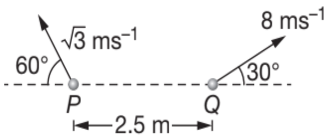
# PRACTICE EXERCISES

## SINGLE CORRECT CHOICE TYPE QUESTIONS

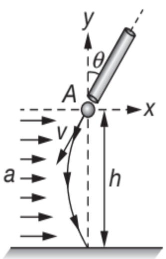
This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

**1.** Two particles $P$ and $Q$ are moving as shown in the figure. At this moment of time the angular speed of $P$ w.r.t. $Q$ is




(A) $5\ \text{rads}^{-1}$ (B) $4\ \text{rads}^{-1}$
(C) $2\ \text{rads}^{-1}$ (D) $1\ \text{rads}^{-1}$

**2.** A particle is ejected from the tube at $A$ with a velocity $v$ at an angle $\theta$ with the vertical $y$-axis. A strong horizontal wind gives the particle a constant horizontal acceleration $a$ in the $x$-direction. If the particle strikes the ground at a point directly under its released position and the downward $y$-acceleration is taken as $g$ then




(A) $h = \dfrac{2v^2 \sin\theta\cos\theta}{a}$

(B) $h = \dfrac{2v^2 \sin\theta\cos\theta}{g}$

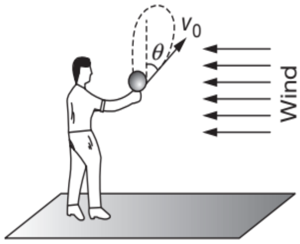
(C) $h = \dfrac{2v^2}{g}\sin\theta\left(\cos\theta + \dfrac{a}{g}\sin\theta\right)$

(D) $h = \dfrac{2v^2}{a}\sin\theta\left(\cos\theta + \dfrac{g}{a}\sin\theta\right)$

**3.** The speed of a projectile when it is at its greatest height is $\sqrt{\dfrac{2}{5}}$ times its speed at half the maximum height. The angle of projection is

(A) $30°$ (B) $\tan^{-1}\left(\dfrac{3}{4}\right)$
(C) $45°$ (D) $60°$

**4.** A boy throws a ball upwards with velocity $v_0 = 20\ \text{ms}^{-1}$. The wind imparts a horizontal acceleration of $4\ \text{ms}^{-2}$ to the left. The angle $\theta$ at which the ball must be thrown so that the ball returns to the boy's hand is $\left(g = 10\ \text{ms}^{-2}\right)$




(A) $\tan^{-1}(1.2)$ (B) $\tan^{-1}(0.2)$
(C) $\cot^{-1}(2)$ (D) $\cot^{-1}(2.5)$

**5.** A particle is moving in a circle of radius $R$ in such a way that at any instant the total acceleration makes an angle of $45°$ with radius. Initial speed of particle is $v_0$. The time taken to complete the first revolution is

(A) $\dfrac{R}{v_0}$ (B) $\dfrac{2R}{v_0}$

(C) $\dfrac{R}{v_0}e^{-2\pi}$ (D) $\dfrac{R}{v_0}\left(1 - e^{-2\pi}\right)$

**6.** A large number of bullets are fired in all the directions with the same speed $v$. The maximum area on the ground on which these bullets will spread is

(A) $\dfrac{\pi v^2}{g}$ (B) $\dfrac{\pi v^4}{g^2}$

(C) $\dfrac{\pi^2 v^4}{g^2}$ (D) $\dfrac{\pi^2 v^2}{g^2}$

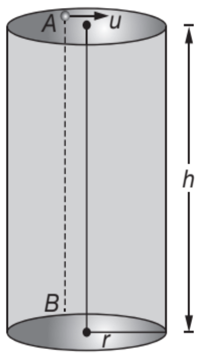
**7.** Starting from rest, a particle rotates in a circle of radius $R = \sqrt{2}\ \text{m}$ with an angular acceleration $\alpha = \dfrac{\pi}{4}\ \text{rads}^{-2}$. The magnitude of average velocity of the particle over the time it rotates quarter circle is

(A) $1\ \text{ms}^{-1}$ (B) $1.25\ \text{ms}^{-1}$
(C) $1.5\ \text{ms}^{-1}$ (D) $2\ \text{ms}^{-1}$

8. A projectile has a horizontal range $R$ for two different angles. If $h_1$ and $h_2$ are the maximum heights reached, then

(A) $R = h_1 h_2$ (B) $R = \sqrt{h_1 h_2}$
(C) $R = 4\sqrt{h_1 h_2}$ (D) $R = 2\sqrt{h_1 h_2}$

9. A hollow vertical cylinder of radius $r$ and height $h$ has a smooth internal surface. A small particle is placed in contact with the inner side of the upper rim, at point $A$ and given a horizontal speed $u$, tangential to the rim. It leaves the lower rim at point $B$, vertically below $A$. If $n$ is an integer then

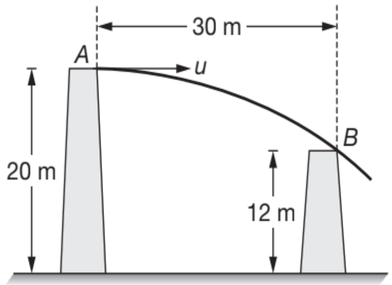



(A) $\frac{u}{2\pi r}\sqrt{\frac{2h}{g}} = n$ (B) $\frac{h}{2\pi r} = n$
(C) $\frac{2\pi r}{h} = n$ (D) $\frac{u}{\sqrt{2gh}} = n$

10. A ball is projected so as to pass a wall at a distance $a$ from the point of projection at an angle of $45°$ and falls at a distance $b$ on the other side of the wall. If $h$ is the height of the wall then

(A) $h = a\sqrt{2}$ (B) $h = b\sqrt{2}$
(C) $h = \frac{\sqrt{2}ab}{a+b}$ (D) $h = \frac{ab}{a+b}$

11. A boy wants to throw a ball from a point $A$ so as to just clear the obstruction at $B$. The minimum horizontal velocity with which the boy should throw the ball is




(A) $23.5\ \text{ms}^{-1}$ (B) $235\ \text{ms}^{-1}$
(C) $47\ \text{ms}^{-1}$ (D) $32.5\ \text{ms}^{-1}$

12. A ball is thrown vertically upward with a speed $v$ from a point $h$ metre above the ground. The time taken for the ball to hit the ground is

(A) $\left(\frac{v}{g}\right)\left(1+\sqrt{1+\frac{2hg}{v^2}}\right)$ (B) $\sqrt{1+\left(\frac{2hg}{v^2}\right)}$

(C) $\left(\frac{v}{g}\right)\sqrt{1+\left(\frac{2hg}{v^{2'}}\right)}$ (D) $\left(\frac{v}{g}\right)\sqrt{1-\left(\frac{2hg}{v^2}\right)}$

13. The muzzle velocity for a certain rifle is $600\ \text{ms}^{-1}$. If the rifle is pointed vertically upward and fired from an automobile moving horizontally at a speed of $72\ \text{kmh}^{-1}$, the radius of curvature of the path of the bullet at maximum altitude is (neglect friction of the air and take $g = 10\ \text{ms}^{-2}$)

(A) 400 m (B) 200 m
(C) 40 m (D) 20 m

14. A particle starts from the origin of co-ordinates at time $t = 0$ and moves in the $xy$ plane with a constant acceleration $\alpha$ in the $y$-direction. Its equation of motion is $y = \beta x^2$. Its velocity component in the $x$-direction is

(A) $\frac{\alpha}{2\beta}$ (B) $\sqrt{\frac{\alpha}{2\beta}}$
(C) $\sqrt{\frac{2\alpha}{\beta}}$ (D) not constant

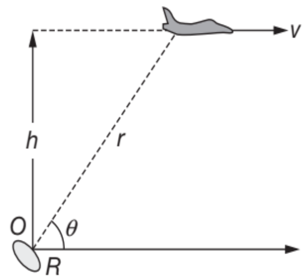
15. The speed of a projectile $u$ reduces by 50% on reaching maximum height. The range on the horizontal plane is

