a function of time between the cannon and the hoop. Since the velocity depends on the mass of the particular clown performing the act, the graph shows data for several different masses.

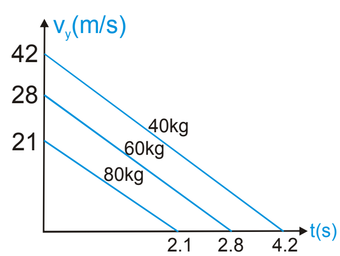


Fig. 2

1. If the angle the cannon makes with the horizontal is increased from 45°, the hoop will have to be :-
(A) Moved farther away from the cannon and lowered
(B) Moved farther away from the cannon and raised
(C) Moved closer to the cannon and lowered
(D) Moved closer to the cannon and raised

2. If the clown's mass is 80 kg, what initial velocity v_0 will he have as he leaves the cannon ?
(A) 3 m/s **(B)** 15 m/s **(C)** 30 m/s **(D)** 300 m/s

3. The slope of the line segments plotted in figure 2 is a constant. Which one of the following physical quantities does this slope represent ?
(A) $-g$ **(B)** v_0 **(C)** $y - y_0$ **(D)** $\sin\theta$

4. From figure 2, approximately how much time will it take for clown with a mass of 60 kg to reach the safety net located 10 m below the height of the cannon ?
(A) 4.3s **(B)** 6.4s **(C)** 5.9s **(D)** 7.2s

5. If the mass of a clown doubles, his initial kinetic energy, $mv_0^2/2$, will :-
(A) Remain the same **(B)** Be reduce to half **(C)** Double **(D)** Four times

6. If a clown holds on to hoop instead of passing through it, what is the position of the cable so that he doesn't hit his head on the ceiling as he swings upward ?
(A) $\frac{2v_0^2}{g}$ **(B)** $\frac{v_0^2}{g}$ **(C)** $\frac{v_0^2}{2g}$ **(D)** $\frac{v_0^2}{4g}$

Comprehension # 5

A student performs an experiment to determine how the range of a ball depends on the velocity with which it is projected. The "range" is the distance between the points where the ball lands and from where it was projected, assuming it lands at the same height from which it was projected. It each trial, the student uses the same baseball, and launches it at the same angle. Table shows the experimental results.

Trail	Launch speed (m/s)	Range (m)
1	10	8
2	20	31.8
3	30	70.7
4	40	122.5

Based on this data, the student then hypothesizes that the range, R, depends on the initial speed v_0, according to the following equation : $R=Cv_0^n$, where C is a constant and n is another constant.

1. Based on this data, the best guess for the value of n is :-
(A) $\frac{1}{2}$ **(B)** 1 **(C)** 2 **(D)** 3

2. The student speculates that the constant C depends on :-
(i) The angle at which the ball was launched (ii) The ball's mass (iii) The ball's diameter
If we neglect air resistance, then C actually depends on :-
(A) I only **(B)** I and II **(C)** I and III **(D)** I, II and III

3. The student performs another trial in which the ball is launched at speed 5.0 m/s. Its range is approximately:
(A) 1.0 m **(B)** 2.0 m **(C)** 3.0 m **(D)** 4.0 m

Comprehension # 6

A projectile is projected with some initial velocity and some initial angle of projection. A wind is also blowing, due to which constant horizontal retardation a is imparted to the particle in the plane of motion. It is found that, the particle is at same height at two different time t_1 & t_2 and particle is at same horizontal distance at two different time t_3 & t_4.

1. Angle of projection of particle is :–

(A) $\tan^{-1}\left(\frac{t_1+t_2}{t_3+t_4}\right)$ **(B)** $\tan^{-1}\left[\frac{a(t_1+t_2)}{g(t_3+t_4)}\right]$ **(C)** $\tan^{-1}\left[\frac{g(t_1+t_2)}{a(t_3+t_4)}\right]$ **(D)** None of these

2. Maximum height of the particle is :–

(A) $\frac{g}{8}(t_1+t_2)^2$ **(B)** $\frac{g}{4}(t_1+t_2)^2$ **(C)** $\frac{g}{2}(t_1+t_2)^2$ **(D)** None of these

3. Range of the projectile is :–

(A) $\frac{1}{2}g(t_1+t_2)^2$ **(B)** $\frac{1}{2}g(t_1+t_2)(t_3+t_4-t_1-t_2)$ **(C)** $\frac{1}{2}g(t_3+t_4-t_1-t_2)^2$ **(D)** can't determined

Comprehension # 7

When a particle is undergoing motion, the displacement of the particle has a magnitude that is equal to or smaller than the total distance travelled by the particle. In many cases the displacement of the particle may actually be zero, while the distance travelled by it is non–zero. Both these quantities, however depend on the frame of reference in which motion of the particle is being observed. Consider a particle which is projected in the earth's gravitational field, close to its surface, with a speed of $100\sqrt{2}$ m/s, at an angle of 45° with the horizontal in the eastward direction. Ignore air resistance and assume that the acceleration due to gravity is 10 m/s^2.

1. The motion of the particle is observed in two different frames : one in the ground frame **(A)** and another frame **(B)**, in which the horizontal component of the displacement is always zero. Two observers located in these frames will agree on :-

(A) The total distance travelled by the particle
(B) The horizontal range of the particle
(C) The maximum height risen by the particle
(D) None of the above

2. "A third observer **(C)** close to the surface of the earth reports that particle is initially travelling at a speed of $100\sqrt{2}$ m/s making on angle of 45° with the horizontal, but its horizontal motion is northward". The third observer is moving in :-

(A) The south–west direction with a speed of $100\sqrt{2}$ m/s
(B) The south–east direction with a speed of $100\sqrt{2}$ m/s
(C) The north–west direction with a speed of $100\sqrt{2}$ m/s
(D) The north–east direction with a speed of $100\sqrt{2}$ m/s

3. There exists a frame **(D)** in which the distance travelled by the particle is a minimum. This minimum distance is equal to :-

(A) 2 km **(B)** 1 km **(C)** 0 km **(D)** 500 m

4. Consider an observer in frame D (of the previous question), who observes a body of mass 10 kg accelerating in the upward direction at 30 m/s^2 (w.r.t. himself). The net force acting on this body, as observed from the ground is :-

(A) 400 N in the upward direction
(B) 300 N in the upward direction
(C) 200 N in the upward direction
(D) 500 N in the upward direction

Exercise # 4 [Subjective Type Questions]

1. The position–time (x–t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in fig. Choose correct entries in the brackets below :

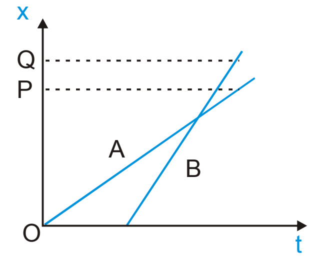
(i) (A/B) lives closer to the school than (B/A)

(ii) (A/B) starts from the school earlier than (B/A)

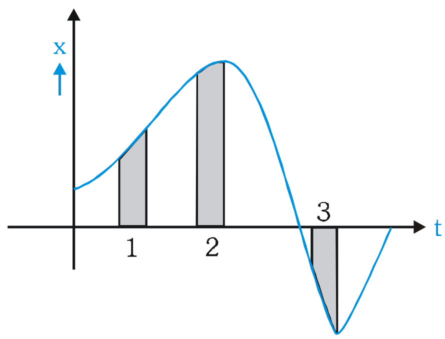
(iii) (A/B) walks faster than (B/A)

(iv) A and B reach home at the (same / different) time

(v) (A/B) overtakes (B/A) on the road (once/ twice).



2. For shown situation in which interval is the average speed greatest ? (Given each interval is of equal duration)



3. A particle is moving along x – axis with acceleration $a = a_0 (1 - t/T)$ where a_0 and T are constants. The particle at t = 0 has zero velocity. Calculate the average velocity between t = 0 and the instant when a = 0.

4. A lift accelerates downwards from rest at rate of 2 m/s^2, starting 100 m above the ground. After 3 sec, an object falls out of the lift. Which will reach the ground first ? What is the time interval between their striking the ground ?

5. A body moving with uniform acceleration, covers a distance of 20 m in the 7^{th} second and 24 m in the 9^{th} second. How much shall it cover in 15^{th} second ?

6. A driver travelling at speed 36 kmh^{-1} sees the light turn red at the intersection. If his reaction time is 0.6s, and then the car can deaccelerate at $4ms^{-2}$. Find the stopping distance of the car.

7. A train, travelling at 20 km/hr is approaching a platform. A bird is sitting on a pole on the platform. When the train is at a distance of 2 km from pole, brakes are applied which produce a uniform deceleration in it. At that instant the bird flies towards the train at 60 km/hr and after touching the nearest point on the train flies back to the pole and then flies towards the train and continues repeating itself. Calculate how much distance will the bird have flown before the train stops ?

8. A parachutist after bailing out falls 52 m without friction . When the parachute opens, she decelerates at 2.1 ms^{-2} & reaches the ground with a speed of 2.9 ms^{-1} .

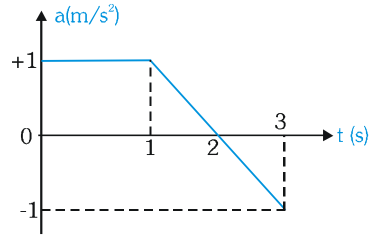
(i) How long has been the parachutist in the air ? (ii) At what height did the fall begin ?

9. A ball is thrown vertically upwards with a velocity of 20 ms^{-1} from the top of a tower. The height of the tower is 25 m from the ground.

(i) How high will the ball rise ?

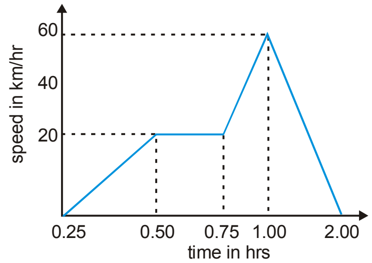
(ii) How long will it be before the ball hits the ground ? (Take g = 10 ms^{-2})

10. A particle starts motion from rest and moves along a straight line. Its acceleration–time graph is shown. Find out speed of particle at t = 2s and at t = 3s.



11. A balloon is going upwards with a constant velocity 15 m/s. When the balloon is at 50 m height, a stone is dropped outside from the balloon. How long will stone take to reach at the ground ? (take g = 10 m/s^2)

12. A train moves from one station to another in two hours time. Its speed during the motion is shown in the graph. Calculate



(i) Maximum acceleration during the journey .
(ii) Distance covered during the time interval from 0.75 hour to 1 hour .

13. Two trains A and B 100 m and 60 m long are moving in opposite directions on the parallel tracks. The speed of shorter train is 3 times that of the longer one. If the train take 4 seconds to cross each other then find the velocities of the trains ?

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

15. Two motor cars start from A simultaneously & reach B after 2 hour . The first car travelled half the distance at a speed of v_1 = 30 km hr^{-1} & the other half at a speed of v_2 = 60 km hr^{-1} . The second car covered the entire distance with a constant acceleration . At what instant of time, were the speeds of both the vehicles same ? Will one of them overtake the other in route ?

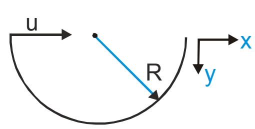
16. In a harbour, wind is blowing at the speed of 72 km/hr and the flag on the mast of a boat anchored in the harbour flutters along the N – E direction. If the boat starts moving at a speed of 51 km/hr to the north, what is the direction of flag on the mast of the boat ?

17. 'n' number of particles are located at the vertices of a regular polygon of n sides having the edge length 'a'. They all start moving simultaneously with equal constant speed 'v' heading towards each other all the time. How long will the particles take to collide ?

18. A particle is projected with a speed v and an angle θ to the horizontal. After a time t, the magnitude of the instantaneous velocity is equal to the magnitude of the average velocity from 0 to t. Find t.

19. A man crosses a river in a boat. If he crosses the river in minimum time he takes 10 minutes with a horizontal drift 120 m. If he crosses the river taking shortest path in 12.5 minutes then find width of the river, velocity of the boat w.r.t. water and speed of flow of river.

20. A particle is projected horizontally as shown from the rim of a large hemispherical bowl. The displacement of the particle when it strikes the bowl the first time is R. Find the velocity of the particle at that instant and the time taken.

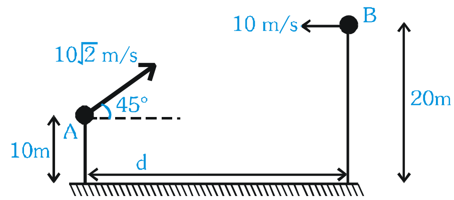


21. A projectile is thrown with speed u making angle θ with horizontal at t = 0. It just crosses the two points at equal height at time t=1 s and t = 3sec respectively. Calculate maximum height attained by it. (g=10m/s^2)

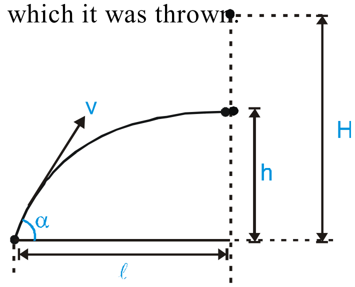
22. A Bomber flying upward at an angle of 53° with the vertical releases a bomb at an altitude of 800 m . The bomb strikes the ground 20s after its release . Find :[Given sin 53° = 0.8 ; g = 10 ms^{-2}]
(i) The velocity of the bomber at the time of release of the bomb .
(ii) The maximum height attained by the bomb .
(iii) The horizontal distance travelled by the bomb before it strikes the ground
(iv) The velocity (magnitude & direction) of the bomb just when it strikes the ground .

23. A food package was dropped from an aircraft flying horizontally. 6 s before it hit the ground, it was at a height of 780 m, and had travelled a distance of 1 km horizontally. Find the speed and the altitude of the aircraft.

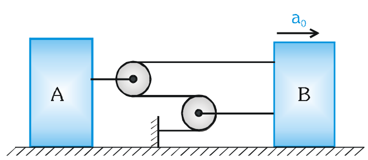
24. Two particles are projected from the two towers simultaneously, as shown in the figure. What should be value of 'd' for their collision.



25. A body falls freely from some altitude H. At the moment the first body starts falling another body is thrown from the earth's surface which collides with the first at an altitude h = H/2 . The horizontal distance is ℓ. Find the initial velocity and the angle at which it was thrown.

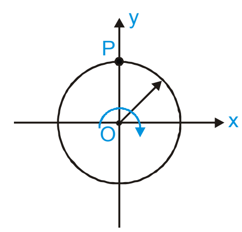


26. Calculate the relative acceleration of A w.r.t. B if B is moving with acceleration a_0 towards right.



27. A particle is performing circular motion of radius 1 m. Its speed is v = ($2t^2$) m/s. What will be magnitude of its acceleration at t = 1s.

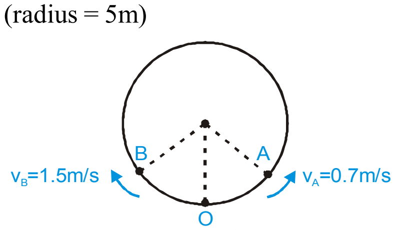
28. A ring rotates about z axis as shown in figure. The plane of rotation is xy.



At a certain instant the acceleration of a particle P (shown in figure) on the ring is $\left(6\tilde{i}-8\tilde{j}\right)m/s^2$. Find the angular acceleration of the ring & the angular velocity at that instant. Radius of the ring is 2m.

29. A particle is moving in a circular orbit with a constant tangential acceleration . After a certain time t has elapsed after the beginning of motion, the angle between the total acceleration a and the direction along the radius r becomes equal to 45°. What is the angular acceleration of the particle .