(A) $\frac{2u^2}{3g}$ (B) $\frac{u^2}{g}$
(C) $\frac{\sqrt{3}u^2}{2g}$ (D) $\frac{3u^2}{g}$

16. It is observed that a projectile is at the same height at 3 s and 5 s from the start. The time of flight of the projectile is equal to

(A) 1 s (B) 2 s
(C) 4 s (D) 8 s

17. A jet plane flying at a constant velocity $v$ at a height $h = 8$ kilometre is being tracked by a radar $R$ located at $O$ directly below the line of flight. If the angle $\theta$ is decreasing at the rate of $0.025\ \text{rads}^{-1}$, the velocity of the plane when $\theta = 60°$ is




(A) $1440\ \text{kmh}^{-1}$ (B) $960\ \text{kmh}^{-1}$

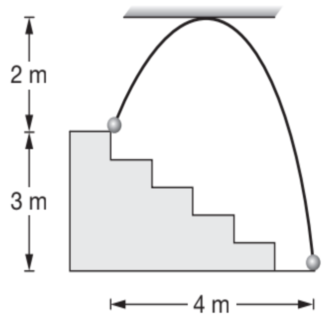
(C) $1920\ \text{kmh}^{-1}$ (D) $480\ \text{kmh}^{-1}$

**18.** A helicopter ascending at the rate of $12\ \text{ms}^{-1}$ drops a food packet from a height of $80$ m above the ground. The time the packet takes to reach the ground is

(A) 2.7 s (B) 5.5 s

(C) 11 s (D) 16.5 s

**19.** A ball is thrown from the top of a staircase which just touches the ceiling and finally hits the bottom of the steps. The initial speed of the ball is




(A) $6.3\ \text{ms}^{-1}$ (B) $7.6\ \text{ms}^{-1}$

(C) $63\ \text{ms}^{-1}$ (D) $76\ \text{ms}^{-1}$

**20.** A stone is projected with a velocity of $10\ \text{ms}^{-1}$ at $60°$ to the horizontal. At any instant, the angles of elevation of the stone from the two extremities of the range are $\alpha$ and $\beta$. Then $\tan\alpha + \tan\beta$ equals

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{1}{3}$

(C) 3 (D) $\sqrt{3}$

**21.** A particle is projected from the ground with a speed of $20\ \text{ms}^{-1}$ making an angle of $60°$ with the horizontal. The radius of curvature of the path of the particle, when its velocity makes an angle of $30°$ with horizontal is $\left(g = 10\ \text{ms}^{-2}\right)$

(A) 10.6 m (B) 12.8 m

(C) 15.4 m (D) 24.2 m

**22.** A particle is projected with a certain velocity at an angle $\alpha$ above the horizontal from the foot of an inclined plane of inclination $30°$. If the particle strikes the plane normally then $\alpha$ is equal to

(A) $30° + \tan^{-1}\left(\frac{1}{2\sqrt{3}}\right)$ (B) $30° + \tan^{-1}\left(2\sqrt{3}\right)$

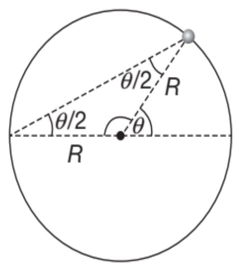
(C) $60°$ (D) $30° + \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

**23.** A particle moves along a parabolic path $y = 9x^2$ in such a way that the $x$ component of velocity remains constant and has a value $\frac{1}{3}\ \text{ms}^{-1}$. The acceleration of the particle is

(A) $\frac{1}{3}\hat{j}\ \text{ms}^{-2}$ (B) $3\hat{j}\ \text{ms}^{-2}$

(C) $\frac{2}{3}\hat{j}\ \text{ms}^{-2}$ (D) $2\hat{j}\ \text{ms}^{-2}$

**24.** A particle moves along a circle of radius $R = 2$ m so that its radius vector $\vec{r}$ relative to a point on its circumference rotates with the constant angular velocity $\omega = 2\ \text{rads}^{-1}$. The linear speed of the particle is




(A) $4\ \text{ms}^{-1}$ (B) $2\ \text{ms}^{-1}$

(C) $1\ \text{ms}^{-1}$ (D) $8\ \text{ms}^{-1}$

**25.** For two projectiles launched with same initial velocity, the maximum heights corresponding to equal ranges are $4$ m and $16$ m. The range has a value

(A) 4 m (B) 8 m

(C) 16 m (D) 32 m

**26.** When a particle is moving along a circular path with uniform speed, it has

(A) radial velocity and radial acceleration

(B) radial velocity and transverse acceleration

(C) transverse velocity and radial acceleration

(D) transverse velocity and transverse acceleration

**27.** A particle moves in the $xy$ plane with constant acceleration $a$ directed along the negative $y$-axis. The equation of motion of the particle has the form $y = \alpha x - \beta x^2$, where $\alpha$ and $\beta$ are positive constants. The velocity of the particle at the origin of coordinates is

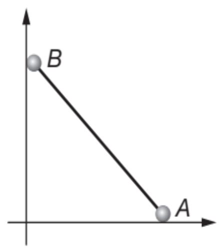
(A) $\sqrt{a\left(\dfrac{\alpha^2+1}{2\beta}\right)}$ (B) $\sqrt{a\left(\dfrac{\beta+1}{2\alpha^2}\right)}$

(C) $\sqrt{a\left(\dfrac{\alpha^2+1}{4\beta}\right)}$ (D) $\sqrt{a\left(\dfrac{\beta+1}{4\alpha^2}\right)}$

**28.** A body of mass $m$ thrown horizontally with velocity $v$ from the top of the tower of height $h$ touches the ground at a distance of 250 m from the foot of the tower. A body of mass $2m$ thrown with a velocity of $\dfrac{v}{2}$ from the top of the tower of height $4h$ will touch the ground at a distance of

(A) 250 m (B) 500 m
(C) 1000 m (D) 125 m

**29.** Two particles $A$ and $B$ are connected by a rigid rod $AB$. The rod slides along perpendicular rails as shown here. The velocity of $A$ to the left is $10\ \text{ms}^{-1}$. The speed of $B$ when angle $\theta = 45°$ is




(A) $5\ \text{ms}^{-1}$ (B) $5\sqrt{2}\ \text{ms}^{-1}$
(C) $7.5\ \text{ms}^{-1}$ (D) $10\ \text{ms}^{-1}$

**30.** A stone is projected so as to pass two walls of heights $a$ and $b$ at distances $b$ and $a$ respectively from the point of projection. If $\alpha$ is the angle of projection then

(A) minimum value of $\tan\alpha$ is $\sqrt{3}$.
(B) minimum value of $\tan\alpha$ is 3.
(C) maximum value of $\tan\alpha$ is $\sqrt{3}$.
(D) maximum value of $\tan\alpha$ is 3.

**31.** Two stones are projected so as to reach the same distance from the point of projection on a horizontal surface. The maximum height reached by one exceeds the other by an amount equal to half the sum of the heights attained by them. Then the angles of projection for the stones are

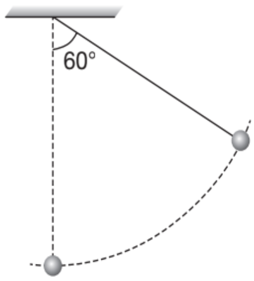
(A) 45°, 135° (B) 0°, 90°
(C) 30°, 60° (D) 20°, 70°

**32.** Two particles are projected from a point at the same instant with velocities whose horizontal components and vertical components are $(u_1, v_1)$ and $(u_2, v_2)$, respectively. The time interval between their passing through the other common point of their path (other than origin) is

(A) $\dfrac{2}{g}\left(\dfrac{v_1u_1 - v_2u_2}{u_1+u_2}\right)$ (B) $\dfrac{2}{g}\left(\dfrac{v_1^2+v_2^2}{u_1+u_2}\right)$

(C) $\dfrac{2}{g}\left(\dfrac{u_1^2+u_2^2}{v_1+v_2}\right)$ (D) $\dfrac{2}{g}\left(\dfrac{v_1u_2 - v_2u_1}{u_1+u_2}\right)$

**33.** A pendulum of length $l = 1\ \text{m}$ is released from $\theta_0 = 60°$. The rate of change of speed of the bob at $\theta = 30°$ is $\left(g = 10\ \text{ms}^{-2}\right)$

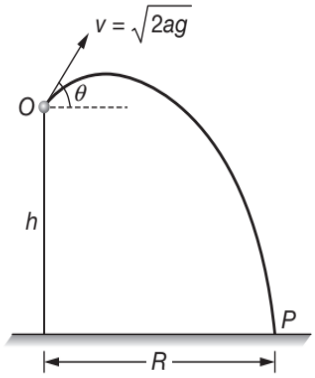



(A) $2.5\ \text{ms}^{-2}$ (B) $5\ \text{ms}^{-2}$
(C) $5\sqrt{3}\ \text{ms}^{-2}$ (D) $10\ \text{ms}^{-2}$

**34.** A projectile is thrown in a viscous medium offering resistance equal to one-tenth of acceleration due to gravity. The time of flight of projectile will

(A) increase by 1% (B) decrease by 1%
(C) increase by 2% (D) decrease by 2%

**35.** A particle is projected under gravity with velocity $\sqrt{2ag}$ from a point at a height $h$ above the level plane. The maximum range $R$ on the ground is



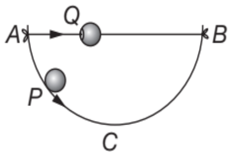

(A) $\sqrt{\left(a^2+1\right)h}$ (B) $\sqrt{a^2h}$
(C) $\sqrt{ah}$ (D) $2\sqrt{a(a+h)}$

**36.** The position vector of particle, moving in $x$-$y$ plane, at any time $t$ is $\vec{r} = \left[(2t)\hat{i} + \left(2t^2\right)\hat{j}\right]\ \text{m}$. If $\theta$ be the angle which its velocity vector makes with positive $x$-axis) then the rate of change of $\theta$ at time $t = 0.5\ \text{s}$.

(A) 6 $rads^{-1}$ (B) 4 $rads^{-1}$
(C) 2 $rads^{-1}$ (D) 1 $rads^{-1}$

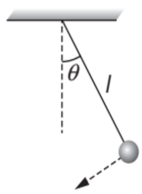
**37.** Two particles are projected simultaneously in the same vertical plane, from the same point, but with different speeds and at different angles with the horizontal. The path followed by one, as seen by the other, is
(A) a vertical straight line.
(B) a straight line making a constant angle $(\neq 90°)$ with the horizontal.
(C) a parabola.
(D) a hyperbola.

**38.** A particle $P$ is sliding down a frictionless hemispherical bowl. It passes the point $A$ at $t = 0$. At this instant of time, the horizontal component of its velocity is $v$. A bead $Q$ of same mass as $P$ is ejected from $A$ at $t = 0$ along the horizontal string $AB$, with a speed $v$. Friction between the bead and the string may be neglected. Let $t_P$ and $t_Q$ be the respective times taken by $P$ and $Q$ to reach the point $B$, then




(A) $t_P < t_Q$
(B) $t_P = t_Q$
(C) $t_P > t_Q$
(D) $\frac{t_P}{t_Q} = \frac{\text{Length of arc } ACB}{\text{Length of chord } AB}$

**39.** For the simple pendulum shown, $l = 200$ mm, when $\theta = 30°$, $\frac{d\theta}{dt} = -9$ $rads^{-1}$. The magnitude of the total acceleration of the pendulum for this position is

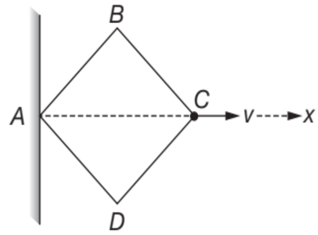



(A) 9.81 $ms^{-2}$ (B) 5 $ms^{-2}$
(C) 16.2 $ms^{-2}$ (D) 17 $ms^{-2}$

**40.** A bomber flying with a horizontal velocity of 500 $kmh^{-1}$ at a vertical height of 5 km above the ground wants to hit a train moving with a velocity of 100 $kmh^{-1}$ in the same direction and in the same vertical plane. The angle $\theta$ between the line of sight of the target and the horizontal at the instant the bomb shell should be released is approximately

(A) 55° (B) 57°
(C) 72° (D) 27°

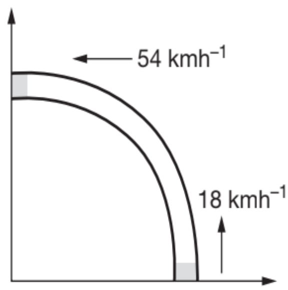
**41.** Four rods each of length $l$ have been hinged to form a rhombus. Vertex $A$ is fixed to rigid support, vertex $C$ is being moved along the $x$-axis with a constant velocity $v$ as shown in the figure. The rate at which vertex $B$ is approaching the $x$-axis at the moment the rhombus is in the form of a square is




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

**42.** The distance $r$ from the origin of a particle moving in $x$-$y$ plane varies with time as, $r = 2t$ and the angle made by the radius vector with positive $x$-axis is $\theta = 4t$. Here, $t$ is in second, $r$ in metres and $\theta$ in radian. The speed of the particle at $t = 1$ s is
(A) 12 $ms^{-1}$ (B) 10 $ms^{-1}$
(C) 8.25 $ms^{-1}$ (D) 8 $ms^{-1}$

**43.** A car enters a curved road in the form of a quarter of a circle, the path length being 200 metre. Its speed at the entrance is 18 $kmh^{-1}$ but when it leaves, it increases to 54 $kmh^{-1}$. If the car is travelling with constant acceleration along the curve, the acceleration when the car leaves the curved road is




(A) 0.9 $ms^{-2}$ (B) 0.45 $ms^{-2}$
(C) 1.9 $ms^{-2}$ (D) 3.68 $ms^{-2}$

**44.** The magnitude of displacement of a particle moving in a circle of radius $a$ with constant angular speed $\omega$ varies with time $t$ as
(A) $2a\cos(\omega t)$ (B) $2a\sin(\omega t)$
(C) $2a\cos\left(\frac{\omega t}{2}\right)$ (D) $2a\sin\left(\frac{\omega t}{2}\right)$

45. Two bodies are thrown simultaneously from the same point. One thrown straight up and the other at an angle $\alpha$ with the horizontal. Both bodies have velocity equal to $v_0$. Neglecting the air drag, the separation between the particles at time $t$ is

(A) $2v_0t\sqrt{1-\cos\alpha}$ (B) $v_0t\sqrt{1-\cos\alpha}$

(C) $2v_0t\sin\left(\frac{\pi}{4}-\frac{\alpha}{2}\right)$ (D) $2v_0t\cos\left(\frac{\pi}{4}-\frac{\alpha}{2}\right)$

46. A boat is moving directly away from the gun on the shore with speed $v_1$. The gun fires a shell with speed $v_2$ at an angle $\alpha$ and hits the boat. The distance of the boat from the gun at the moment it is fired is

(A) $\dfrac{2v_2\sin\alpha(v_1\cos\alpha-v_2)}{g}$

(B) $\dfrac{2v_1\sin\alpha(v_1\cos\alpha-v_2)}{g}$

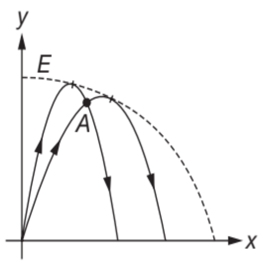
(C) $\dfrac{2v_2\sin\alpha(v_2\cos\alpha-v_1)}{g}$

(D) $\dfrac{2v_2\cos\alpha(v_1\sin\alpha-v_2)}{g}$

47. A projectile is thrown into space so as to have maximum possible range of 400 m. Taking the point of projection as the origin, the co-ordinate of the point where the velocity of the projectile is minimum is

(A) (400, 100) (B) (200, 100)
(C) (400, 200) (D) (200, 200)