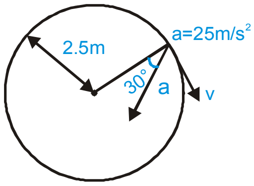
30. Two particles A and B start at O and travel in opposite directions along the circular path at constant speed v_A = 0.7 m/s and v_B= 1.5 m/s respectively. Determine the time when they collide and the magnitude of the acceleration of B just before this happening. (radius = 5m)



31. Two particles A and B move anticlockwise with the same speed v in a circle of radius R and are diametrically opposite to each other. At t=0, A is given a constant acceleration (tangential) $a_t = \dfrac{72v^2}{25\pi R}$. Calculate the time in which A collides with B, the angle traced by A, its angular velocity and radial acceleration at the time of collision.

32. A particle moves clockwise in a circle of radius 1m with centre at (x,y) = (1m,0). It starts at rest at the origin at time t=0. Its speed increases at the constant rate of $\left(\frac{\pi}{2}\right)$ m/s^2. (i) How long does it take to travel halfway around the circle? (ii) What is the speed at that time?

33. Figure shows the total acceleration and velocity of a particle moving clockwise in a circle of radius 2.5m at a given instant of time. At this instant, Find :(i) the radial acceleration, (ii) the speed of the particle and (iii) its tangential acceleration.



34. The brakes of a train which is travelling at 30 m/s are applied as the train passes point A. The brakes produce a constant retardation of magnitude 3 λ m/s^2 until the speed of the train is reduced to 10 m/s. The train travels at this speed for a distance and is then uniformly accelerated at λ m/s^2 until it again reaches a speed of 30 m/s as it passes point B . The time taken by the train in travelling from A to B, a distance of 4 km, is 4 min. Sketch the speed time graph for this motion and calculate :-
(i) The value of λ (ii) Distance travelled at 10 m/s .

35. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km h^{-} in the direction A to B notices that a bus goes past him every 18 min. in the direction of his motion, and every 6 min. in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road ?

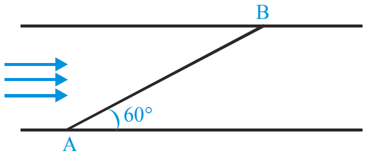
36. A balloon starts ascending from the ground at a constant speed of 25 m/s. After 5 s, a bullet is shot vertically upwards from the ground.
(i) What should be the minimum speed of the bullet so that it may reach the balloon ?
(ii) The bullet is shot at twice the speed calculated in (i). Find the height at which it passes the balloon.

37. A ship is moving at a constant speed of 10 km/hr in the direction of the unit vector $\tilde{i}$. Initially, its position vector, relative to a fixed origin is $10\left(-\tilde{i}+\tilde{j}\right)$ where $\tilde{i}$ & $\tilde{j}$ are perpendicular vectors of length 1 km . Find its position vector relative to the origin at time t hours later. A second ship is moving with constant speed u km/hr parallel to the vector $\tilde{i}+2\tilde{j}$ and is initially at the origin .
(i) If $u=10\sqrt{5}$ km / h . Find the minimum distance between the ships and the corresponding value of t
(ii) Find the value of u for which the ships are on a collision course and determine the value of t at which the collision would occur if no avoiding action were taken .

38. A helicopter takes off along the vertical with an acceleration of 3 m/sec^2 & zero initial velocity . In a certain time , the pilot switches off the engine . At the point of take–off, the sound dies away in 30 sec. Determine the velocity of the helicopter at the moment when its engine is switched off, assuming the velocity of sound is 320 m/s.

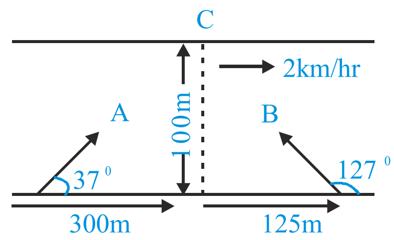
39. Two bodies move towards each other in a straight line at initial velocities v_1 & v_2 & with constant accelerations a_1 & a_2 directed against the corresponding velocities at the initial instant . What must be the maximum initial separation ℓ_{max} between the bodies for which they meet during the motion ?

40. A swimmer starts to swim from point A to cross a river. He wants to reach point B on the opposite side of the river. The line AB makes an angle 60° with the river flow as shown. The velocity of the swimmer in still water is same as that of the water



(i) In what direction should he try to direct his velocity? Calculate angle between his velocity and river velocity.
(ii) Find the ratio of the time taken to cross the river in this situation to the minimum time in which he can cross this river.

41. Two swimmers start a race. One who reaches the point C first on the other bank wins the race. A makes his strokes in a direction of 37^0 to the river flow with velocity 5km/hr relative to water. B makes his strokes in a direction 127^0 to the river flow with same relative velocity. River is flowing with speed of 2km/hr and is 100m wide. Who will win the race? Compute the time taken by A and B to reach the point C if the speeds of A and B on the ground are 8 km/hr and 6 km/hr respectively.



42. A shell is fired from a point O at an angle of 60° with a speed of 40 m/s & it strikes a horizontal plane through O, at a point A . The gun is fired a second time with the same angle of elevation but a different speed v . If it hits the target which starts to rise vertically from A with a constant speed $9\sqrt{3}$ m/s at the same instant as the shell is fired, find v .

43. Hailstones falling vertically with speed of 10 m/s hit the wind screen of a moving car and rebound elastically . Find the velocity of the car if the driver find the hailstones rebound vertically after striking . Wind screen makes an angle 30° with the horizontal.

44. A stone is projected from the point of a ground in such a direction so as to hit a bird on the top of a telegraph post of height h and then attain the maximum height 2h above the ground. If at the instant of projection, the bird were to fly away horizontally with a uniform speed, find the ratio between the horizontal velocities of the bird and the stone, if the stone still hits the bird while descending.

45. Two inclined planes OA and OB having inclinations 30^0 and 60^0 respectively, intersect each other at O as in figure. A particle is projected from point P with velocity $u = 10\sqrt{3}m/s$ along a direction perpendicular to plane OA. If the particle strikes the plane OB perpendicularly at Q. Calculate

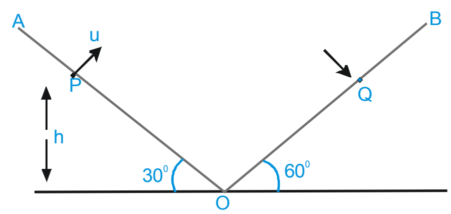
(i) Time of flight.

(ii) Velocity with which particle strikes the plane OB.

(iii) Vertical height of P from O.

(iv) Maximum height from O attained by the particle .

(v) Distance PQ.



46. A particle is projected with a velocity $2\sqrt{ag}$ so that it just clears two walls of equal height 'a'. which are at a distance 2a apart. Show that the time of passing between the walls is $2\sqrt{a/g}$.

47. A projectile is launched at an angle α from a cliff of height H above the sea level. If it falls into the sea at a distance D from the base of the cliff, show that its maximum height above the sea level is $\left[H + \frac{D^2 \tan^2 \alpha}{4(H + D\tan\alpha)}\right]$.

Exercise # 5

Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. A ball whose kinetic energy is E, is projected at an angle of 45° to the horizontal. The kinetic energy of the ball at the highest point of its flight will be- **[AIEEE - 2002]**

(1) E **(2)** $E/\sqrt{2}$ **(3)** E/2 **(4)** zero

2. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 m/s at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground ?
$[g = 10\ m/s^2, \sin 30° = 1/2, \cos 30° = \sqrt{3}/2]$ **[AIEEE - 2003]**

(1) 5.20 m **(2)** 4.33 m **(3)** 2.60 m **(4)** 8.66 m

3. A ball is thrown from a point with a speed v_0 at an angle of projection θ. From the same point and at the same instant, a person starts running with a constant speed $\frac{v_0}{2}$ to catch the ball. Will the person be able to catch the ball ? If yes, what should be the angle of projection ? **[AIEEE - 2004]**

(1) Yes, 60° **(2)** Yes, 30° **(3)** No **(4)** Yes, 45°

4. A projectile can have the same range R for two angles of projection. If t_1 and t_2 be the times of flights in the two cases, then the product of the two times of flights is proportional to- **[AIEEE - 2005]**

(1) R^2 **(2)** $\frac{1}{R^2}$ **(3)** $\frac{1}{R}$ **(4)** R

5. A particle is projected at 60° to the horizontal with a kinetic energy K. The kinetic energy at the highest point is- **[AIEEE - 2007]**

(1) K **(2)** zero **(3)** K/4 **(4)** K/2

6. A particle is moving with velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is: **[AIEEE - 2010]**

(1) $y^2 = x^2 + \text{constant}$ **(2)** $y = x^2 + \text{constant}$
(3) $y^2 = x + \text{constant}$ **(4)** $xy = \text{constant}$

7. A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is v, the total area around the fountain that gets wet is :- **[AIEEE - 2011]**

(1) $\frac{\pi}{2}\frac{v^4}{g^2}$ **(2)** $\pi\frac{v^2}{g^2}$ **(3)** $\pi\frac{v^2}{g}$ **(4)** $\pi\frac{v^4}{g^2}$

8. A boy can throw a stone up to a maximum height of 10 m. The maximum horizontal distance that the boy can throw the same stone up to will be :- **[AIEEE - 2012]**

(1) 20 m **(2)** $20\sqrt{2}$ m **(3)** 10 m **(4)** $10\sqrt{2}$ m

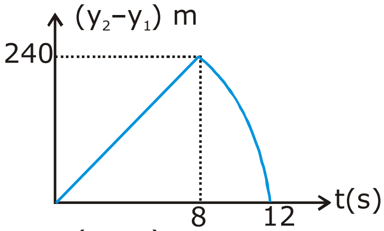
9. A projectile is given an initial velocity of $(\hat{i} + 2\hat{j})$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If $g = 10\ m/s^2$, the equation of its trajectory is : **[JEE (Main) - 2013]**

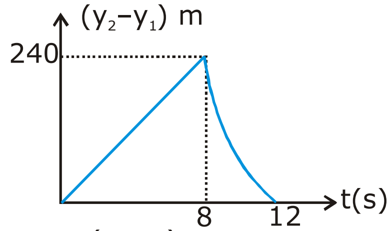
(1) $y = x - 5x^2$ **(2)** $y = 2x - 5x^2$ **(3)** $4y = 2x - 5x^2$ **(4)** $4y = 2x - 25x^2$

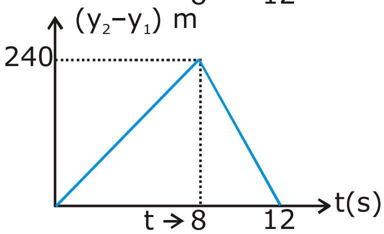
10. From a tower of height H, a particle is thrown vertically upwards with a speed U. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is: **[JEE (Main) - 2014]**

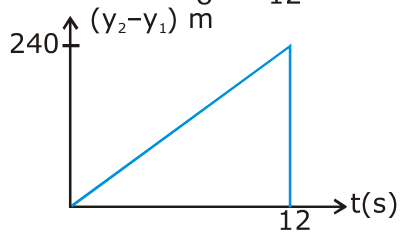
(1) $2gH = nu^2(n-2)$ **(2)** $gH = (n-2)u^2$ **(3)** $2gH = n^2u^2$ **(4)** $gH = (n-2)^2u^2$

11. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ?
(Assume stones do no rebound after hitting the ground and neglect air resistance, take $g = 10\ m/s^2$)
(The figures are schematic and not drawn to scale) **[JEE (Main) - 2015]**

(1)


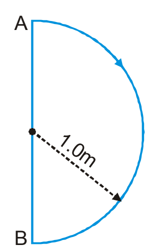
(2)


(3)


(4)


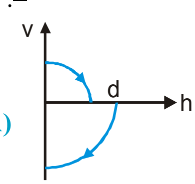
Part # II [Previous Year Questions][IIT-JEE ADVANCED]

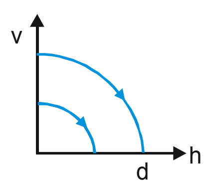
1. In 1.0s, a particle goes from point A to point B, moving in a semicircle (see figure). The magnitude of the average velocity is :– **[IIT-JEE 1999]**

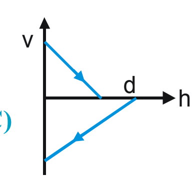


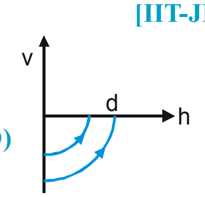
(A) 3.14 m/s
(B) 2.0 m/s
(C) 1.0 m/s
(D) zero

2. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height d/2. Neglecting subsequent motion and air resistance, its velocity v varies with height h above the ground as :– **[IIT-JEE 2000]**

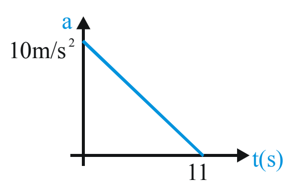
(A)


(B)


(C)


(D)


3. A particle starts from rest. Its acceleration **(A)** versus time (t) is as shown in the figure. The maximum speed of the particle will be :– **[IIT-JEE 2004]**

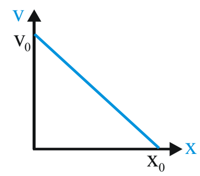


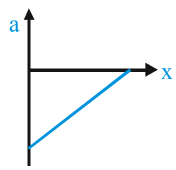
(A) 110 m/s **(B)** 55 m/s **(C)** 550 m/s **(D)** 660 m/s

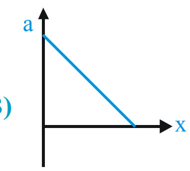
4. A small block slides without friction down an inclined plane starting from rest. Let s_n be the distance travelled from t = n – 1 to t = n. Then $\frac{s_n}{s_{n+1}}$ is :– **[IIT-JEE 2004]**

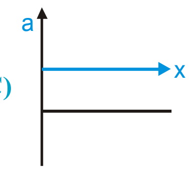
(A) $\frac{2n-1}{2n}$ **(B)** $\frac{2n+1}{2n-1}$ **(C)** $\frac{2n-1}{2n+1}$ **(D)** $\frac{2n}{2n+1}$

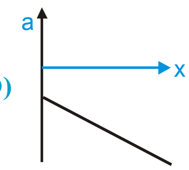
5. The given graph shows the variation of velocity with displacement. Which one of the graph given below correctly represents the variation of acceleration with displacement :– **[IIT-JEE 2005]**



(A) 

(B) 

(C) 

(D) 

Assertion-Reasoning Type Questions

1. **Statement–I :** For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary. **[IIT-JEE 2008]**

Statement-2 : If the observer and the object are moving at velocities $\vec{V}_1$ and $\vec{V}_2$ respectively with reference to a laboratory frame, the velocity of the object with respect to the observer is $\vec{V}_2 - \vec{V}_1$.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

MCQ's with one or More Than One Correct Answer

1. The coordinates of a particle moving in a plane are given by x(t) = acos(pt) and y(t) = bsin(pt) where a, b (<a) and p are positive constants of appropriate dimensions. Then : **[IIT-JEE 1999]**

(A) The path of the particle is an ellipse.

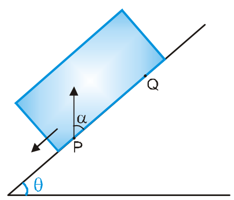
(B) The velocity and acceleration of the particle are normal to each other at $t = \pi/2p$

(C) The acceleration of the particle is always directed towards a focus.

(D) The distance travelled by the particle in time interval t = 0 to $t = \frac{\pi}{2p}$ is a

Subjective Questions

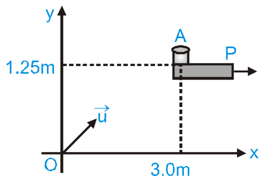
1. A large heavy box is sliding without friction down a smooth plane of inclination θ. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to the box is u and the direction of projection makes an angle α with the bottom as shown in the figure.