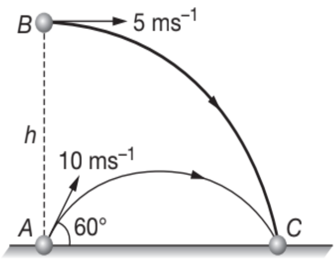
48. A number of projectiles each with a fixed muzzle velocity $u$ are fired at different angles lying between $0°$ and $90°$ as shown. Neglecting air resistance and assuming $g$ to be constant, then the equation of the envelope E of the parabolic trajectories (as shown in figure) is




(A) $y=\frac{u^2}{2g}-\frac{gx^2}{2u^2}$ (B) $y=\frac{gx^2}{2u^2}+\frac{u^2}{2g}$

(C) $y=\frac{2u^2}{gx^2}-\frac{2g}{u^2}$ (D) $y=\frac{2u^2}{gx^2}+\frac{2g}{u^2}$

49. A particle $A$ is projected from the ground with an initial velocity of $10\ \text{ms}^{-1}$ at an angle of $60°$ with horizontal. At the same instant, another particle $B$ is projected horizontally with velocity $5\ \text{ms}^{-1}$ from height $h$ above $A$ so that both the particles collide at point $C$ on the ground. Taking $g=10\ \text{ms}^{-2}$, then




(A) $h=10$ m (B) $h=30$ m
(C) $h=15$ m (D) $h=25$ m

50. A body is projected with a velocity $u$ at an angle $\alpha$ with the horizontal. It passes over a wall at a distance $x$ from the point of projection. The maximum height of the wall corresponds to

(A) $\tan\alpha=\frac{u}{gx}$ (B) $\tan\alpha=\frac{u^2}{2gx}$

(C) $\tan\alpha=\frac{u^2}{gx}$ (D) $\tan\alpha=\frac{u^2}{2g}$

51. In PROBLEM 50, the maximum height of the wall is

(A) $h=\frac{u^2}{2g}$ (B) $h=\frac{gx^2}{2u^2}$

(C) $h=\frac{u^2}{2g}+\frac{gx^2}{2u^2}$ (D) $h=\frac{u^2}{2g}-\frac{gx^2}{2u^2}$

52. Two bodies are projected simultaneously in the same vertical plane, from the same point with different speeds and at different angles of projection with the horizon. The path followed by one projectile as seen from the other is
(A) a horizontal straight line.
(B) a parabola.
(C) a hyperbola.
(D) a straight line inclined at an acute angle with the horizontal.

53. Two particles are projected from the ground simultaneously with speeds $10\ \text{ms}^{-1}$ and $\frac{10}{\sqrt{3}}\ \text{ms}^{-1}$ at angles $30°$ and $60°$ with the horizontal in the same direction. The maximum distance between them till both of them strike the ground is approximately $\left(g=10\ \text{ms}^{-2}\right)$

(A) 10 m (B) 16 m
(C) 23 m (D) 30 m

**54.** Two particles are projected simultaneously in the same vertical plane from the same point, with different speeds $u_1$ and $u_2$, making angles $\theta_1$ and $\theta_2$ respectively with the vertical, such that $u_1 \sin\theta_1 = u_2 \sin\theta_2$. The path followed by one, as seen by the other (as long as both are in flight), is
(A) a straight line making an angle $|\theta_1 - \theta_2|$ with the horizontal.
(B) a parabola.
(C) a horizontal straight line.
(D) a vertical straight line.

**55.** A ball rolls of the top of a stair way with a horizontal velocity $u$ ms$^{-1}$. If the steps are $h$ m high and $b$ m wide, the ball will hit the edge of the $n$th step, if

(A) $n = \dfrac{2hu}{gb^2}$ (B) $n = \dfrac{2hu^2}{gb^2}$

(C) $n = \dfrac{2hu^2}{gb}$ (D) $n = \dfrac{hu^2}{gb^2}$

**56.** The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where $a$, $b$ are constants and $x$, $y$ are respectively the horizontal and vertical distances of the projectile from the point of projection. The maximum height attained by the particle and the angle of projection from the horizontal are

(A) $\dfrac{b^2}{2a}$, $\tan^{-1}(2a)$

(B) $\dfrac{a^2}{b}$, $\tan^{-1}(2a)$

(C) $\dfrac{a^2}{4b}$, $\tan^{-1}(a)$

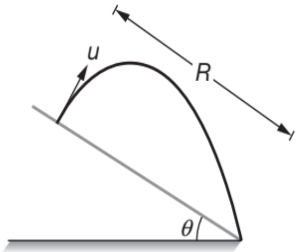
(D) $\dfrac{2a^2}{b}$, $\tan^{-1}(a)$

**57.** The velocity of a particle moving in the $x$-$y$ plane is given by

$$\frac{dx}{dt} = 8\pi \sin(2\pi t) \text{ and } \frac{dy}{dt} = 8\pi \cos(2\pi t)$$

when $t = 0$, $x = 8$ and $y = 0$. The path of the particle is
(A) a straight line (B) a circle
(C) an ellipse (D) a parabola

**58.** A projectile is fired with a velocity $u$ at right angle to the slope which is inclined at an angle $\theta$ with the horizontal. The expression for $R$ is




(A) $\dfrac{2u^2}{g}\tan\theta$ (B) $\dfrac{2u^2}{g}\sec\theta$

(C) $\dfrac{u^2}{g}\tan^2\theta$ (D) $\dfrac{2u^2}{g}\tan\theta\sec\theta$

**59.** The horizontal range and maximum height attained by a projectile are $R$ and $H$, respectively. If a constant horizontal acceleration $a = \dfrac{g}{2}$ is imparted to the projectile due to wind, then its horizontal range and maximum height will be

(A) $(R + H)$, $\dfrac{H}{2}$ (B) $\left(R + \dfrac{H}{2}\right)$, $H$

(C) $(R + 2H)$, $H$ (D) $(R + H)$, $H$

**60.** A particle moves in space along the path $z = ax^3 + by^2$ in such a way that $\dfrac{dx}{dt} = c = \dfrac{dy}{dt}$, where $a$, $b$ and $c$ are constants. The acceleration of the particle is

(A) $(2ax^2 + 6by^2)\hat{k}$ (B) $(6ac^2x + 2bc^2)\hat{k}$

(C) $(bc^2x + 2by)\hat{k}$ (D) $(4bc^2x + 3ac^2)\hat{k}$

**61.** A stone is thrown from a point at a distance $a$ from a wall of height $b$. If it just clears the wall then the maximum height $h$ reached by the stone for angle of projection $\alpha$ is

(A) $\dfrac{a^2\tan^2\alpha}{4(a\tan\alpha - b)}$ (B) $\dfrac{a^2\sec^2\alpha}{4(a\sec\alpha - b)}$

(C) $\dfrac{a^2\tan^2\alpha}{4b}$ (D) $\dfrac{a^2\tan^2\alpha}{4(a - b\cot\alpha)}$

**62.** An aeroplane flying at a constant speed releases a food-packet for flood victims. As the packet drops away from the aeroplane,
(A) it will always be vertically below the aeroplane only if the aeroplane was flying at an angle of 45° to the horizontal.
(B) it will always be vertically below the aeroplane only if the aeroplane was flying horizontally.
(C) it will gradually fall behind the aeroplane if the aeroplane was flying horizontally.
(D) it will always be vertically below the aeroplane.