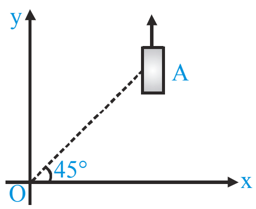
(i) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands (Assume that the particle does not hit any other surface of the box. Neglect air resistance)

(ii) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected. **[IIT-JEE 1998]**

2. An object A is kept fixed at the point x = 3m and y=1.25 m on a plank P raised above the ground. At time t = 0 the plank starts moving along the +x direction with an acceleration 1.5 m/s^2. At the same instant a stone is projected from the origin with a velocity $\vec{u}$ as shown. A stationary person on the ground observes the stone hitting the object during its downward motion at an angle of 45° to the horizontal. All the motions are in x–y plane. Find $\vec{u}$ and the time after which the stone hits the object. Take g = 10 m/s^2. **[IIT-JEE 2000]**



3. On a frictionless horizontal surface, assumed to be the x–y plane, a small trolley A is moving along a straight line parallel to the y–axis (see figure) with a constant velocity of $(\sqrt{3}-1)$ m/s. At a particular instant when the line OA makes an angle of 45° with the x–axis, a ball is thrown along the surface from the origin O. Its velocity makes on angle ϕ with the x–axis and it hits the trolly.



(i) The motion of the ball is observed from the frame of the trolley. Calculate the angle θ made by the velocity vector of the ball with the x–axis in this frame.

(ii) Find the speed of the ball with respect to the surface, if $\phi = \frac{4\theta}{3}$. **[IIT-JEE 2002]**

Integer Type Questions

1. A train is moving along a straight line with a constant acceleration 'a'. A boy standing in the train throws a ball forward with a speed of 10 m/s, at an angle of 60° to the horizontal. The boy has to move forward by 1.15 m inside the train to catch the ball back at the initial height. The acceleration of the train, in m/s^2, is **[IIT-JEE 2011]**

2. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in the figure. The speed of A is $100\sqrt{3}\ ms^{-1}$. At time t = 0 s, an observer in A finds B at a distance of 500 m. This observer sees B moving with a constant velocity perpendicular to the line of motion of A. If at $t = t_0$, A just escapes being hit by B, t_0 in seconds is **[IIT-JEE 2014]**

3. A rocket is moving in a gravity free space with a constant acceleration of $2\ ms^{-2}$ along + x direction (see figure). The length of a chamber inside the rocket is 4 m. A ball is thrown from the left end of the chamber in + x direction with a speed of $0.3\ ms^{-1}$ relative to the rocket. At the same time, another ball is thrown in –x direction with a speed of $0.2\ ms^{-1}$ from its right end relative to the rocket. The time in seconds when the two balls hit each other is **[IIT-JEE 2014]**

4. A horizontal circular platform of radius 0.5 m and mass 0.45 kg is free to rotate about its axis. Two massless spring toy-guns, each carrying a steel ball of mass 0.05 kg are attached to the platform at a distance 0.25 m from the centre on its either sides along its diameter (see figure). Each gun simultaneously fires the balls horizontally and perpendicular to the diameter in opposite directions. After leaving the platform, the balls have horizontal speed of $9\ ms_{-1}$ with respect to the ground. The rotational speed of the platform in rad s_{-1} after the balls leave the platform is **[IIT-JEE 2014]**

Comprehension

A frame of reference that is accelerated with respect to an inertial frame of reference is called a non-inertial frame of reference. A coordinate system fixed on a circular disc rotating about a fixed axis with a constant angular velocity ω is an example of a non-inertial frame of reference.

The relationship between the force $\vec{F}_{rot}$ experienced by a particle of mass m moving on the rotating disc and the force $\vec{F}_{in}$ experienced by the particle in an inertial fame of reference is $\vec{F}_{rot} = \vec{F}_{in} + 2m(\vec{v}_{rot} \times \vec{\omega}) + m(\vec{\omega} \times \vec{r}) \times \vec{\omega}$ where $\vec{v}_{rot}$ is the velocity of the particle in the rotating frame of reference and $\vec{r}$ is the position vector of the particle with respect to the centre of the disc.

Now consider a smooth slot along a diameter of a disc of radius R rotating counter-clockwise with a constant angular speed w about its vertical axis through its center. We assign a coordinate system with the origin at the centre of the disc, the x-axis along the slot, the y-axis perpendicular to the slot and the z-axis along the rotation axis $(\vec{\omega} = \omega\hat{k})$. A small block of mass m is gently placed in the slot at $\vec{r} = (R/2)\hat{i}$ at t = 0 and is constrained to move only along the slot. **[IIT-JEE 2016]**

1. The distance r of the block at time t is

(A) $\frac{R}{4}(e^{\omega t} + e^{-\omega t})$ (B) $\frac{R}{2}\cos\omega t$ (C) $\frac{R}{4}(e^{2\omega t} + e^{-2\omega t})$ (D) $\frac{R}{2}\cos 2\omega t$

2. The net reaction of the disc on the block is

(A) $\frac{1}{2}m\omega^2 R(e^{2\omega t} - e^{-2\omega t})\hat{j} + mg\hat{k}$ (B) $\frac{1}{2}m\omega^2 R(e^{\omega t} - e^{-\omega t})\hat{j} + mg\hat{k}$

(C) $-m\omega^2 R\cos\omega t\hat{j} - mg\hat{k}$ (D) $m\omega^2 R\cos\omega t\hat{j} - mg\hat{k}$

MOCK TEST : RECTILINEAR MOTION

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. A hall has the dimensions 10 m × 10 m × 10 m. A fly starting at one corner ends up at diagonally opposite corner. The magnitude of its displacement is :

(A) $5\sqrt{3}$ m **(B)** $10\sqrt{3}$ m **(C)** $20\sqrt{3}$ m **(D)** $30\sqrt{3}$ m

2. A body starts from rest and is uniformly accelerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then $x_1 : x_2 : x_3$ is the same as :

(A) 1 : 1 : 1 **(B)** 1 : 2 : 4 **(C)** 1 : 3 : 5 **(D)** 2 : 3 : 5

3. A ball is dropped from the top of a building. The ball takes 0.5 s to fall past the 3 m length of a window some distance from the top of the building. If the velocities of the ball at the top and at the bottom of the window are v_T and v_B respectively, then (take g = 10 m/s^2) :

(A) $v_T + v_B = 12\ ms^{-1}$ **(B)** $v_T - v_B = 4.9\ m\ s^{-1}$ **(C)** $v_B v_T = 1\ ms^{-1}$ **(D)** $\frac{v_B}{v_T} = 1\ ms^{-1}$

4. Two trains, which are moving along different tracks in opposite directions, are put on the same track due to a mistake. Their drivers, on noticing the mistake, start slowing down the trains when the trains are 300 m apart. Graphs given below show their velocities as function of time as the trains slow down. The separation between the trains when both have stopped, is :

(A) 120 m **(B)** 280 m **(C)** 60 m **(D)** 20 m.

5. A stone is projected vertically upwards at t = 0 second. The net displacement of stone is zero in time interval between t = 0 second to t = T seconds. Pick up the incorrect statement :

(A) From time $t = \frac{T}{4}$ second to $t = \frac{3T}{4}$ second, the average velocity is zero.

(B) The change in velocity from time t = 0 to $t = \frac{T}{4}$ second is same as change in velocity from $t = \frac{T}{8}$ second to $t = \frac{3T}{8}$ second

(C) The distance travelled from t = 0 to $t = \frac{T}{4}$ second is larger than distance travelled from $t = \frac{T}{4}$ second to $t = \frac{3T}{4}$ second

(D) The distance travelled from $t = \frac{T}{2}$ second to $t = \frac{3T}{4}$ second is half the distance travelled from $t = \frac{T}{2}$ second to t = T second.

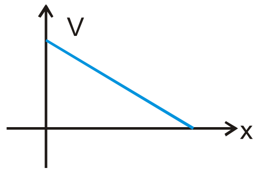
6. A point moves in a straight line under the retardation av^2. If the initial velocity is u , the distance covered in ' t ' seconds is:

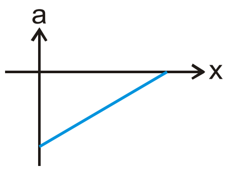
(A) a u t **(B)** $\frac{1}{a}\ell n\,(a\,u\,t)$ **(C)** $\frac{1}{a}\ell n\,(1 + a\,u\,t)$ **(D)** $a\,\ell n\,(a\,u\,t)$

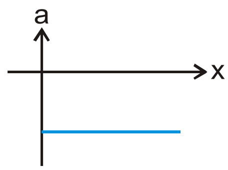
7. A particle is thrown upwards from ground . It experiences a constant resistance force which can produce retardation of 2 m/s^2 . The ratio of time of ascent to the time of descent is : [g = 10 m/s^2]

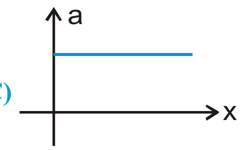
(A) 1 : 1 **(B)** $\sqrt{\frac{2}{3}}$ **(C)** $\frac{2}{3}$ **(D)** $\sqrt{\frac{3}{2}}$

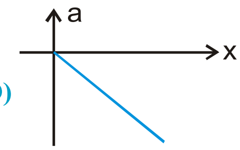
8. A particle moves along x-axis with initial position x = 0. Its velocity varies with x-coordinate as shown in graph. The acceleration 'a' of this particle varies with x as :



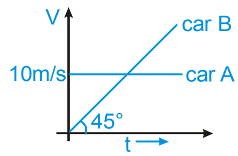
(A) 

(B) 

(C) 

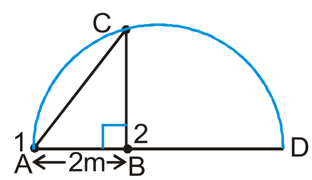
(D) 

9. Initially car A is 10.5 m ahead of car B. Both start moving at time t = 0 in the same direction along a straight line. The velocity time graph of two cars is shown in figure. The time when the car B will catch the car A, will be :



(A) t = 21 sec **(B)** t = $2\sqrt{5}$ sec **(C)** 20 sec. **(D)** None of these

10. A semicircle of radius R = 5m with diameter AD is shown in figure. Two particles 1 and 2 are at points A and B on shown diameter at t = 0 and move along segments AC and BC with constant speeds u_1 and u_2 respectively. Then the value of $\frac{u_1}{u_2}$ for both particles to reach point C simultaneously will be :



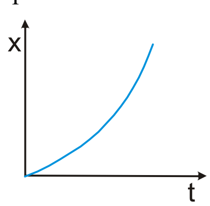
(A) $\frac{5\sqrt{2}}{4}$ **(B)** $\frac{2\sqrt{2}}{5}$

(C) $2\sqrt{2}$ **(D)** $\sqrt{\frac{5}{4}}$

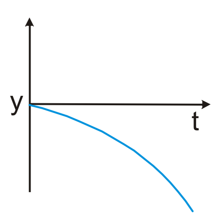
11. Two bikes A and B start from a point. A moves with uniform speed 40 m/s and B starts from rest with uniform acceleration 2 m/s^2. If B starts at t = 0 and A starts from the same point at t = 10 s, then the time during the journey in which A was ahead of B is :

(A) 20 s **(B)** 8 s **(C)** 10 s **(D)** A was never ahead of B

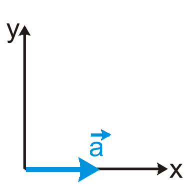
12. Graphs I and II give coordinates x(t) and y(t) of a particle moving in the x-y plane Acceleration of the particle is constant and the graphs are drawn to the same scale. Which of the vector shown in options best represents the acceleration of the particle :

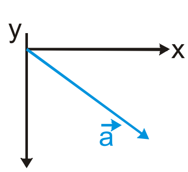


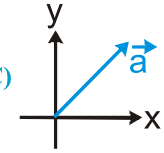
(I)

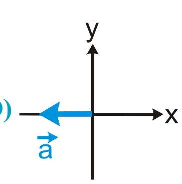


(II)

(A) 

(B) 

(C) 

(D) 

13. An insect moving along a straight line, (without returning) travels in every second distance equal to the magnitude of time elapsed. Assuming acceleration to be constant, and the insect starts at t = 0. Find the magnitude of initial velocity of insect.

(A) $\frac{1}{2}$ unit **(B)** $\frac{1}{4}$ unit **(C)** $\frac{3}{2}$ unit **(D)** 1 unit

14. A stone is dropped from the top of building and at the same time a second stone is thrown vertically upward from the bottom of the building with a speed of 20 ms^{-1} . They pass each other 3 seconds later. Find the height of the building.

(A) 40 m **(B)** 60 m **(C)** 65 m **(D)** 80 m

15. The position vector of a particle is given as $\vec{r} = (t^2 - 4t + 6)\hat{i} + (t^2)\hat{j}$. The time after which the velocity vector and acceleration vector becomes perpendicular to each other is equal to

(A) 1sec **(B)** 2 sec **(C)** 1.5 sec **(D)** not possible

16 Each of the four particles move along x axis. Their coordinates (in metres) as function of time (in seconds) are given by

Particle 1 : $x(t) = 3.5 - 2.7t^3$

Particle 2 : $x(t) = 3.5 + 2.7t^3$

Particle 3 : $x(t) = 3.5 + 2.7t^2$

Particle 4 : $x(t) = 3.5 - 3.4t - 2.7t^2$

which of these particles is speeding up for t > 0?

(A) All four **(B)** only 1 **(C)** only 1, 2 and 3. **(D)** only 2, 3 and 4.

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

17. Mark the correct statements:

(A) Average velocity of a particle moving on a straight line was zero in a time interval but its instantaneous velocity was never zero in that interval (Consider finite acceleration only)

(B) Average velocity of a particle was zero in a time interval but its speed was never zero in that interval (Consider finite acceleration only)

(C) We can have a situation where magnitude of acceleration is non-zero, but rate of change of speed is zero

(D) Average speed of particle in a given time interval is always greater than or equal to the magnitude of the average velocity in the same time interval.

18. Which of the following statements are true for a moving body ?

(A) if its speed changes, its velocity must change and it must have some acceleration.

(B) if its velocity changes, its speed must change and it must have some acceleration.

(C) if its velocity changes, its speed may or may not change, and it must have some acceleration.

(D) if its speed changes but direction of motion does not change, its velocity may remain constant.

19. If velocity of the particle is given by $v = \sqrt{x}$, where x denotes the position of the particle and initially particle was at x = 4, then which of the following are correct?

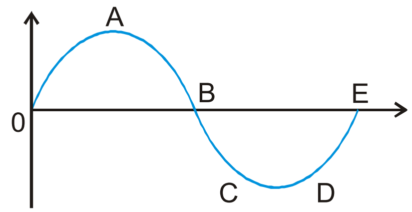
(A) at t = 2 sec, the position of the particle is at x = 9.

(B) Particle's acceleration at t = 2 sec. is 1 m/s^2.

(C) Particle's acceleration is $\frac{1}{2}$ m/s^2 throughout the motion.

(D) Particle will never go in negative direction from it's starting position.

20. A particle has a rectilinear motion and the figure gives its displacement as a function of time . Which of the following statements are true with respect to the motion ?



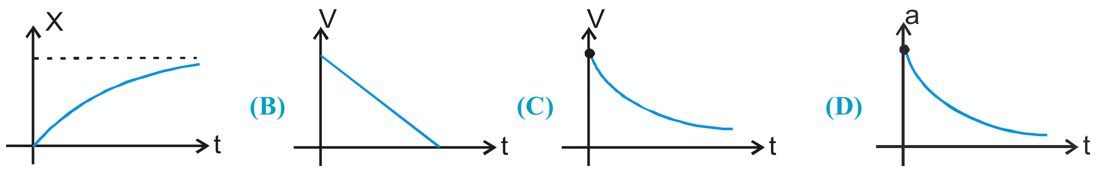
(A) In the motion between O and A the velocity is positive and acceleration is negative.

(B) Between A and B the velocity and acceleration are positive .

(C) Between B and C the velocity is negative and acceleration is positive .

(D) Between D and E the acceleration is positive .

21. A rabbit is moving in straight line towards a carrot, slowing down its speed so that in each second it moves half the remaining distance from his nose to a carrot. If the total distance travelled by the rabbit in time t is X, its instantaneous speed V and magnitude of its instantaneous acceleration 'a' then which of the following graph(S) is/are best representing the motion ?



22. A particle moves with an initial velocity v_0 and retardation βv, where v is its velocity at any time t (β is a positive constant).

(A) the particle will cover a total distance of v_0/β

(B) the particle will continue to move for a very long time

(C) the particle will stop shortly

(D) the velocity of particle will become $v_0/2$ after time $1/\beta$.

SECTION - III : ASSERTION AND REASON TYPE

23. **Statement 1 :** Magnitude of average velocity is equal to average speed.

Statement 2 : Magnitude of instantaneous velocity is equal to instantaneous speed.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

24. **Statement 1 :** When velocity of a particle is zero then acceleration of particle is also zero.

Statement 2 : Acceleration is equal to rate of change of velocity.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

25. **Statement-1 :** A particle moves in a straight line with constant acceleration. The average velocity of this particle cannot be zero in any time interval

Statement-2 : For a particle moving in straight line with constant acceleration, the average velocity in a time interval is $\frac{u+v}{2}$, where u and v are initial and final velocity of the particle of the given time interval.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

26. **Statement-1 :** For a particle moving in a straight line, velocity (v in m/s) of the particle in terms of time (t in sec) is given by $v = t^2 - 6t + 8$. Then the speed of the particle is minimum at t = 2 sec.

Statement-2 : For a particle moving in a straight line the velocity v at any time t may be minimum or may be maximum when $\frac{dv}{dt} = 0$.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension - 1

A particle moves along x-axis and its acceleration at any time t is $a = 2\sin(\pi t)$, where t is in seconds and a is in m/s^2. The initial velocity of particle (at time t = 0) is u = 0.

27. Then the distance travelled (in meters) by the particle from time t = 0 to t = 1 s will be :

(A) $\frac{2}{\pi}$ **(B)** $\frac{1}{\pi}$ **(C)** $\frac{4}{\pi}$ **(D)** None of these

28. Then the distance travelled (in meters) by the particle from time t = 0 to t = t will be :

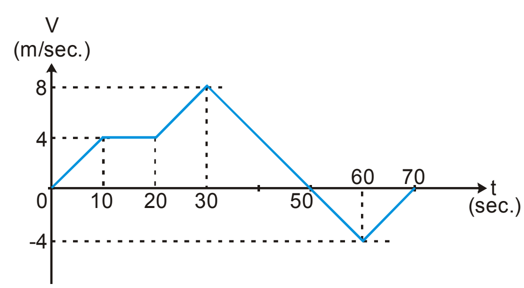
(A) $\frac{2}{\pi^2}\sin\pi t - \frac{2t}{\pi}$ **(B)** $-\frac{2}{\pi^2}\sin\pi t + \frac{2t}{\pi}$ **(C)** $\frac{2t}{\pi}$ **(D)** None of these

29. Then the magnitude of displacement (in meters) by the particle from time t = 0 to t = t will be :

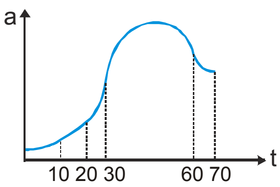
(A) $\frac{2}{\pi^2}\sin\pi t - \frac{2t}{\pi}$ **(B)** $-\frac{2}{\pi^2}\sin\pi t + \frac{2t}{\pi}$ **(C)** $\frac{2t}{\pi}$ **(D)** None of these

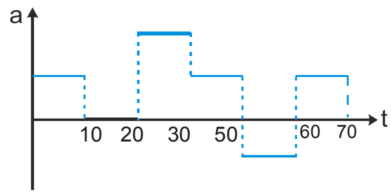
Comprehension - 2

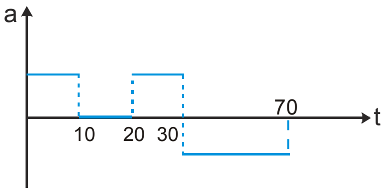
A car is moving on a straight road. The velocity of the car varies with time as shown in the figure. Initially (at t = 0), the car was at x = 0, where, x is the position of the car at any time 't'.

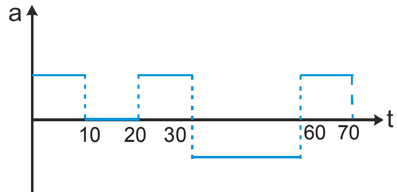


30. The variation of acceleration **(A)** with time (t) will be best represented by :

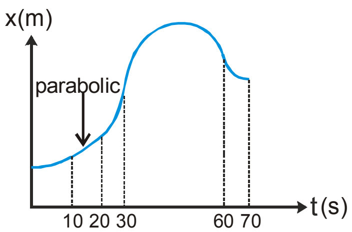
(A)


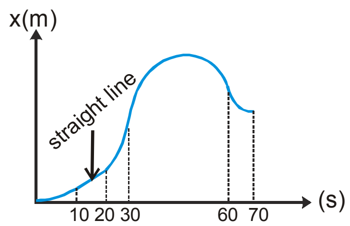
(B)


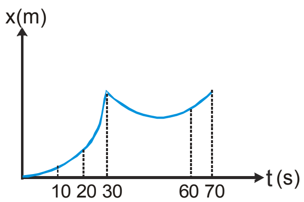
(C)


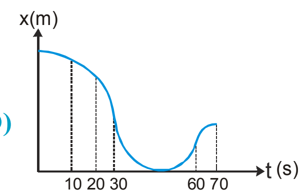
(D)


31. The displacement time graph will be best represented by :

(A)


(B)


(C)


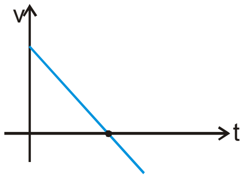
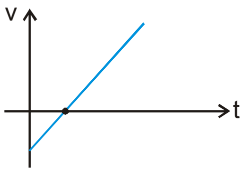
(D)


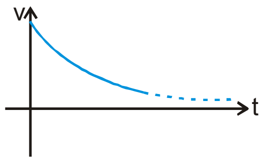
32. The maximum displacement from the starting position will be :

(A) 200 m **(B)** 250 m **(C)** 160 m **(D)** 165 m

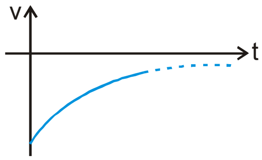
SECTION - V : MATRIX - MATCH TYPE

33. The velocity time graph for a particle moving along a straight line is given in each situation of column-I. In the time interval $\infty > t > 0$, match the graph in column-I with corresponding statements in column-II.

Column-I	Column-II
(A) 	**(p)** speed of particle is continuously decreasing.
(B) 	**(q)** magnitude of acceleration of particle is decreasing with time.

(C) 

(r) direction of acceleration of particle does not change.

(D) 

(s) magnitude of acceleration of particle is increasing with time.

(t) magnitude of acceleration of particle does not change.

34. The equation of motion of the particle is described in column I. At t = 0, particle is at origin and at rest. Match the column I with the statements in column II .

Column I	Column II
(A) $x = (3t^2 + 2t)$m	(p) velocity of particle at t = 1 s is 8 m/s.
(B) $v = 8t$ m/s	(q) particle moves with uniform acceleration.
(C) $a = 16\,t$	(r) particle moves with variable acceleration.
(D) $v = 6t - 3t^2$	(s) acceleration of the particle at t = 1sec is $2m/s^2$
	(t) particle will change its direction some time.

SECTION - VI : INTEGER TYPE

35. A railway track runs parallel to a road until a turn brings the road to railway crossing. A cyclist rides along the road everyday at a constant speed 20 km/hr. He normally meets a train that travels in same direction at the crossing. One day he was late by 25 minutes and met the train 10 km before the railway crossing. Find the speed of the train (in km/hr) .

36. A particle starts moving rectilinearly at time t = 0 such that its velocity 'v' changes with time 't' according to the equation $v = t^2 - t$ where t is in seconds and v is in m/s. Find the time interval for which the particle retards. (in m/s)

37. A bird is at a point P(4m, –1m, 5m) and sees two points P_1(–1m, –1m, 0m) and P_2(3m, –1m, –3m). At time t = 0, it starts flying in a plane of the three positions, with a constant speed of 2 m/s in a direction perpendicular to the straight line P_1P_2 till it sees P_1 & P_2 collinear at time t . If t is $\frac{x}{10}$ sec then x is

MOCK TEST : PROJECTILE MOTION

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. A body is thrown horizontally with a velocity $\sqrt{2gh}$ from the top of a tower of height h. It strikes the level ground through the foot of the tower at a distance x from the tower. The value of x is:

(A) h **(B)** $\frac{h}{2}$ **(C)** 2h **(D)** $\frac{2h}{3}$

2. It was calculated that a shell when fired from a gun with a certain velocity and at an angle of elevation $\frac{5\pi}{36}$ rad should strike a given target. In actual practice, it was found that a hill just prevented the trajectory. At what angle of elevation should the gun be fired to hit the target?

(A) $\frac{5\pi}{36}$ rad **(B)** $\frac{11\pi}{36}$ rad **(C)** $\frac{7\pi}{36}$ rad **(D)** $\frac{13\pi}{36}$ rad.

3. A ball is projected horizontally with a speed v from the top of a plane inclined at an angle 45° with the horizontal. How far from the point of projection will the ball strike the plane?

(A) $\frac{v^2}{g}$ **(B)** $\sqrt{2}\,\frac{v^2}{g}$ **(C)** $\frac{2v^2}{g}$ **(D)** $\sqrt{2}\left[\frac{2v^2}{g}\right]$

4. Consider a boy on a trolley who throws a ball with speed 20 m/s at an angle 37° with respect to trolley in direction of motion of trolley which moves horizontally with speed 10 m/s then what will be maximum distance travelled by ball parallel to road :

(A) 20.2 m **(B)** 12 m **(C)** 31.2 m **(D)** 62.4 m

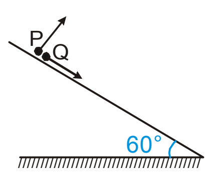
5. A particle is projected up the inclined plane such that its component of velocity along the incline is 10 m/s. Time of flight is 2 sec and maximum height above the incline is 5 m. Then velocity of projection will be :

(A) 10 m/s **(B)** $10\sqrt{2}$ m/s **(C)** $5\sqrt{5}$ m/s **(D)** none

6. Two men A and B, A standing on the extended floor nearby a building and B is standing on the roof of the building. Both throw a stone each towards each other. Then which of the following will be correct:

(A) stone will hit A, but not B
(B) stone will hit B, but not A
(C) stone will not hit either of them, but will collide with each other
(D) none of these.

7. A particle P is projected from a point on the surface of smooth inclined plane (see figure). Simultaneously another particle Q is released on the smooth inclined plane from the same position. P and Q collide on the inclined plane after t = 4 second. The speed of projection of P is : (in m/s)



(A) 5 m/s **(B)** 10 m/s **(C)** 15 m/s **(D)** 20 m/s

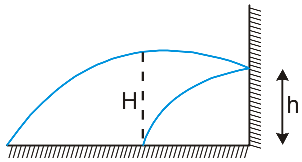
8. A particle is projected from a point (0, 1) on Y-axis (assume + Y direction vertically upwards) aiming towards a point (4, 9). It fell on ground along x axis in 1 sec. Taking $g = 10\ m/s^2$ and all coordinate in metres. Find the X-coordinate where it fell:

(A) (3, 0) **(B)** (4, 0) **(C)** (2, 0) **(D)** $(2\sqrt{5}, 0)$

9. Velocity of a stone projected, 2 second before it reaches the maximum height, makes angle 53° with the horizontal then the velocity at highest point will be : (in m/s)

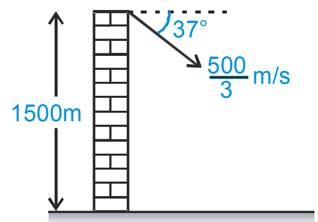
(A) 20 m/s **(B)** 15 m/s **(C)** 25 m/s **(D)** 80/3 m/s

10. A stone is projected from a horizontal plane. It attains maximum height 'H' & strikes a stationary smooth wall & falls on the ground vertically below the maximum height. Assume the collision to be elastic, the height of the point on the wall where ball will strike is :



(A) $\frac{H}{2}$ **(B)** $\frac{H}{4}$ **(C)** $\frac{3H}{4}$ **(D)** None of these

11. A particle is projected from a tower as shown in figure, then the distance from the foot of the tower where it will strike the ground will be : (take $g = 10\ m/s^2$)



(A) 4000/3 m **(B)** 5000/3 m **(C)** 2000 m **(D)** 3000 m

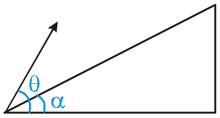
12. Distance between a frog and an insect on a horizontal plane is 10 m. Frog can jump with a maximum speed of $\sqrt{10}$ m/s. $g = 10\ m/s^2$. Minimum number of jumps required by the frog to catch the insect is :

(A) 5 **(B)** 10 **(C)** 100 **(D)** 50

13. A particle starts from the origin at t = 0 and moves in the x-y plane with constant acceleration 'a' in the y direction. Its equation of motion is $y = bx^2$. The x component of its velocity (at t = 0) is :

(A) variable **(B)** $\sqrt{\frac{2a}{b}}$ **(C)** $\frac{a}{2b}$ **(D)** $\sqrt{\frac{a}{2b}}$

14. A projectile is fired at an angle θ with the horizontal. Find the condition under which it lands perpendicular on an inclined plane inclination α as shown in figure.



(A) $\sin\alpha = \cos(\theta - \alpha)$ **(B)** $\cos\alpha = \sin(\theta - \alpha)$

(C) $\tan\theta = \cot(\theta - \alpha)$ **(D)** $\cot(\theta - \alpha) = 2\tan\alpha$

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

15. A particle is projected at an angle θ from ground with speed u ($g = 10\ m/s^2$) :

(A) if u = 10 m/s and $\theta = 30^0$, then time of flight will be 1 sec.

(B) if u = $10\sqrt{3}$ m/s and $\theta = 60^0$, then time of flight will be 3 sec.

(C) if u = $10\sqrt{3}$ m/s and $\theta = 60^0$, then after 2 sec velocity becomes perpendicular to initial velocity.

(D) if u = 10 m/s and $\theta = 30^0$, then velocity never becomes perpendicular to initial velocity during its flight.

16. A particle is projected vertically upwards with a velocity u from a point O . When it returns to the point of projection :

(A) its average velocity is zero

(B) its displacement is zero

(C) its average speed is u/2

(D) its average speed is u.

17. A particle of mass m moves along a curve $y = x^2$. When particle has x – co-ordinate as 1/2 and x-component of velocity as 4m/s then:

(A) the position coordinate of particle are (1/2, 1/4)

(B) the velocity of particle will be along the line 4x – 4y – 1 = 0.

(C) the magnitude of velocity at that instant is $4\sqrt{2}$ m/s

(D) the magnitude of angular momentum of particle about origin at that position is 0.