**63.** Position vector of a particle moving in $x$-$y$ plane at time $t$ is $\vec{r} = a(1-\cos(\omega t))\hat{i} + a\sin(\omega t)\hat{j}$. The path of the particle is
(A) an ellipse
(B) a circle of radius $a$ and centre at $(0, 0)$
(C) a circle of radius $a$ and centre at $(a, 0)$
(D) neither a circle nor an ellipse

**64.** Ratio of minimum kinetic energies of two projectiles of same mass is $4:1$. The ratio of the maximum height attained by them is also $9:1$. The ratio of their ranges would be
(A) $16:1$ (B) $8:1$
(C) $6:1$ (D) $2:1$

**65.** A person at the point $P$ aims his rifle at an angle of $20°$ with the horizontal so that the bullet fired is to hit an object at $A$ but the bullet hits at point $B$, a vertical distance $\delta$ below $A$. If the initial velocity of the bullet is $600\ \text{ms}^{-1}$ and the point $P$ is at a horizontal distance of 1 km from the point $A$ then,
(A) $\delta = 1543$ m (B) $\delta = 154$ m
(C) $\delta = 154.3$ m (D) $\delta = 15.43$ m

**66.** A particle moves along the positive branch of the curve $y = \frac{x^2}{2}$ with $x$ governed by $x = \frac{1}{2}t^2$, where $x$ and $y$ are measured in metre and $t$ in second. At $t = 2$ s, the velocity of the particle is
(A) $2\hat{i} - 4\hat{j}\ \text{ms}^{-1}$ (B) $2\hat{i} + 4\hat{j}\ \text{ms}^{-1}$
(C) $4\hat{i} + 2\hat{j}\ \text{ms}^{-1}$ (D) $4\hat{i} - 2\hat{j}\ \text{ms}^{-1}$

**67.** A particle moves in the $x$-$y$ plane according to the equations $x = 4t^2 + 4t + 5$ and $y = -t^3 + 12t + 3$. At $t = 1$ s, the acceleration of the particle is
(A) $5\ \text{ms}^{-2}$ (B) $10\ \text{ms}^{-2}$
(C) $15\ \text{ms}^{-2}$ (D) $20\ \text{ms}^{-2}$

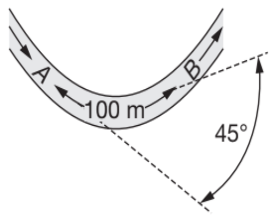
**68.** A particle is moving in $x$-$y$ plane. At certain instant of time, the components of its velocity and acceleration are $v_x = 3\ \text{ms}^{-1}$, $v_y = 4\ \text{ms}^{-1}$, $a_x = 2\ \text{ms}^{-2}$ and $a_y = 1\ \text{ms}^{-2}$. The rate of change of speed at this moment is
(A) $\sqrt{5}\ \text{ms}^{-2}$ (B) $\sqrt{10}\ \text{ms}^{-2}$
(C) $2\ \text{ms}^{-2}$ (D) $4\ \text{ms}^{-2}$

**69.** A particle is projected at an angle of $60°$ above the horizontal with a speed of $10\ \text{ms}^{-1}$. After some time the direction of its velocity makes an angle of $30°$ above the horizontal. The speed of the particle at this instant is
(A) $\frac{5}{\sqrt{3}}\ \text{ms}^{-1}$ (B) $5\sqrt{3}\ \text{ms}^{-1}$
(C) $5\ \text{ms}^{-1}$ (D) $\frac{10}{\sqrt{3}}\ \text{ms}^{-1}$

**70.** A particle is thrown with a speed $u$ at an angle $\theta$ with the vertical. When the particle makes an angle $\phi$ with the vertical, its speed changes to $v$.
(A) $v = u\cos\theta$ (B) $v = u\sin\theta\cos\phi$
(C) $v = u\left(\frac{\sec\phi}{\sec\theta}\right)$ (D) $v = u\left(\frac{\operatorname{cosec}\phi}{\operatorname{cosec}\theta}\right)$

**71.** At a height 0.4 m from the ground, the velocity of a projectile in vector form is $\vec{v} = (6\hat{i} + 2\hat{j})\ \text{ms}^{-1}$. The angle of projection with the vertical is $(g = 10\ \text{ms}^{-2})$
(A) $45°$ (B) $60°$
(C) $30°$ (D) $\tan^{-1}\left(\frac{3}{4}\right)$

**72.** A car moves round a turn of constant curvature between $A$ and $B$ (curve $AB = 100$ metre) with a steady speed of $72\ \text{kmh}^{-1}$. If an accelerometer were mounted in the car, the magnitude of acceleration it would record between $A$ and $B$ is




(A) ZERO (B) $3.14\ \text{ms}^{-2}$
(C) $31.4\ \text{ms}^{-2}$ (D) $6.28\ \text{ms}^{-2}$

**73.** After one second the velocity of a projectile makes an angle of $45°$ with the horizontal. After another 3 s, it is travelling horizontally. The magnitude of its initial velocity and angle of projection are $(g = 10\ \text{ms}^{-2})$
(A) $50\ \text{ms}^{-1}$, $\tan^{-1}\left(\frac{3}{4}\right)$ (B) $25\ \text{ms}^{-1}$, $\tan^{-1}\left(\frac{4}{3}\right)$
(C) $50\ \text{ms}^{-1}$, $\tan^{-1}\left(\frac{4}{3}\right)$ (D) $25\ \text{ms}^{-1}$, $\tan^{-1}\left(\frac{3}{4}\right)$

**74.** The minimum speed with which a particle must be projected from the origin so that it just passes through the point $P(30\ \text{m}, 40\ \text{m})$, taking $g = 10\ \text{ms}^{-2}$, is

(A) $30\ ms^{-1}$ (B) $40\ ms^{-1}$

(C) $50\ ms^{-1}$ (D) $60\ ms^{-1}$

**75.** Two shots are projected from a gun at the top of a cliff with the same velocity $u$ at angles of projection $\alpha$ and $\beta$ with the horizon respectively. If the shots strike the horizontal ground through the foot of the cliff at the same point and if $h$ is the height of the cliff, then

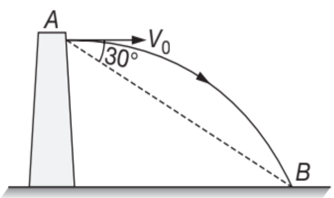
(A) $h=\frac{2u^2}{g}\left(\frac{1-\tan\alpha}{1-\tan\beta}\right)$

(B) $h=\frac{2u^2}{g}(\tan\alpha-\tan\beta)$

(C) $h=\frac{2u^2}{g}(\tan\alpha+\tan\beta)$

(D) $h=\frac{2u^2}{g}\cot(\alpha+\beta)$

**76.** An object is thrown horizontally from a tower at $A$ and hits the ground 3 second later at $B$. The line of sight from $A$ to $B$ makes an angle of $30°$ with the horizontal. The initial velocity of the object, taking $g=10\ ms^{-2}$ is




(A) $10\ ms^{-1}$ (B) $13\ ms^{-1}$

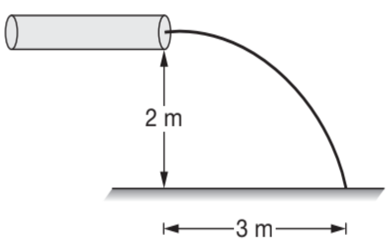
(C) $26\ ms^{-1}$ (D) $28.8\ ms^{-1}$

**77.** A point on the rim of a flywheel has a peripheral speed of $10\ ms^{-1}$ at an instant when it is decreasing at the rate of $60\ ms^{-2}$. If the magnitude of the total acceleration of the point at this instant is $100\ ms^{-2}$, the radius of the flywheel is

(A) 25 metre (B) 12.5 metre

(C) 2.5 metre (D) 1.25 metre

**78.** Water flows from a horizontal pipe which is fixed at a height of 2 m from the ground. If it falls at a distance of 3 m as shown in figure, the speed of water when it leaves the pipe is




(A) $4.7\ ms^{-1}$ (B) $7.4\ ms^{-1}$

(C) $14.7\ ms^{-1}$ (D) $47\ ms^{-1}$

**79.** A particle is projected from the ground with an initial speed of $u$ at an angle $\theta$ with horizontal. The average velocity of the particle between its point of projection and highest point of trajectory is

(A) $\frac{u}{2}\sqrt{1+2\cos^2\theta}$ (B) $\frac{u}{2}\sqrt{1+\cos^2\theta}$

(C) $\frac{u}{2}\sqrt{1+3\cos^2\theta}$ (D) $u\cos\theta$

**80.** Shots are fired at the same instant from the top and bottom of a vertical cliff at angle $\alpha$ and $\beta$ and they strike an object simultaneously at the same point. If the horizontal distance of the object from the cliff is $l$ and $h$ be the height of the cliff then

(A) $h=l(\cot\beta-\cot\alpha)$ (B) $h=l(\cos\beta-\cos\alpha)$

(C) $h=l(\tan\beta-\tan\alpha)$ (D) $h=l(\sin\beta-\sin\alpha)$

**81.** A ball thrown upward at an angle of $30°$ to the horizontal lands on the top edge of a building 20 metre away. The top edge is 5 metre above the throwing point. The ball was thrown with a velocity of

(A) $20\ ms^{-1}$ (B) $30\ ms^{-1}$

(C) $40\ ms^{-1}$ (D) $60\ ms^{-1}$

**82.** A particle is projected vertically upwards from $O$ with velocity $v$ and a second particle is projected at the same instant from $P$ (at a height $h$ above $O$) with velocity $v$ at an angle of projection $\theta$. The time when the distance between them is minimum is

(A) $\frac{h}{2v\sin\theta}$ (B) $\frac{h}{2v\cos\theta}$

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

**83.** A projectile is given an initial velocity of $\hat{i}+2\hat{j}$. The cartesian equation of its path is $(g=10\ ms^{-2})$

(A) $y=2x-\frac{x^2}{5}$ (B) $y=2x-x^2$

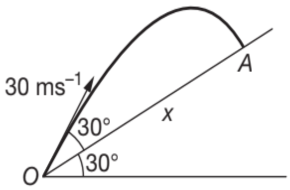
(C) $y=x-5x^2$ (D) $y=2x-5x^2$

**84.** A ball is launched with an initial velocity of $20\sqrt{2}\ ms^{-1}$ making at angle $45°$ with horizontal. The angular velocity of the particle at highest point of its journey about point of projection is

(A) $0.1\ rads^{-1}$ (B) $0.2\ rads^{-1}$

(C) $0.3\ rads^{-1}$ (D) $0.4\ rads^{-1}$

**85.** An object is projected up the incline at the angle shown in figure with an initial velocity of $30\ \text{ms}^{-1}$. The distance $x$ up the incline at which the object lands is




(A) 600 m (B) 104 m
(C) 60 m (D) 208 m

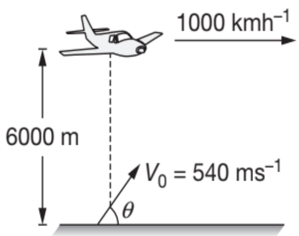
**86.** A very broad elevator is going up vertically with a constant acceleration of $2\ \text{ms}^{-2}$. At the instant when its velocity is $4\ \text{ms}^{-1}$ a ball is projected from the floor of the lift with a speed of $4\ \text{ms}^{-1}$ relative to the floor at an elevation of $30°$. The time taken by the ball to return the floor is $\left(g = 10\ \text{ms}^{-2}\right)$

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

**87.** In PROBLEM 86, range of the ball over the floor of the lift is

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

**88.** An aircraft moving with a speed of $1000\ \text{kmh}^{-1}$ is at a height of $6000\ \text{m}$, just overhead of an anti-aircraft gun. If the muzzle velocity is $540\ \text{ms}^{-1}$, the firing angle $\theta$ should be

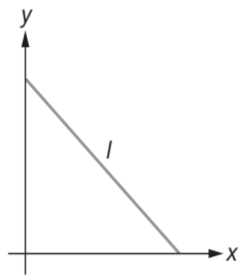



(A) 73° (B) 30°
(C) 59° (D) 45°

**89.** A particle moves in the $x$-$y$ plane with velocity $v_x = 8t - 2$ and $v_y = 2$. If it passes through the point $(14,\ 4)$ m at $t = 2$ s, the equation of the path is

(A) $x = y^2 - y + 2$ (B) $x = y + 2$
(C) $x = y^2 + 2$ (D) $x = y^2 + y - 2$

**90.** A rod of length $l$ leans by its upper end against a smooth vertical wall, while its other end leans against the floor. The end that leans against the wall moves uniformly downward with velocity $v_0$. Then




(A) the other end also moves uniformly
(B) the speed of other end goes on decreasing
(C) the speed of other end goes on increasing
(D) the speed of other end first decreases and then increases

**91.** A particle is projected from the ground with an initial velocity of $30\ \text{ms}^{-1}$ at an angle of $60°$ with horizontal. The magnitude of change in velocity in 2 s is $\left(g = 10\ \text{ms}^{-2}\right)$

(A) $5\ \text{ms}^{-1}$ (B) $10\ \text{ms}^{-1}$
(C) $20\ \text{ms}^{-1}$ (D) $40\ \text{ms}^{-1}$

**92.** A boy throws a ball with a velocity $u$ at an angle $\alpha$ with the vertical. At the same instant he starts running with uniform velocity to catch the ball before it hits the ground. To achieve this, he should run with a velocity of

(A) $u\cos\alpha$ (B) $u\sin\alpha$
(C) $u\tan\alpha$ (D) $\sqrt{u^2\tan\alpha}$

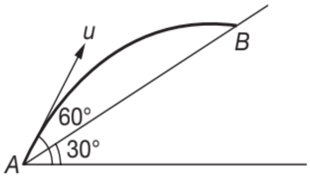
**93.** The rotor of a turbine rotates at the rate of 2000 rpm. If the diameter of the rotor is 5 m, the centripetal acceleration at the edge of the rotor is $\left(\text{take } \pi^2 = 10\right)$

(A) $11\times10^5\ \text{ms}^{-2}$ (B) $1.1\times10^5\ \text{ms}^{-2}$
(C) $2.2\times10^4\ \text{ms}^{-2}$ (D) $2.2\times10^5\ \text{ms}^{-2}$

**94.** A projectile is thrown with an initial velocity of $\left(a\hat{i} + b\hat{j}\right)\ \text{ms}^{-1}$. If the range of the projectile is twice the maximum height reached by it, then

(A) $a = 2b$ (B) $b = a$
(C) $b = 2a$ (D) $b = 4a$

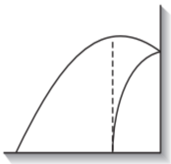
**95.** Time taken by the projectile to reach from $A$ to $B$ is $t$. Thet the distance $AB$ is equal to




(A) $\frac{ut}{\sqrt{3}}$ (B) $\frac{\sqrt{3}ut}{2}$

(C) $\sqrt{3}ut$ (D) $2ut$

**96.** A stone is projected from a horizontal plane. It attains maximum height $H$ and strikes a stationary smooth wall and falls on the ground vertically below the maximum height. Assume the collision to be elastic, the height of the point on the wall where stone will strike is



(A) $\frac{H}{2}$ (B) $\frac{H}{4}$

(C) $\frac{3H}{4}$ (D) $\frac{H}{3}$

**97.** A circular disc of radius $r = 5$ m is rotating in horizontal plane about $y$-axis. $Y$-axis is vertical axis passing through the centre of disc and $x$-$z$ is the horizontal plane at ground. The height of disc above ground is $h = 5$ m. Small particles are ejecting from disc in horizontal direction with speed $12$ ms$^{-1}$ from the circumference of disc then the distance of these particles from origin when they hits the $x$-$z$ plane is

(A) 12 m (B) 13 m
(C) 5 m (D) 6 m

**98.** It was calculated that a shell when fired from a gun with a certain velocity and at an angle of elevation $\frac{5\pi}{36}$ radians should strike a given target. In actual practice it was found that a hill just prevented in the trajectory. At what angle of elevation should the gun be fired to hit the target.