18. A stone is projected from level ground at time t=0. Let v_x and v_y are the horizontal and vertical components of velocity at any time t ; x and y are displacements along horizontal and vertical from the point of projection at any time t. Then:

(A) v_y – t graph is a straight line

(B) x – t graph is a straight line passing through origin

(C) y – t graph is a straight line passing through origin

(D) v_x – t graph is a straight line

19. Two balls are thrown from an inclined plane at angle of projection α with the plane one up the incline plane and other down the incline as shown in the figure. If R_1 & R_2 be their respective ranges and h_1 & h_2 be their respective maximum height then

(A) $h_1 = h_2$

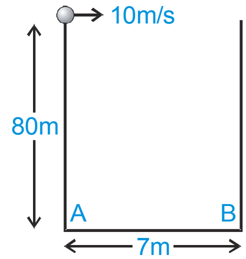
(B) $R_2 - R_1 = T_1^2$

(C) $R_2 - R_1 = g \sin\theta\, T_2^2$

(D) $R_2 - R_1 = g \sin\theta\, T_1^2$

[here T_1 & T_2 are times of flight in the two cases respectively]

20. A ball is projected horizontally from top of a 80 m deep well with velocity 10 m/s. Then particle will fall on the bottom at a distance of (all the collisions with the wall are elastic) :



(A) 5 m from A **(B)** 5 m from B **(C)** 2 m from A **(D)** 2 m from B

SECTION - III : ASSERTION AND REASON TYPE

21. **Statement-1 :** Two stones are simultaneously projected from level ground from same point with same speed but different angles with horizontal. Both stones move in same vertical plane. Then the two stones may collide in mid air.

Statement-2 : For two stones projected simultaneously from same point with same speed at different angles with horizontal, their trajectories may intersect at some point.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

22. **Statement–1 :** During flight under action of gravity, the change in velocity of a projectile in same time intervals is same. (Neglect air friction)

Statement–2 : Neglecting air friction, the acceleration of projectile is constant during flight.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True.

23. **Statement–1 :** The velocity of a particle depends on its position vector.

Statement–2 : If $\vec{r}$ is position vector of a particle at any time t, then velocity is given by $\vec{v} = \frac{d\vec{r}}{dt}$.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

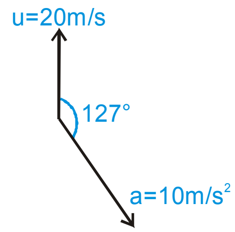
(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True.

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

The direction of velocity of a particle at time t=0 is as shown in the figure and has magnitude u = 20m/s. The acceleration of particle is always constant and has magnitude $10m/s^2$ .The angle between its initial velocity and acceleration is 127°. (Take sin 37° = 3/5)



24. The instant of time at which acceleration and velocity are perpendicular is :

(A) 0.6 sec. **(B)** 1.2 sec. **(C)** 2.4 sec. **(D)** None of these

25. The instant of time at which speed of particle is least :

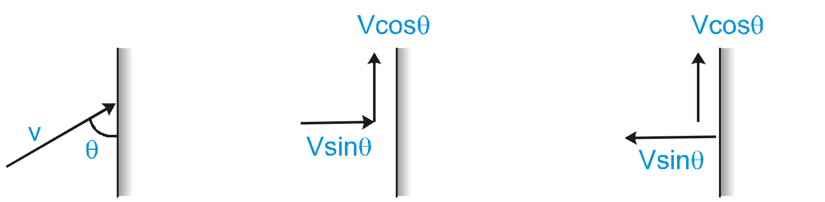
(A) 0.6 sec. **(B)** 1.2 sec. **(C)** 2.4 sec. **(D)** None of these

26. The instant of time t at which acceleration of particle is perpendicular to its displacement (displacement from t = 0 till that instant t) is :

(A) 0.6 sec. **(B)** 1.2 sec. **(C)** 2.4 sec. **(D)** None of these

Comprehension # 2

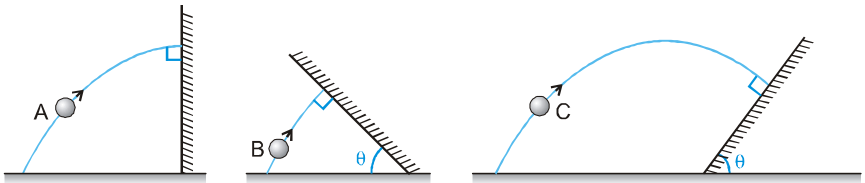
We know how by neglecting the air resistance, the problems of projectile motion can be easily solved and analysed. Now we consider the case of the collision of a ball with a wall. In this case the problem of collision can be simplified by considering the case of elastic collision only. When a ball collides with a wall we can divide its velocity into two components, one perpendicular to the wall and other parallel to the wall. If the collision is elastic then the perpendicular component of velocity of the ball gets reversed with the same magnitude.



Velocity just before collision — Components of velocity just before collision — Components of velocity just after collision

The other parallel component of velocity will remain constant if wall is given smooth.

Now let us take a problem. Three balls 'A' and 'B' & 'C' are projected from ground with same speed at same angle with the horizontal. The balls A,B and C collide with the wall during their flight in air and all three collide perpendicularly with the wall as shown in figure.



27. Which of the following relation about the maximum height H of the three balls from the ground during their motion in air is correct :

(A) $H_A = H_C > H_B$ **(B)** $H_A > H_B = H_C$ **(C)** $H_A > H_C > H_B$ **(D)** $H_A = H_B = H_C$

28. If the time taken by the ball A to fall back on ground is 4 seconds and that by ball B is 2 seconds. Then the time taken by the ball C to reach the inclined plane after projection will be :

(A) 6 sec. **(B)** 4 sec. **(C)** 3 sec. **(D)** 5 sec.

29. The maximum height attained by ball 'A' from the ground is :

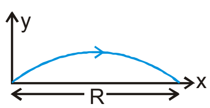
(A) 10 m **(B)** 15 m **(C)** 20 m **(D)** Insufficient information

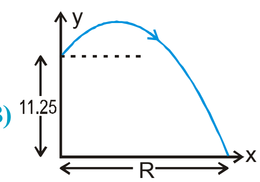
SECTION - V : MATRIX - MATCH TYPE

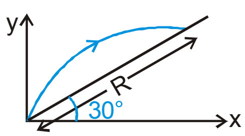
30. In the column-I, the path of a projectile (initial velocity 10 m/s and angle of projection with horizontal 60° in all cases) is shown in different cases. Range 'R' is to be matched in each case from column-II. Take $g = 10\ m/s^2$. Arrow on the trajectory indicates the direction of motion of projectile.

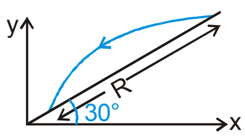
Match each entry of column–I with its corresponding entry in column–II

Column-I

(A) 

(B) 

(C) 

(D) 

Column-II

(p) $R = \frac{15\sqrt{3}}{10}$ m

(q) $R = \frac{40}{3}$ m

(r) $R = 5\sqrt{3}$ m

(s) $R = \frac{20}{3}$ m

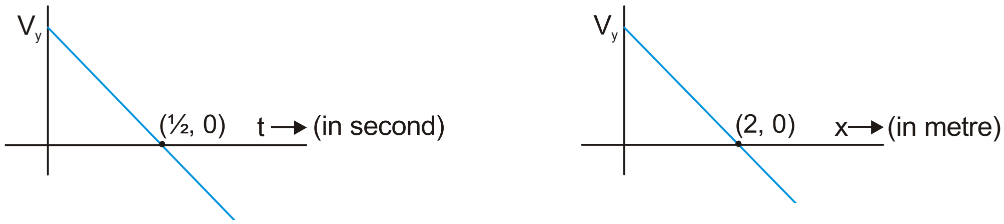
(t) R = 100 m

31. A ball is thrown at an angle 75° with the horizontal at a speed of 20 m/s towards a high wall at a distance d. If the ball strikes the wall, its horizontal velocity component reverses the direction without change in magnitude and the vertical velocity component remains same. Ball stops after hitting the ground. Match the statement of column I with the distance of the wall from the point of throw in column II .

Column I	Column II
(A) Ball strikes the wall directly	**(p)** d = 8 m
(B) Ball strikes the ground at x = 12 m from the wall	**(q)** d = 10 m
(C) Ball strikes the ground at x = 10 m from the wall	**(r)** d = 15 m
(D) Ball strikes the ground at x = 5 m from the wall	**(s)** d = 25 m
	(t) d = 30 m

SECTION - VI : INTEGER TYPE

32. Two graphs of the same projectile motion (in the xy plane) projected from origin are shown. X axis is along horizontal direction & Y axis is vertically upwards. Take g = 10 m/s^2.



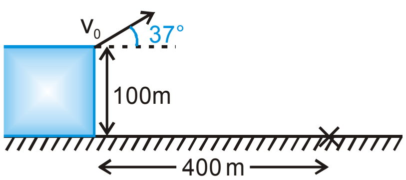
Find (i) Y component of initial velocity and

(ii) X component of initial velocity

33. A stone is dropped from a height of 45 m from horizontal level ground. There is horizontal wind blowing due to which horizontal acceleration of the stone becomes 10 m/s^2 . (Take g= 10m/s^2)

(A) Find time taken by stone to reach the ground. (in m/s)

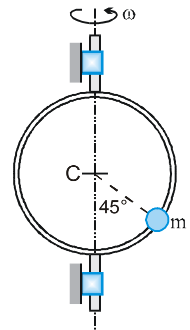
34. A projectile is fired into the air from the edge of a 100 m high cliff at an angle of 37° above the horizontal. The projectile hits a target 400 m away from the base of the cliff. If initial velocity of the projectile, v_0 is $x\sqrt{5}$ m/s then x is ? (Neglect air friction and assume x-axis to be horizontal and y-axis to be vertical).



MOCK TEST : CIRCULAR MOTION

SECTION - I : STRAIGHT OBJECTIVE TYPE

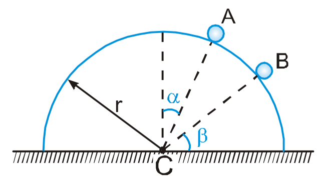
1. A small bead of mass m = 1 kg is carried by a circular hoop having centre at C and radius r = 1 m which rotates about a fixed vertical axis (as shown). The coefficient of friction between bead and hoop is μ = 0.5. The maximum angular speed of the hoop for which the bead does not have relative motion with respect to hoop: initial position of bead is shown in figure



(A) $(5\sqrt{2})^{1/2}$ **(B)** $(10\sqrt{2})^{1/2}$

(C) $(15\sqrt{2})^{1/2}$ **(D)** $(30\sqrt{2})^{1/2}$

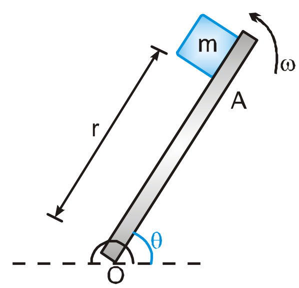
2. A particle initially at rest starts moving from point A on the surface of a fixed smooth hemisphere of radius r as shown. The particle looses its contact with hemisphere at point B. C is centre of the hemisphere. The equation relating α and β is :



(A) 3 sin α = 2 cos β **(B)** 2 sin α = 3 cos β

(C) 3 sin β = 2 cos α **(D)** 2 sin β = 3 cos α

3. The member OA rotates about a horizontal axis through O with a constant counter clockwise velocity ω = 3 rad/sec. As it passes the position θ = 0, a small mass m is placed upon it at a radial distance r= 0.5 m. If the mass is observed to slip at θ = 37°, the coefficient of friction between the mass & the member is ______.



(A) $\frac{3}{16}$ **(B)** $\frac{9}{16}$

(C) $\frac{4}{9}$ **(D)** $\frac{5}{9}$

4. Two particles A & B separated by a distance 2 R are moving counter clockwise along the same circular path of radius R each with uniform speed v. At time t = 0, A is given a tangential acceleration of magnitude a $= \frac{72\,v^2}{25\,\pi\,R}$.

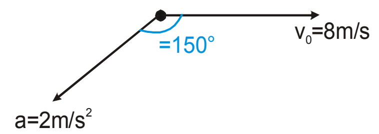
(A) the time lapse for the two bodies to collide is $\frac{6\pi R}{5V}$

(B) the angle covered by A is $\frac{11\pi}{6}$

(C) angular velocity of A is $\frac{11V}{5R}$

(D) radial acceleration of A is $\frac{289\,v^2}{5R}$

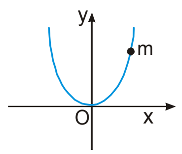
5. The figure shows the velocity and acceleration of a point like body at the initial moment of its motion. The acceleration vector of the body remains constant. The minimum radius of curvature of tra jectory of the body is (in m.)



(A) 2 m **(B)** 4 m **(C)** 8 m **(D)** 16 m

6. A bead of mass m is located on a parabolic wire with its axis vertical and vertex at the origin as shown in figure and whose equation is $x^2 = 4ay$. The wire frame is fixed and the bead can slide on it without friction. The bead is released from the point y = 4a on the wire frame from rest. The tangential acceleration of the bead when it reaches the position given by y = a is :

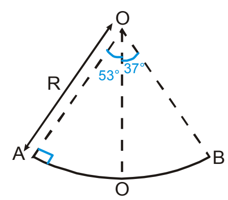
(A) $\frac{g}{2}$ **(B)** $\frac{\sqrt{3}g}{2}$ **(C)** $\frac{g}{\sqrt{2}}$ **(D)** $\frac{g}{\sqrt{5}}$



7. A particle is moving in a circular path. The acceleration and momentum vectors at an instant of time are $\vec{a} = 2\hat{i} + 3\hat{j}$ m/s² and $\vec{P} = 6\hat{i} - 4\hat{j}$ kgm/s. Then the motion of the particle is

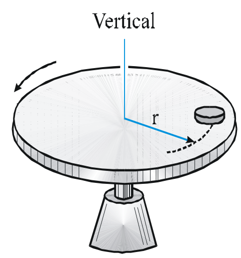
(A) uniform circular motion
(B) circular motion with tangential acceleration
(C) circular motion with tangential retardation
(D) we cannot say anything from $\vec{a}$ and $\vec{P}$ only.

8. A section of fixed smooth circular track of radius 20 m. in vertical plane is shown in the figure. A block is released from position A and leaves the track at B. The radius of curvature of its trajectory when it just leaves the track at B is: (in m.)



(A) R **(B)** $\frac{R}{4}$ **(C)** $\frac{R}{2}$ **(D)** none of these

9. A small coin of mass 40 g is placed on the horizontal surface of a rotating disc. The disc starts from rest and is given a constant angular acceleration $\alpha = 2$ rad/s². The coefficient of static friction between the coin and the disc is $\mu_s = 3/4$ and coefficient of kinetic friction is $\mu_k = 0.5$. The coin is placed at a distance r = 1 m from the centre of the disc. The magnitude of the resultant force on the coin exerted by the disc just before it starts slipping on the disc is :



(A) 0.2 N **(B)** 0.3 N **(C)** 0.4 N **(D)** 0.5 N

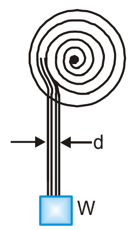
10. A ring of mass 2π kg and of radius 0.25m is making 300rpm about an axis through its centre perpendicular to its plane. The tension (in newtons) developed in the ring is:

(A) 50 **(B)** 100 **(C)** 175 **(D)** 250

11. A car driver going at some speed suddenly finds a wide wall at a distance r. To avoid hitting the wall he should

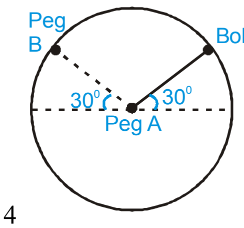
(A) apply the brakes
(B) should turn the car in a circle of radius r.
(C) apply the brakes and also turn the car in a circle of radius r.
(D) jump on the back seat.

12. A weight W attached to the end of a flexible rope of diameter d=0.75cm is raised vertically by winding the rope on a reel as shown. If the reel is turned uniformly at the rate of 2 r.p.s. What is the tension in rope. The inertia of rope may be neglected.



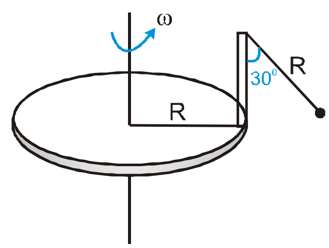
(A) 1.019W **(B)** 0.51W **(C)** 2.04W **(D)** W

13. A bob is attached to one end of a string other end of which is fixed at peg A. The bob is taken to a position where string makes an angle of 30^0 with the horizontal. On the circular path of the bob in vertical plane there is a peg 'B' at a symmetrical position with respect to the position of release as shown in the figure. If v_c and v_a be the minimum speeds in clockwise and anticlockwise directions respectively, given to the bob in order to hit the peg 'B' then ratio $v_c : v_a$ is equal to :



(A) 1 : 1 **(B)** $1 : \sqrt{2}$ **(C)** 1 : 2 **(D)** 1 : 4

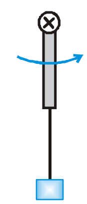
14. A disc of radius R has a light pole fixed perpendicular to the disc at the circumference which in turn has a pendulum of length R attached to its other end as shown in figure. The disc is rotated with a constant angular velocity ω. The string is making an angle 30^0 with the rod. Then the angular velocity ω of disc is:



(A) $\left(\dfrac{\sqrt{3}\,g}{R}\right)^{1/2}$ **(B)** $\left(\dfrac{\sqrt{3}\,g}{2R}\right)^{1/2}$

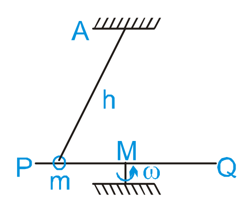
(C) $\left(\dfrac{g}{\sqrt{3}\,R}\right)^{1/2}$ **(D)** $\left(\dfrac{2g}{3\sqrt{3}\,R}\right)^{1/2}$

15. One end of a light rod of length 1 m is attached with a string of length 1m. Other end of the rod is attached at point O such that rod can move in a vertical circle. Other end of the string is attached with a block of mass 2kg. The minimum velocity that must be given to the block in horizontal direction so that it can complete the vertical circle is ($g = 10\ m/s^2$).



(A) $4\sqrt{5}$ **(B)** $5\sqrt{5}$ **(C)** 10 **(D)** $3\sqrt{5}$

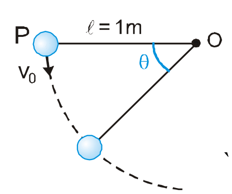
16. A smooth rod PQ rotates in a horizontal plane about its mid point M which is h = 0.1 m vertically below a fixed point A at a constant angular velocity 14 rad/s. A light elastic string of natural length 0.1 m requiring 1.47 N/cm has one end fixed at A and its other end attached to a ring of mass m = 0.3 kg which is free to slide along the rod. When the ring is stationary relative to rod, then inclination of string with vertical, tension in string.



(A) cos θ = 3/5 , T = 9.8 N **(B)** θ = 60 , T = 0

(C) cos θ = 2/5 , T = 4.9 N **(D)** θ = 30 , T = 0

17. The sphere at P is given a downward velocity v_0 and swings in a vertical plane at the end of a rope of ℓ = 1m attached to a support at O. The rope breaks at angle 30° from horizontal, knowing that it can withstand a maximum tension equal to three times the weight of the sphere. Then the value of v_0 will be: ($g = \pi^2\ m/s^2$)

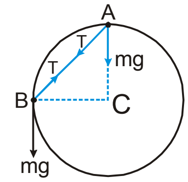


(A) $\dfrac{g}{2}$ m/s **(B)** $\dfrac{2g}{3}$ m/s **(C)** $\sqrt{\dfrac{3g}{2}}$ m/s **(D)** $\dfrac{g}{3}$ m/s

18. A simple pendulum is oscillating in a vertical plane. If resultant acceleration of bob of mass m at a point A is in horizontal direction, find the tangential force at this point in terms of tension T and mg.

(A) mg **(B)** $\frac{mg}{T}\sqrt{T^2-(mg)^2}$ **(C)** $\frac{mg}{T}\sqrt{(mg)^2+T^2}$ **(D)** $\frac{T}{mg}\sqrt{(mg)^2+T^2}$

19. Objects A and B each of mass m are connected by light inextensible cord. They are constrained to move on a frictionless ring in a vertical plane as shown in figure. The objects are released from rest at the positions shown. The tension in the cord just after release will be

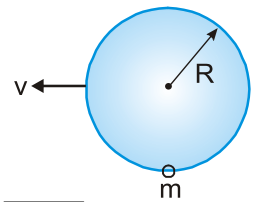


(A) mg $\sqrt{2}$ **(B)** $\frac{mg}{\sqrt{2}}$ **(C)** $\frac{mg}{2}$ **(D)** $\frac{mg}{4}$

20. A circular curve of a highway is designed for traffic moving at 72 km/h. If the radius of the curved path is 100 m, the correct angle of banking of the road should be given by :

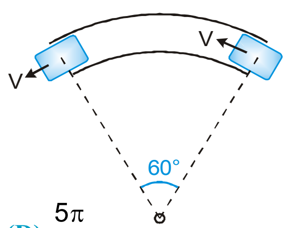
(A) $\tan^{-1}\frac{2}{3}$ **(B)** $\tan^{-1}\frac{3}{5}$ **(C)** $\tan^{-1}\frac{2}{5}$ **(D)** $\tan^{-1}\frac{1}{4}$

21. A ring of radius R lies in vertical plane. A bead of mass 'm' can move along the ring without friction. Initially the bead is at rest at the bottom most point on ring. The minimum constant horizontal speed v with which the ring must be pulled such that the bead completes the vertical circle



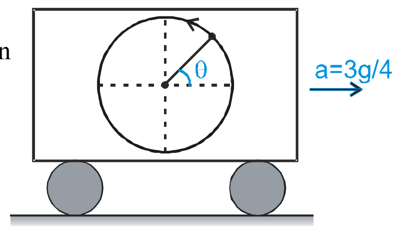
(A) $\sqrt{3gR}$ **(B)** $\sqrt{4gR}$ **(C)** $\sqrt{5gR}$ **(D)** $\sqrt{5.5gR}$

22. A car moves around a curve at a constant speed. When the car goes around the arc subtending 60° at the centre, then the ratio of magnitude of instantaneous acceleration to average acceleration over the 60° arc is :



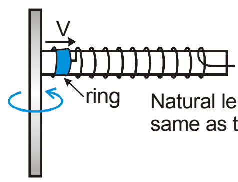
(A) $\frac{\pi}{3}$ **(B)** $\frac{\pi}{6}$ **(C)** $\frac{2\pi}{3}$ **(D)** $\frac{5\pi}{3}$

23. A bus is moving with a constant acceleration a = 3g/4 towards right. In the bus, a ball is tied with a rope and is rotated in vertical circle as shown in the figure. The tension in the rope will be minimum, when the rope makes an angle θ = ______ .



(A) 53° **(B)** 37°
(C) 180 – 53° **(D)** 180 + 37°

24. A ring attached with a spring is fitted in a smooth rod. The spring is fixed at the outer end of the rod. The mass of the ring is 3kg & spring constant of spring is 300 N/m. The ring is given a velocity 'V' towards the outer end of the rod. And the rod is set to be rotating with an angular velocity ω. Then ring will move with constant speed with respect to the rod if :



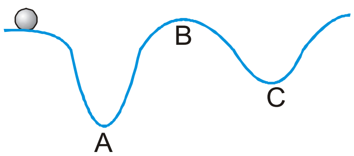
Natural length of spring is same as that of length of rod.

(A) angular velocity of rod is increased continuously
(B) ω = 10 rad/s
(C) angular velocity of rod is decreased continuously.
(D) constant velocity of ring is not possible.

25. A uniform rod of mass m and length ℓ is rotating with constant angular velocity ω about an axis which passes through its one end and perpendicular to the length of rod. The area of cross section of the rod is A and its Young's modulus is Y. Neglect gravity. The strain at the mid point of the rod is :

(A) $\frac{m\omega^2\ell}{8AY}$ **(B)** $\frac{3m\omega^2\ell}{8AY}$ **(C)** $\frac{3m\omega^2\ell}{4AY}$ **(D)** $\frac{m\omega^2\ell}{4AY}$

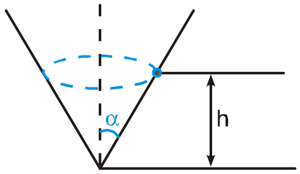
26. A body moves along an uneven surface with constant speed at all points.The normal reaction of the road on the body is:



(A) maximum at A
(B) maximum at B
(C) minimum at C
(D) the same at A, B & C

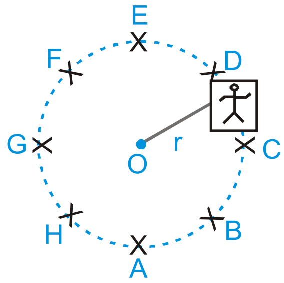
SECTION - II : MULTIPLE CORRECT ANSWER TYPE

27. A particle is describing circular motion in a horizontal plane in contact with the smooth inside surface of a fixed right circular cone with its axis vertical and vertex down. The height of the plane of motion above the vertex is h and the semivertical angle of the cone is α. The period of revolution of the particle:



(A) increases as h increases **(B)** decreases as h increases
(C) increases as α increases **(D)** decreases as α increases

28. A machine, in an amusement park, consists of a cage at the end of one arm, hinged at O. The cage revolves along a vertical circle of radius r (ABCDEFGH) about its hinge O, at constant linear speed $v = \sqrt{gr}$. The cage is so attached that the man of weight 'w' standing on a weighing machine, inside the cage, is always vertical. Then which of the following is/are correct



(A) the weight reading at A is greater than the weight reading at E by 2 w.
(B) the weight reading at G = w
(C) the ratio of the weight reading at E to that at A = 0
(D) the ratio of the weight reading at A to that at C = 2.

29. A small sphere of mass m suspended by a thread is first taken aside so that the thread forms the right angle with the vertical and then released, then :

(A) total acceleration of sphere as a function of θ is $g\sqrt{1+3\cos^2\theta}$

(B) thread tension as a function of θ is $T = 3mg\cos\theta$

(C) the angle θ between the thread and the vertical at the moment when the total acceleration vector of the sphere is directed horizontally is $\cos^{-1} 1/\sqrt{3}$

(D) thread tension at the moment when the vertical component of the sphere's velocity is maximum will be mg

30. On a circular table, A and B are moving on the circumference. Man A runs behind man B to catch him. A runs with constant angular speed ω_1 with respect to table and B runs at constant tangential speed v_2 with respect to ground. If it is found that the table rotates 30° in the opposite direction in every one second and the initial angular separation between A and B is 30°, then A catches B after : (Radius of table is 3 m).

(A) 0.5 sec, if $\omega_1 = \frac{5\pi}{6}$ rad/s and $v_2 = 3.14$ m/s

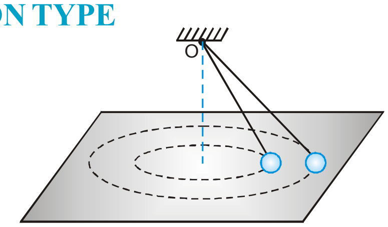
(B) 0.5 sec, if $\omega_1 = \frac{4\pi}{3}$ rad/s and $v_2 = 3.14$ m/s

(C) 0.5 sec, if $\omega_1 = \frac{4\pi}{3}$ rad/s and $v_2 = 6.28$ m/s

(D) A can not catch B within 0.5 s, if $\omega_1 = \frac{\pi}{6}$ rad/s and $v_2 = 6.28$ m/s

SECTION - III : ASSERTION AND REASON TYPE

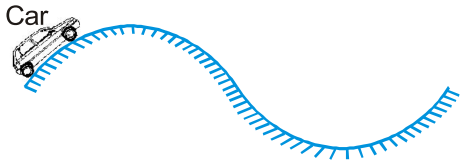
31. **Statement-1 :** Two small spheres are suspended from same point O on roof with strings of different lengths. Both spheres move along horizontal circles as shown. Then both spheres may move along circles in same horizontal plane.



Statement-2 : For both spheres in statement-1 to move in circular paths in same horizontal plane, their angular speeds must be same.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

32. **Statement-1 :** A car moves along a road with uniform speed. The path of car lies in vertical plane and is shown in figure.The radius of curvature(R) of the path is same everywhere. If the car does not loose contact with road at the highest point, it can travel the shown path without loosing contact with road anywhere else.



Statement-2 : For car to loose contact with road, the normal reaction between car and road should be zero.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

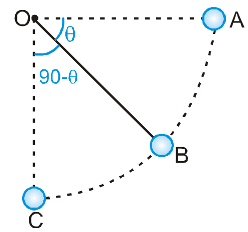
33. **Statement-1 :** A ball tied by thread is undergoing circular motion (of radius R) in a vertical plane. (Thread always remains in vertical plane). The difference of maximum and minimum tension in thread is independent of speed (u) of ball at the lowest position ($u > \sqrt{5gR}$)

Statement-2 : For a ball of mass m tied by thread undergoing vertical circular motion (of radius R), difference in maximum and minimum magnitude of centripetal acceleration of the ball is independent of speed (u) of ball at the lowest position ($u > \sqrt{5gR}$).

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1



One end of a light string of length L is connected to a ball and the other end is connected to a fixed point O. The ball is released from rest at t = 0 with string horizontal and just taut. The ball then moves in vertical circular path as shown.The time taken by ball to go from position A to B is t_1 and from B to lowest position C is t_2. Let the velocity of ball at B is $\vec{v}_B$ and at C is $\vec{v}_C$ respectively.

34. If $|\vec{v}_C| = 2|\vec{v}_B|$ then the value of θ as shown is

(A) $\cos^{-1}\frac{1}{4}$ **(B)** $\sin^{-1}\frac{1}{4}$ **(C)** $\cos^{-1}\frac{1}{2}$ **(D)** $\sin^{-1}\frac{1}{2}$

35. If $|\vec{v}_C| = 2|\vec{v}_B|$ then :

(A) $t_1 > t_2$ **(B)** $t_1 < t_2$ **(C)** $t_1 = t_2$ **(D)** Information insufficient

36. If $|\vec{v}_C - \vec{v}_B| = |\vec{v}_B|$, then the value of θ as shown is :

(A) $\cos^{-1}\left(\frac{1}{4}\right)^{1/3}$ **(B)** $\sin^{-1}\left(\frac{1}{4}\right)^{1/3}$ **(C)** $\cos^{-1}\left(\frac{1}{2}\right)^{1/3}$ **(D)** $\sin^{-1}\left(\frac{1}{2}\right)^{1/3}$

Comprehension # 2

A particle of mass M attached to an inextensible string is moving in a vertical circle of radius R about fixed point O. It is imparted a velocity u in horizontal direction at lowest position as shown in figure.

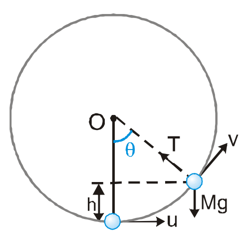
Following information is being given :

(i) Velocity at a height h can be calculated by using formula $v^2 = u^2 - 2gh$.

(ii) Particle will complete the circle if $u \geq \sqrt{5gR}$,

(iii) Particle will oscillates in lower half $(0° < \theta \leq 90°)$ if $0 < u \leq \sqrt{2gR}$

(iv) The magnitude of tension at a height 'h' is calculated by using formula $T = \frac{M}{R}\{u^2 + gR - 3gh\}$.



37. If R = 2m, M = 2 kg and u = 12 m/s. Then value of tension at lowest position is :

(A) 120 N **(B)** 164 N **(C)** 264 N **(D)** zero

38. Tension at highest point of its trajectory in above question will be :

(A) 100 N **(B)** 44 N **(C)** 144 N **(D)** 264 N

39. If M = 2 kg, R = 2m and u = 10 m/s the velocity of particle when θ = 60°,

(A) $2\sqrt{5}$ m/s **(B)** $4\sqrt{5}$ m/s **(C)** $5\sqrt{2}$ m/s **(D)** 5 m/s

SECTION - V : MATRIX - MATCH TYPE

40. In column-I condition on velocity, force and acceleration of a particle is given. Resultant motion is described in column-II. $\vec{u}$ = initial velocity, $\vec{F}$ = resultant force and $\vec{v}$ = instantaneous velocity.