(A) $\frac{5\pi}{36}$ radians (B) $\frac{11\pi}{36}$ radians

(C) $\frac{7\pi}{36}$ radians (D) $\frac{13\pi}{36}$ radians

**99.** A body is thrown with speed of $30$ ms$^{-1}$ at angle $30°$ with horizontal from a perfectly inelastic horizontal floor. The time after which it is moving perpendicular to its initial direction of motion is

(A) 6 s (B) 3 s
(C) 1.5 s (D) never

**100.** A body is thrown from a point with speed $50$ ms$^{-1}$ at an angle $37°$ with horizontal. When it has moved a horizontal distance of $80$ m then its distance from point of projection is

(A) 40 m (B) $40\sqrt{2}$ m

(C) $40\sqrt{5}$ m (D) None of these

**101.** A ball is thrown from ground level so as to just clear a wall 4 meters high at a distance of 4 meters and falls at a distance of 14 meters from the wall, then the magnitude of the velocity of the ball is

(A) $\sqrt{281}$ ms$^{-1}$ (B) $\sqrt{812}$ ms$^{-1}$

(C) $\sqrt{182}$ ms$^{-1}$ (D) $\sqrt{128}$ ms$^{-1}$

**102.** An object is thrown at an angle $\alpha$ to the horizontal $(0° < \alpha < 90°)$ with a velocity. Then during ascent (ignoring air drag) the acceleration

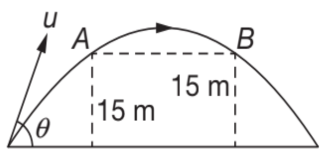
(A) with which the object moves is $\vec{g}$, at all points.
(B) tangential to the path decreases.
(C) normal to the path increases, becoming equal to $g$ at the highest point.
(D) All of these

**103.** A projectile is thrown with a velocity of $20$ ms$^{-1}$, at an angle of $60°$ with the horizontal. After how much time the velocity vector will make an angle of $45°$ with the horizontal? $\left(\text{Take } g = 10 \text{ ms}^{-2}\right)$

(A) $\sqrt{3}$ s (B) $\frac{1}{\sqrt{3}}$ s

(C) $\left(\sqrt{3}+1\right)$ s (D) $\left(\sqrt{3}-1\right)$ s

**104.** A golfer standing on level ground hits a ball with a velocity of $u = 52$ ms$^{-1}$ at an angle $\theta$ above the horizontal. If $\tan\theta = \frac{5}{12}$, then the time for which the ball is at least $15$ m above the ground (i.e. between $A$ and $B$) will be $\left(\text{take } g = 10 \text{ ms}^{-2}\right)$




(A) 1 s (B) 2 s
(C) 3 s (D) 4 s

**105.** Which of the following ideas is helpful in understanding projectile motion?

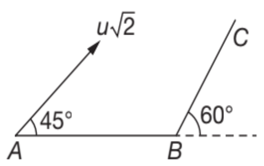
(A) $v_x^2 + v_y^2 =$ constant
(B) Acceleration is $+g$ when the object is rising and $-g$ when falling
(C) In the absence of friction the trajectory will depend on the object's mass as well as its initial velocity and launch angle
(D) The horizontal motion is independent of the vertical motion

**106.** A ball is projected upwards from the top of the tower with a velocity $50\ \text{ms}^{-1}$ making an angle $30°$ with the horizontal. The height of tower is $70\ \text{m}$. After how many seconds the ball will strike the ground?
(A) 3 s (B) 5 s
(C) 7 s (D) 9 s

**107.** The equation of projectile is $y = \sqrt{3}x - \frac{g}{2}x^2$. The angle of projection and initial velocity is
(A) $30°$, $4\ \text{ms}^{-1}$ (B) $60°$, $2\ \text{ms}^{-1}$
(C) $60°$, $4\ \text{ms}^{-1}$ (D) $90°$, $4\ \text{ms}^{-1}$

**108.** A projectile is fired at an angle of $30°$ to the horizontal such that the vertical component of its initial velocity is $80\ \text{ms}^{-1}$. Its time of flight is $T$. Its velocity at $t = \frac{T}{4}$ has a magnitude of nearly
(A) $200\ \text{ms}^{-1}$ (B) $300\ \text{ms}^{-1}$
(C) $140\ \text{ms}^{-1}$ (D) $100\ \text{ms}^{-1}$

**109.** A particle is projected from a point $A$ with velocity $u\sqrt{2}$ at an angle of $45°$ with horizontal as shown in figure. It strikes the plane $BC$ at right angles. The velocity of the particle at the time of collision is:




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

**110.** Consider a boy on a trolley who throws a ball with speed $20\ \text{ms}^{-1}$ at an angle $37°$ with respect to trolley in direction of motion of trolley which moves horizontally with speed $10\ \text{ms}^{-1}$ 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

**111.** A projectile is thrown at angle $\beta$ with vertical. It reaches a maximum height $H$. The time taken to reach highest point of its path is
(A) $\sqrt{\frac{H}{g}}$ (B) $\sqrt{\frac{2H}{g}}$
(C) $\sqrt{\frac{H}{2g}}$ (D) $\sqrt{\frac{2H}{g\cos\beta}}$

**112.** A body is projected at angle $45°$ to horizontal with velocity $20\ \text{ms}^{-1}$ from ground. If there is an acceleration in horizontal direction of $2\ \text{ms}^{-2}$, then calculate horizontal range of this particle
(A) 40 m (B) 48 m
(C) 8 m (D) 20 m

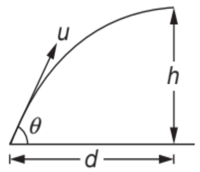
**113.** A particle is projected with a velocity of $20\ \text{ms}^{-1}$ at an angle of 30° to an inclined plane of inclination 30° to the horizontal. The particle hits the inclined plane at an angle 30°, during its journey. The time of flight is
(A) $\frac{20\sin(60°)}{g}$ (B) $\frac{20\sin(60°)}{g\cos(30°)}$
(C) $\frac{20\sin(30°)}{g\cos(60°)}$ (D) $\frac{20\sin(30°)}{g}$

**114.** A particle starts flying in the $xy$-plane with a speed of $2\hat{i} + 5x\hat{j}$. Initial position of the particle was the origin $(0, 0)$ of the plane. The trajectory of the particle is represented by the equation
(A) $y = 1.25x^2$ (B) $y = 5x^2$
(C) $y = 2.5x^2$ (D) $x = 5y^2$

**115.** The ceiling of a tunnel is $5\ \text{m}$ high. What is the maximum horizontal distance that a ball thrown with a speed of $20\ \text{ms}^{-1}$, can go without hitting the ceiling of the tunnel? $(\text{Take } g = 10\ \text{ms}^{-2})$
(A) 30 m (B) 40 m
(C) $30\sqrt{2}$ m (D) $20\sqrt{3}$ m

**116.** In projectile motion, the modulus of rate of change of speed
(A) is constant
(B) first increases then decreases
(C) first decreases then increases
(D) None of these

**117.** If a stone is to hit at a point which is at a horizontal distance $d$ away and at a height $h$ above the point from where the stone starts, then what is the value of initial speed $u$ if the stone is launched at an angle $\theta$?



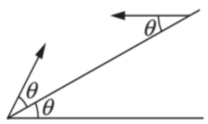

(A) $\dfrac{g}{\cos\theta}\sqrt{\dfrac{d}{2(d\tan\theta-h)}}$

(B) $\dfrac{d}{\cos\theta}\sqrt{\dfrac{g}{2(d\tan\theta-h)}}$

(C) $\sqrt{\dfrac{gd^2}{h\cos^2\theta}}$

(D) $\sqrt{\dfrac{gd^2}{d-h}}$

**118.** From an inclined plane two particles are projected with same speed at same angle $\theta$, one up and other down the plane as shown in figure. Which of the following statement(s) is/are correct?