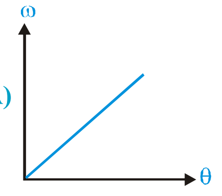
Column-I		Column-II
(A) $\vec{u}\times\vec{F}=0$ and $\vec{F}$ = constant	**(p)**	path will be circular path
(B) $\vec{u}\cdot\vec{F}=0$ and $\vec{F}$ = constant	**(q)**	speed will increase
(C) $\vec{v}\cdot\vec{F}=0$ all the time and $\lvert\vec{F}\rvert$ = constant and the particle always remains in one plane.	**(r)**	path will be straight line
(D) $\vec{u}=2\hat{i}-3\hat{j}$ and acceleration at all time $\vec{a}=6\hat{i}-9\hat{j}$	**(s)**	path will be parabolic
	(t)	Particle may retrace back

41. A particle is moving with speed $v = 2t^2$ on the circumference of circle of radius R. Match the quantities given in column-I with corresponding results in column-II

Column-I		Column-II
(A) Magnitude of tangential acceleration of particle	**(p)**	decreases with time.
(B) Magnitude of Centripetal acceleration of particle	**(q)**	increases with time
(C) Magnitude of angular speed of particle with respect to centre of circle	**(r)**	remains constant
(D) Value of tan θ, where θ is angle between the total acceleration vector and centripetal acceleration vector of particle	**(s)**	proportional to R
	(t)	inversely proportional to R

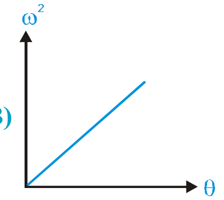
42. Each situation in column I gives graph of a particle moving in circular path. The variables ω,θ and t represent angular speed (at any time t) , angular displacement (in time t) and time respectively. Column II gives certain resulting interpretation. Match the graphs in column I with statements in column II and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in the OMR.

Column-I **Column-II**

(A)


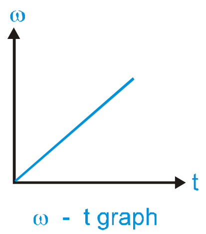
ω - θ graph

(p) Angular acceleration of particle is uniform

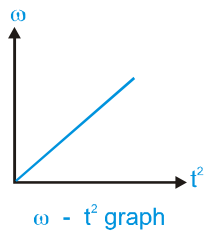
(B)


ω^2 - θ graph

(q) Angular acceleration of particle is non-uniform

(C) 

(r) Angular acceleration of particle is directly proportional to t.

(D) 

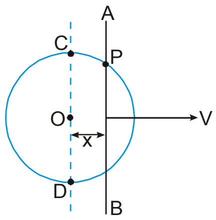
(s) Angular acceleration of particle is directly proportional to θ.

(t) Angular acceleration of particle is directly proportional to slope of the curve.

SECTION - VI : INTEGER TYPE

43. A ball is projected making an angle θ with the vertical. Consider a small part of the trajectory near the highest position and take it approximately to be a circular arc. What is the radius of this circle? This radius is called the radius of curvature of the curve at the point.if u = 20 then ROC in m.

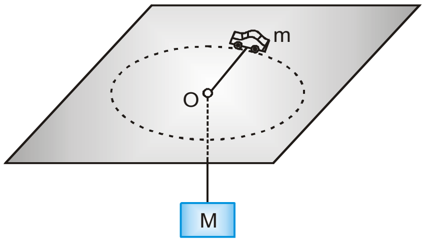
44. A rod AB is moving on a fixed circle of radius R with constant velocity 'v' as shown in figure. P is the point of intersection of the rod and the circle. At an instant the rod is at a distance $x = \frac{3R}{5}$ from centre of the circle. The velocity of the rod is perpendicular to the rod and the rod is always parallel to the diameter CD.



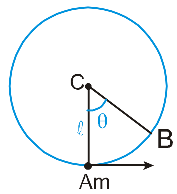
(A) the speed of point of intersection P is xv/4 m./sec. then x is

(B) Find the angular speed of point of intersection P with respect to centre of the circle.

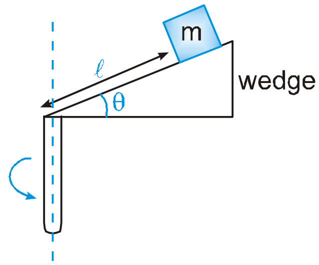
45. A toy car of mass m can travel at a fixed speed. It moves in a circle on a fixed horizontal table. A string is connected to car and attached to a block of mass M that hangs as shown in figure (the portion of string below the table is always vertical). The coefficient of friction between the surface of table and tyres of the toy car is μ. Find the ratio of the maximum radius to the minimum radius for which the toy car can move in a circular path with centre O on table.



46. A particle of mass m is attached at one end of a light, inextensible string of length ℓ whose other end is fixed at the point C. The particle is given minimum velocity at the lowest point to complete the circular path in the vertical plane. As it moves in the circular path the tension in the string changes with θ. θ is defined in the figure. As θ varies from 'O' to '2π' (i.e. the particle completes one revolution) plot the variation of tension 'T' against 'θ'.



47. A small wedge whose base is horizontal is fixed to a vertical rod as shown in the figure. $\theta = 45°$ $l = \frac{1}{5\sqrt{2}}$ m. The sloping side of the wedge is frictionless and the wedge is spun with a constant angular speed ω about vertical axis as shown in the figure. Find



(A) The value of angular speed ω for which the block of mass m just does not slide down the wedge?

MOCK TEST : RELATIVE MOTION

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. A train is standing on a platform , a man inside a compartment of a train drops a stone . At the same instant train starts to move with constant acceleration . The path of the particle as seen by the person who drops the stone is :

(A) parabola
(B) straight line for sometime & parabola for the remaining time
(C) straight line
(D) variable path that cannot be defined

2. A man wearing a hat of extended length 12 cm is running in rain falling vertically downwards with speed 10 m/s. The maximum speed with which man can run, so that rain drops does not fall on his face (the length of his face below the extended part of the hat is 16 cm) will be :

(A) 7.5 m/s **(B)** 13.33 m/s **(C)** 10 m/s **(D)** zero

3. A car starts with constant acceleration $a = 2 m/s^2$ at $t = 0$. Two coins are released from the car at $t = 3$ & $t = 4$. Each coin takes 1 second to fall on ground. Then the distance between the two coins will be : (Assume coin sticks to the ground)

(A) 9 m **(B)** 7 m **(C)** 15 m **(D)** 2m

4. A man crosses the river perpendicular to river flow in time t seconds and travels an equal distance down the stream in T seconds. The ratio of man's speed in still water to the speed of river water will be :

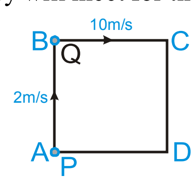
(A) $\frac{t^2 - T^2}{t^2 + T^2}$ **(B)** $\frac{T^2 - t^2}{T^2 + t^2}$ **(C)** $\frac{t^2 + T^2}{t^2 - T^2}$ **(D)** $\frac{T^2 + t^2}{T^2 - t^2}$

5. A swimmer crosses the river along the line making an angle of 45° with the direction of flow. Velocity of the river is 5 m/s. Swimmer takes 6 seconds to cross the river of width 60 m. The velocity of the swimmer with respect to water will be:

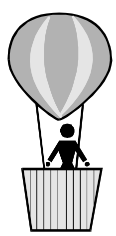
(A) 10 m/s **(B)** 12 m/s **(C)** $5\sqrt{5}$ m/s **(D)** $10\sqrt{2}$ m/s

6. Two men P & Q are standing at corners A & B of square ABCD of side 8 m. They start moving along the track with constant speed 2 m/s and 10 m/s respectively. The time when they will meet for the first time, is equal to:

(A) 2 sec
(B) 3 sec
(C) 1 sec
(D) 6 sec



7. A man in a balloon, throws a stone downwards with a speed of 5 m/s with respect to balloon . The balloon is moving upwards with a constant acceleration of $5 m/s^2$. Then velocity of the stone relative to the man after 2 second is :



(A) 10 m/s **(B)** 30 m/s **(C)** 15 m/s **(D)** 35 m/s

8. Three stones A, B and C are simultaneously projected from same point with same speed. A is thrown upwards, B is thrown horizontally and C is thrown downwards from a building. When the distance between stone A and C becomes 10 m, then distance between A and B will be:

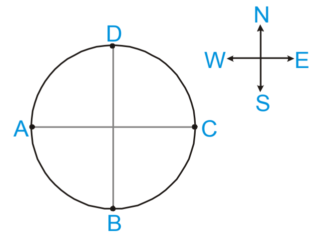
(A) 10 m **(B)** 5 m **(C)** $5\sqrt{2}$ m **(D)** $10\sqrt{2}$ m

9. A projectile A is projected from ground. An observer B running on ground with uniform velocity of magnitude 'v' observes A to move along a straight line. The time of flight of A as measured by B is T. Then the range R of projectile on ground is :

(A) $R = vT$ **(B)** $R < vT$
(C) $R > vT$ **(D)** information insufficient to draw inference

10. Two aeroplanes fly from their respective position 'A' and 'B' starting at the same time and reach the point 'C' (along straight line) simultaneously when wind was not blowing. On a windy day they head towards 'C' but both reach the point 'D' simultaneously in the same time which they took to reach 'C'. Then the wind is blowing in:

(A) North-East direction
(B) North-West direction
(C) Direction making an angle $0 < \theta < 90$ with North towards West.
(D) North direction



11. A particle is thrown up inside a stationary lift of sufficient height. The time of flight is T. Now it is thrown again with same initial speed v_0 with respect to lift. At the time of second throw, lift is moving up with speed v_0 and uniform acceleration g upward (the acceleration due to gravity). The new time of flight is:

(A) $\frac{T}{4}$ **(B)** $\frac{T}{2}$ **(C)** T **(D)** 2T

12. A swimmer crosses a river with minimum possible time 10 second. And when he reaches the other end starts swimming in the direction towards the point from where he started swimming. Keeping the direction fixed the swimmer crosses the river in 15 sec. The ratio of speed of swimmer with respect to water and the speed of river flow is (Assume constant speed of river & swimmer) :

(A) $\frac{3}{2}$ **(B)** $\frac{9}{4}$ **(C)** $\frac{2}{\sqrt{5}}$ **(D)** $\frac{\sqrt{5}}{2}$

13. A taxi leaves the station X for station Y every 10 minutes. Simultaneously, a taxi also leaves the station Y for station X every 10 minutes. The taxis move at the same constant speed and go from X to Y or vice versa in 2 hours. How many taxis coming from the other side will meet each taxi enroute from Y to X:

(A) 11 **(B)** 12 **(C)** 23 **(D)** 24

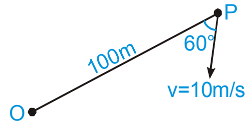
14. Consider a collection of a large number of particles each with speed v. The direction of velocity is randomly distributed in the collection. The magnitude of the relative velocity between a pair of particles averaged over all the pairs in the collection is :

(A) greater than v **(B)** less than v **(C)** equal to v **(D)** we can't say anything

15. An aeroplane is flying in geographic meridian vertical plane at an angle of 30^0 with the horizontal (north) and wind is blowing from west. A package is dropped from an aeroplane. The velocity of the wind if package hits a kite flying in the space with a position vector $\vec{R} = (400\sqrt{3}\hat{i} + 80\hat{j} + 200\hat{k})$ m with respect to the point of dropping.(Here $\hat{i}$ and $\hat{j}$ are the unit vectors along north and vertically up respectively and $\hat{k}$ be the unit vector due east. Assume that the bag is light enough to get carried away by the wind) :

(A) 50 m/sec **(B)** 25 m/sec **(C)** 20 m/sec **(D)** 10 m/sec

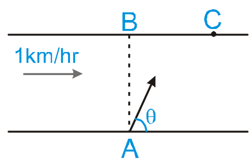
16. P is a point moving with constant speed 10 m/s such that its velocity vector always maintains an angle 60° with line OP as shown in figure (O is a fixed point in space). The initial distance between O and P is 100 m. After what time shall P reach O.



(A) 10 sec. **(B)** 15 sec. **(C)** 20 sec. **(D)** $20\sqrt{3}$ sec

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

17. A river is flowing with a speed of 1 km/hr. A swimmer wants to go to point 'C' starting from 'A'. He swims with a speed of 5 km/hr, at an angle θ w.r.t. the river. If AB = BC = 400 m. Then :



(A) the value of θ is 53° **(B)** time taken by the man is 6 min

(C) time taken by the man is 8 min **(D)** the value of θ is 45°

18. A swimmer who can swim in a river with speed *mv* (with respect to still water) where *v* is the velocity of river current, jumps into the river from one bank to cross the river:

(A) If $m \le 1$ he can not reach a point on other bank directly opposite to his starting point

(B) If $m < 1$ he can not cross the river

(C) If $m > 1$ then only he can reach a point on other bank

(D) He can reach the other bank at some point, whatever be the value of *m*.

19. A man is standing on a road and observes that rain is falling at angle 45° with the vertical. The man starts running on the road with constant acceleration 0.5 m/s². After a certain time from the start of the motion, it appears to him that rain is still falling at angle 45° with the vertical, with speed $2\sqrt{2}$ m/s . Motion of the man is in the same vertical plane in which the rain is falling. Then which of the following statement(s) are true:

(A) It is not possible

(B) Speed of the rain relative to the ground is 2 m/s.

(C) Speed of the man when he finds rain to be falling at angle 45° with the vertical, is 4m/s.

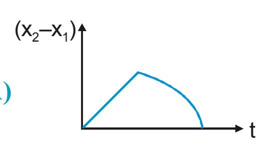
(D) The man has travelled a distance 16m on the road by the time he again finds rain to be falling at angle 45°.

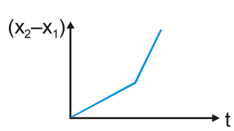
20. Two stones are thrown vertically upwards simultaneously from the same point on the ground with initial speed u_1 = 30 m/sec and u_2 = 50 m/sec. Which of the curve represents correct variation (for the time interval in which both reach the ground) of

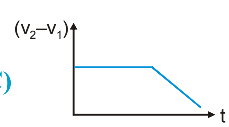
$(x_2 - x_1)$ = the relative position of second stone with respect to first with time (t).

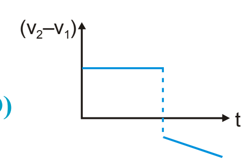
$(v_2 - v_1)$ = the relative velocity of second stone with respect to first with time (t).

Assume that stones do not rebound after hitting the ground

(A)


(B)


(C)


(D)


SECTION - III : ASSERTION AND REASON TYPE

21. **Statement-1 :** The magnitude of velocity of two boats relative to river is same. Both boats start simultaneously from same point on one bank may reach opposite bank simultaneously moving along different paths.

Statement-2 : For boats to cross the river in same time. The component of their velocity relative to river in direction normal to flow should be same.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

22. **Statement-1 :** Three projectiles are moving in different paths in the air. Vertical component of relative velocity between any of the pair does not change with time as long as they are in air. Neglect the effect of air friction.

Statement-2 : Relative acceleration between any of the pair of projectiles is zero.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

23. **STATEMENT–1 :** Two stones are projected with different velocities from ground from same point and at same instant of time. Then these stones cannot collide in mid air. (Neglect air friction)

STATEMENT–2 : If relative acceleration of two particles initially at same position is always zero, then the distance between the particle either remains constant or increases continuously with time.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

SECTION - IV : COMPREHENSION TYPE

A swimmer can swim with a speed v in still water.

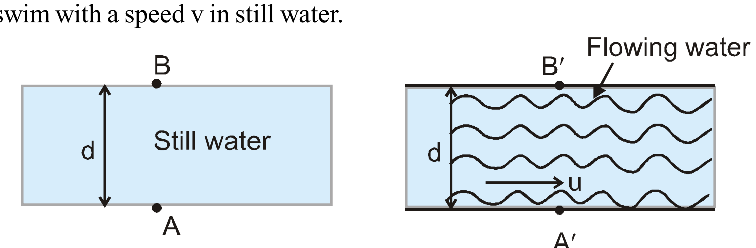


fig (i) fig(ii)

24. If the swimmer crosses a swimming pool 'd' from A to directly opposite point B on other side in time t_1 as shown in figure (i) and in a flowing river (river velocity 'u') of same width d from A′ to directly opposite point B′ on other bank in time t_2, then (t_1/t_2) is equal to : **(Assume v > u)**

(A) $\sqrt{1-\frac{v^2}{u^2}}$ **(B)** $\sqrt{1+\frac{u^2}{v^2}}$ **(C)** $\sqrt{1-\frac{u^2}{v^2}}$ **(D)** 1

25. If the minimum time taken in swimming pool to reach opposite bank is t_1' and minimum. time to reach opposite bank in river is t_2', then the ratio $\frac{t_1'}{t_2'}$ will have a value :

(A) 1 **(B)** $\frac{\sqrt{v^2+u^2}}{v}$ **(C)** $\frac{\sqrt{v^2-u^2}}{u}$ **(D)** $\frac{u}{v}$

26. If the time taken by swimmer to reach opposite point on other bank in river is T_1 and the time taken to travel an equal distance upstream (against the water current) in the river is T_2, then ratio $\frac{T_2}{T_1}$ will have a value :

(A) $\sqrt{\frac{1-u/v}{1+u/v}}$ (B) $\sqrt{\frac{1+u/v}{1-u/v}}$ (C) $\frac{\sqrt{v^2-u^2}}{(v+u)}$ (D) $\frac{\sqrt{v^2-u^2}}{v}$

Comprehension - 2

Raindrops are falling with a velocity $10\sqrt{2}$ m/s making an angle of 45^0 with the vertical. The drops appear to be falling vertically to a man running with constant velocity. The velocity of rain drops change such that the rain drops now appear to be falling vertically with $\sqrt{3}$ times the velocity it appeared earlier to the same person running with same velocity.

27. The magnitude of velocity of man with respect to ground is:

(A) $10\sqrt{2}$ m/s (B) $10\sqrt{3}$ m/s (C) 20 m/s (D) 10 m/s

28. After the velocity of rain drops change, the magnitude of velocity of raindrops with respect to ground is:

(A) 20 m/s (B) $20\sqrt{3}$ m/s (C) 10 m/s (D) $10\sqrt{3}$ m/s

29. The angle (in degrees) between the initial and the final velocity vectors of the raindrops with respect to the ground is:

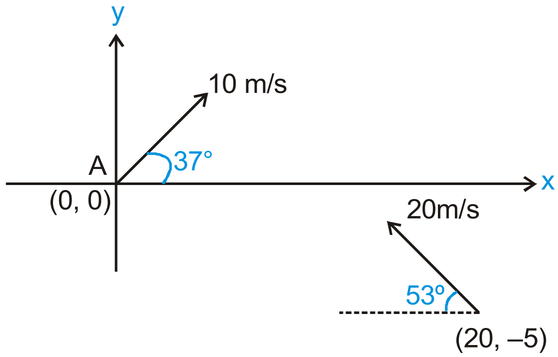
(A) 8 (B) 15 (C) 22.5 (D) 37

SECTION - V : MATRIX - MATCH TYPE

30. Two particles A and B moving in x-y plane are at origin at t = 0 sec. The initial velocity vectors of A and B are $\vec{u}_A = 8\hat{i}$ m/s and $\vec{u}_B = 8\hat{j}$ m/s. The acceleration of A and B are constant and are $\vec{a}_A = -2\hat{i}$ m/s^2 and $\vec{a}_B = -2\hat{j}$ m/s^2. Column I gives certain statements regarding particle A and B. Column II gives corresponding results. Match the statements in column I with corresponding results in Column II.

	Column I		Column II
(A)	The time (in seconds) at which velocity of A relative to B is zero	(p)	$16\sqrt{2}$
(B)	The distance (in metres) between A and B when their relative velocity is zero.	(q)	$8\sqrt{2}$
(C)	The time (in seconds) after t = 0 sec, at which A and B are at same position	(r)	8
(D)	The magnitude of relative velocity of A and B at the instant they are at same position.	(s)	4
		(t)	6 secconds

31. Two particles A & B are projected as shown in fig in x–y plane. Under the effect of force which provide a constant acceleration a =11 m/s^2 in negative y-direction. Then match situation in column-I with the corresponding results in column-II (All positions are given in metre) ($\vec{V}_{AB}$ = velocity of A w.r.t. B; $\vec{r}_{AB}$ = Position of A w.r.t. B).



	Column–I		Column–II
(A)	Separation between the two particles is minimum at ....sec.	(p)	0
(B)	Minimum separation between the two particles is ....m.	(q)	0.5
(C)	Time when velocities of both particles are perpendicular each other at .... sec.	(r)	0.9
(D)	At the time of minimum separation $\vec{V}_{AB}.\vec{r}_{AB}$ =	(s)	2
		(t)	$2\sqrt{5}$

SECTION - VI : INTEGER TYPE

32. When two bodies move uniformly towards each other, the distance between them diminishes by 16 m every 10 s. If velocity of one body is reversed the distance between them will decrease 3 m every 5 s. Calculate the speed of second body is $\frac{10}{x}$ m/s then x is.

33. A swimmer jumps from a bridge over a canal and swims 1km upstream. After that first km, he passes a floating cork. He continues swimming for half an hour and then turns around and swims back to the bridge. The swimmer and the cork reach the bridge at the same time. The swimmer has been swimming at a constant speed. How fast does the water in the canal flow?

ANSWER KEY

EXERCISE - 1

1. B **2.** D **3.** B **4.** D **5.** A **6.** D **7.** C **8.** C **9.** C **10.** D **11.** A **12.** B **13.** A
14. A **15.** B **16.** C **17.** D **18.** C **19.** A **20.** A **21.** C **22.** A **23.** B **24.** B **25.** A **26.** B
27. A **28.** C **29.** C **30.** B **31.** C **32.** B **33.** C **34.** B **35.** C **36.** A **37.** B **38.** B **39.** B
40. D **41.** C **42.** C **43.** B **44.** C **45.** C **46.** A **47.** C **48.** A **49.** D **50.** D **51.** A

EXERCISE - 2 : PART # I

1. C **2.** B **3.** A **4.** A **5.** A **6.** D **7.** C **8.** A
9. A **10.** B **11.** A **12.** C **13.** D **14.** C **15.** B **16.** A,B
17. C **18.** C **19.** C **20.** B **21.** D **22.** C **23.** A **24.** D
25. B **26.** A,B,C,D **27.** A,B,D **28.** A,C,D **29.** AD **30.** A,C,D **31.** A,B **32.** B,C,D
33. C,D **34.** A,B,C **35.** B,C **36.** A,C,D **37.** A,C **38.** C **39.** B **40.** B,C
41. A,D **42.** A,B **43.** A,C **44.** B,C,D **45.** B,C,D **46.** A **47.** A,B,C **48.** C
49. B **50.** D **51.** D **52.** C **53.** A **54.** D **55.** C **56.** B **57.** A

PART # II

1. D **2.** A **3.** D **4.** B **5.** D **6.** A **7.** A **8.** A **9.** C **10.** A **11.** A **12.** D **13.** A
14. C **15.** A **16.** B **17.** A **18.** D **19.** A

EXERCISE - 3 : PART # I

1. A→P; B→V, C→S, D, →Q, E→U, F→T,G→R
2. (A)→Q, (B)– p, q (C) –p, r, (D) –r, s
3. A –r, B –p, C–r, D–s
4. (A)–r, (B) –p, (C) –s, (D) –q
5. A–r, B –q, C –r, D –p
6. (A) -s, (B)-r, (C)-q

PART # II

Comp. #1 : 1. (D) **2.** (B) **3.** (A) **4.** (B) **5.** (C)
Comp. #2 : 1. (A) **2.** (D) **3.** (A)
Comp. #3 : 1. (B) **2.** (B) **3.** (A) **4.** (A) **5.** (D)
Comp. #4 : 1. (D) **2.** (C) **3.** (A) **4.** (C) **5.** (B) **6.** (D)
Comp. #5 : 1. (C) **2.** (A) **3.** (B)
Comp. #6 : 1. (C) **2.** (A) **3.** (B)
Comp. #7 : 1. (C) **2.** (B) **3.** (C) **4.** (C)

EXERCISE - 4

1. (i) A, B (ii) A, B (iii) B, A (iv) same (v) B, A, once **2.** 3 **3.** $a_0T/3$ **4.** object, 3.3 s
5. 36 m **6.** 18.5 m **7.** 12 km **8.** (i) 17.1s (ii) 293.8 m **9.** (i) 20 m (ii) 5s **10.** 1.5 m/s, 1 m/s
11. 5s **12.** (i) 160 km/hr^2 (ii) 10 km **13.** $v_A = 10\ ms^{-1}$, $v_B = 30\ ms^{-1}$ **14.** 89m

15. 0.75 hr, 1.5 hr after the moment of departure,No overtaking **16.** east **17.** $\dfrac{a}{v\left(1-\cos\dfrac{2\pi}{n}\right)}$ **18.** $\dfrac{4}{3}\dfrac{v\sin\theta}{g}$

19. 200m, $v_{boat} = 1.20$ km/hr, $v_{water} = 0.72$ km/hr, **20.** $u\hat{i} + \sqrt{\sqrt{3}Rg}\,\hat{j}$, $\sqrt{\dfrac{\sqrt{3}R}{g}}$ **21.** 20 m

22. (i) 100 m/s (ii) 980 m (iii) 1600 m (iv) $\left(80\hat{i} - 140\hat{j}\right)$ **23.** 360 km/hr, 1.28 km **24.** 20 m **25.** $v_0 = \sqrt{gH\left(1+\dfrac{\ell^2}{H^2}\right)}$, $\tan\alpha = \dfrac{H}{\ell}$

26. $\frac{a_0}{2}$ **27.** $-3\tilde{k}\ rad/s^2$, $-2\tilde{k}\ rad/s$ **27.** $4\sqrt{2}\ ms^{-2}$ **29.** $\frac{1}{t^2}$ **30.** 14.3s, $0.45\ ms^{-2}$

31. $\frac{5\pi R}{6v}$, $\frac{11\pi}{6}$, $\frac{17v}{5R}$, $\frac{289v^2}{25R}$ **32.** (i) t= 2s, (ii) 3.14 m/s **33.** (i) $25\frac{\sqrt{3}}{2}$ m/s² (ii) $\left(125\frac{\sqrt{3}}{4}\right)^{1/2}$ m/s (iii) $\frac{25}{2}$ m/s²

34. (i) $\lambda = \frac{1}{6}$, (ii) 800m **35.** 9 min, 40 km hr^{-1} **36.** 75 ms^{-1}, $(437.5 \pm 62.5\sqrt{21})$m

37. $\vec{s} = 10(t-1)\tilde{i} + 10\tilde{j}$ (a) $t = \frac{1}{2}h, 10km$ (b) $\frac{10\sqrt{5}}{2}$, t = 2 hr **38.** 80 ms^{-1} **39.** $\frac{(v_1+v_2)^2}{2(a_1+a_2)}$ **40.** (a) 120^0 (b) $2/\sqrt{3}$

41. B, $t_A = 165$ s, $t_B = 150$ s **42.** 50 ms^{-1} **43.** $10\sqrt{3}\ ms^{-1}$ **44.** $\frac{2}{\sqrt{2}+1}$ **45.** (i) 2s (ii) 10 ms^{-1} (iii) 5m (iv) 16.25 m (v) 20 m

EXERCISE - 5 : PART # I

1. 3 **2.** 4 **3.** 1 **4.** 4 **5.** 3 **6.** 1 **7.** 4 **8.** 1 **9.** 2 **10.** 1 **11.** 1

PART # II

MCQ's with one correct answer **1.** B **2.** A **3.** B **4.** C **5.** A

Assertion-Reasoning **1.** B

MCQ's with one or more than one correct answer **1.** ABC

Subjective Questions **1.** (i) $\frac{u^2 \sin 2\alpha}{g\cos\theta}$ (ii) $v = \frac{u\cos(\alpha+\theta)}{\cos\theta}$ **2.** u=7.29 ms^{-1}, t = 1s **3.** (i) 45^0 (ii) 2 ms^{-1}

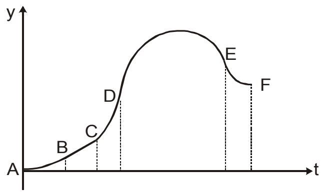
Integer Type Question **1.** 5 **2.** 5 **3.** 2 or 8 **4.** 4

Comprehension Type Questions **1.** A **2.** B

MOCK TEST : RECTILINEAR MOTION

1. B **2.** C **3.** A **4.** D **5.** D **6.** C **7.** B **8.** A **9.** A **10.** D **11.** D **12.** B **13.** A
14. B **15.** A **16.** A **17.** B,C,D **18.** A,C,D **19.** A,C,D **20.** A,C,D **21.** A,C,D **22.** A,B **23.** D
24. D **25.** D **26.** B **27.** A **28.** B **29.** B **30.** D

31.



AB = Slope increasing, BC = Slope constant,
CD = Slope increasing
DE = Slope decreasing, EF = Slope increasing
F = Slope is 0

32. (A) **33.** (A) r,t (B) r,t (C) p,q,r (D) p,q,r **34.** (A) p, q (B) p, q (C) p, r (D) r, t **35.** 120 **36.** 500 **37.** 35

MOCK TEST : PROJECTILE MOTION

1. C **2.** D **3.** D **4.** D **5.** C **6.** D **7.** B **8.** C **9.** B **10.** C **11.** A **12.** B **13.** D
14. D **15.** A,B,C,D **16.** A,B,C **17.** A,B,C **18.** A,B,D **19.** A,C,D **20.** B,C **21.** D **22.** A **23.** D
24. B **25.** B **26.** C **27.** A **28.** C **29.** C **30.** A - r ; B - p ; C - s ; D - q
31. A - p, q, r ; B - p ; C - q, t ; D - r, s **32.** 4 **33.** 3 **34.** 25

MOCK TEST : CIRCULAR MOTION

1. D **2.** C **3.** A **4.** B **5.** C **6.** C **7.** D **8.** C **9.** D **10.** D **11.** A **12.** A **13.** C
14. D **15.** C **16.** A **17.** C **18.** B **19.** B **20.** C **21.** B **22.** A **23.** A **24.** B **25.** B **26.** A
27. A,C **28.** A,B,C,D **29.** A,B,C **30.** A,D **31.** A **32.** D **33.** A **34.** B **35.** B **36.** B **37.** B
38. B **39.** B **40.** A - r, t ; B - q,s ; C - p ; D - q,r
41. A - q ; B - q, t ; C - q, t ; D - p, s **42.** A - q,s ; B - p,t ; C - p,t ; D - q,r **43.** 20

44. (A) (5) (B) $\omega = \frac{V_P}{R} = \frac{5V}{4R}$ **45.** $\frac{r_{max}}{r_{min}} = \frac{M+\mu m}{M-\mu m}$ **46.** $3mg\ (1+\cos\theta) = 6\ mg\cos^2(\theta/2)$

47. $\omega = \sqrt{\frac{g\sin\theta}{\ell\cos^2\theta}}$

MOCK TEST : RELATIVE MOTION

1. C **2.** A **3.** A **4.** C **5.** C **6.** B **7.** D **8.** C **9.** A **10.** B **11.** B **12.** C **13.** C
14. A **15.** B **16.** C **17.** A,B **18.** A, D **19.** C, D **20.** A, D **21.** A **22.** A **23.** A **24.** C
25. A **26.** B **27.** D **28.** A **29.** B **30.** A - s ; B - p ; C - r ; D - q **31.** A – r ; B – t; C – p, s ; D – p
32. 5 **33.** 1