(A) The particles will collide the plane with same speed
(B) The times of flight of each particle are same
(C) Both particles strikes the plane perpendicularly
(D) None of these

**119.** A large box is moving on horizontal floor with constant acceleration $a = g$. A particle is projected inside box with velocity $u$ and angle $\theta$ with horizontal with respect to box frame. For the given $u$, the value of $\theta$ for which horizontal range inside box will be maximum is

(A) $\dfrac{\pi}{4}$ (B) $\dfrac{\pi}{8}$

(C) $\dfrac{3\pi}{8}$ (D) $\dfrac{\pi}{3}$

**120.** An object is projected with a velocity of $20\ \text{ms}^{-1}$ making an angle of $45°$ with horizontal. The equation for the trajectory is $h = Ax - Bx^2$ where $h$ is height, $x$ is horizontal distance. $A$ and $B$ are constants. The ratio $A:B$ is $\left(g = 10\ \text{ms}^{-2}\right)$

(A) $1:5$ (B) $5:1$
(C) $1:40$ (D) $40:1$

**121.** The $x$ and $y$ coordinates of a particle at any time $t$ are given by $x = 2t + 4t^2$ and $y = 5t$, where $x$ and $y$ are in metre and $t$ in second. The acceleration of the particle at $t = 5$ s is

(A) $40\ \text{ms}^{-2}$ (B) $20\ \text{ms}^{-2}$
(C) $8\ \text{ms}^{-2}$ (D) ZERO

**122.** A particle starts from the origin at $t = 0$. It moves in a plane with a velocity given by $\vec{v} = v_0\hat{i} + (a\omega\cos\omega t)\hat{j}$. The equation of trajectory of the particle is

(A) $y = a\sin(\omega t)$ (B) $y = a\cos(\omega t)$

(C) $y = a\sin\left(\dfrac{\omega x}{v_0}\right)$ (D) $y = a\cos\left(\dfrac{\omega x}{v_0}\right)$

**123.** Ratio of minimum kinetic energies of two projectiles of same mass is $4:1$. The ratio of the maximum height attained by them is also $4:1$. The ratio of their ranges would be

(A) $16:1$ (B) $4:1$
(C) $8:1$ (D) $2:1$

**124.** At a height $0.4$ m from the ground, the velocity of a projectile is, $\vec{v} = \left(6\hat{i} + 2\hat{j}\right)\ \text{ms}^{-1}$. The angle of projection is $\left(g = 10\ \text{ms}^{-2}\right)$

(A) $45°$ (B) $60°$

(C) $30°$ (D) $\tan^{-1}\left(\dfrac{3}{4}\right)$

**125.** A person standing on a truck moving with a uniform velocity $14.7\ \text{ms}^{-1}$ on a horizontal road throws a ball in such a way that it returns to him after 4 s. The speed and angle of projection as seen by a man on the road are

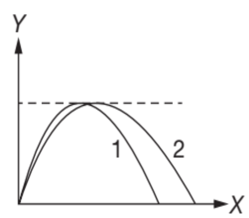
(A) $19.6\ \text{ms}^{-1}$, vertical

(B) $24.5\ \text{ms}^{-1}$, vertical

(C) $19.6\ \text{ms}^{-1}$, $53°$ with the road

(D) $24.5\ \text{ms}^{-1}$, $53°$ with the road

**126.** Trajectories of two projectiles are shown in the figure. Let $T_1$ and $T_2$ be the time periods and $u_1$ and $u_2$ be their speeds of projection. Then



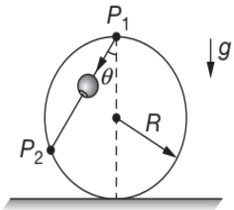

(A) $T_2 > T_1$ (B) $T_1 > T_2$

(C) $u_1 > u_2$ (D) $u_1 < u_2$

## MULTIPLE CORRECT CHOICE TYPE QUESTIONS

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. A bead is free to slide down a smooth wire tightly stretched between the points $P_1$ and $P_2$ on a vertical circle of radius $R$. If the bead starts from rest from $P_1$, the highest point on the circle and $P_2$ lies anywhere on the circumference of the circle. Then,




(A) time taken by bead to go from $P_1$ to $P_2$ is dependent on position of $P_2$ and equals $2\sqrt{\frac{R}{g}}\cos\theta$.

(B) time taken by bead to go from $P_1$ to $P_2$ is independent of position of $P_2$ and equals $2\sqrt{\frac{R}{g}}$.

(C) acceleration of bead along the wire is $g\cos\theta$.

(D) velocity of bead when it arrives at $P_2$ is $2\sqrt{gR}\cos\theta$.

2. For an oblique projectile, if $T$ is the total time of flight, $H$ the maximum height and $R$ is the horizontal range, then $x$ and $y$ co-ordinates at any time $t$ are related as (neglect air drag)

(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) $y = 4H\left(\frac{R}{x}\right)\left(1-\frac{R}{x}\right)$

3. From a point $P$, a particle is projected with a velocity $u$ at an angle $\theta$ with horizontal. At a certain point $Q$, the particle moves at right angles to its initial direction of motion. Then

(A) velocity of particle at $Q$ is $u\sin\theta$.

(B) time of flight from $P$ to $Q$ is $\left(\frac{u}{g}\right)\sec\theta$

(C) speed of particle at $Q$ is $u\cot\theta$.

(D) time of flight from $P$ to $Q$ is $\left(\frac{u}{g}\right)\text{cosec}\,\theta$

4. A particle is projected with a velocity $2\sqrt{hg}$ so that it just clears two walls of equal height $h$ at horizontal separation $2h$ from each other. Then the

(A) angle of projection is $30^\circ$ with vertical.

(B) angle of projection is $30^\circ$ with horizon.

(C) time of passing between the walls is $\sqrt{\frac{2h}{g}}$.

(D) time of passing between the walls is $2\sqrt{\frac{h}{g}}$.

5. A particle is launched from the origin with an initial velocity $\vec{u} = (3\hat{i})\ \text{ms}^{-1}$ under the influence of a constant acceleration $\vec{a} = -\left(\hat{i}+\frac{1}{2}\hat{j}\right)\text{ms}^{-2}$. Its velocity $\vec{v}$ and position vector $\vec{r}$ when it reaches its maximum $x$-co-ordinate are

(A) $\vec{v} = (-1.5\hat{j})\ \text{ms}^{-1}$  (B) $\vec{v} = -2\hat{j}$

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

6. A projectile is projected from the ground making an angle $\alpha$ with the horizontal. Air exerts a drag which is proportional to the velocity of the projectile

(A) the time of ascent will be equal to the time of descent

(B) the time of ascent will be greater than time of descent

(C) the time of descent will be greater than time of ascent

(D) at highest point velocity will be horizontal

7. Two particles projected from the same point with same speed $u$ at angles of projection $\alpha$ and $\beta$ strike the horizontal ground at the same point. If $h_1$ and $h_2$ are the maximum heights attained by projectiles, $R$ be the range for both and $t_1$ and $t_2$ be their time of flights respectively then

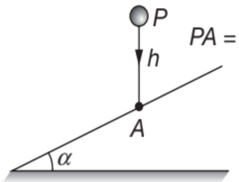
(A) $\alpha+\beta = \frac{\pi}{2}$  (B) $R = 4\sqrt{h_1h_2}$

(C) $\frac{t_1}{t_2} = \tan\alpha$  (D) $\tan\alpha = \sqrt{\frac{h_1}{h_2}}$

8. The co-ordinates of a particle moving in a plane are given by $x = a\cos(pt)$ and $y = b\sin(pt)$, where $a$, $b(<a)$ and $p$ are positive constants of appropriate dimensions. Then

(A) the path of the particle is an ellipse.
(B) the velocity and acceleration of the particle are normal to each other at $t=\dfrac{\pi}{2p}$.
(C) the acceleration of the particle is always directed towards the focus.
(D) the distance travelled by the particle in time interval $t=0$ to $t=\dfrac{\pi}{2p}$ is $a$.

**9.** A ball starts falling freely from a height $h$ from a point on the inclined plane forming an angle $\alpha$ with the horizontal as shown. After collision with the incline it rebounds elastically off the inclined plane. Then




(A) it again strikes the incline at $t=\sqrt{\dfrac{8h}{g}}$ after it strikes the incline at $A$.
(B) it again strikes the incline at $t=\sqrt{\dfrac{2h}{g}}$ after it strikes the incline at $A$.
(C) it again strikes the incline at a distance $4h\sin\alpha$ from $A$ along the incline.
(D) it again strikes the incline at a distance $8h\sin\alpha$ from $A$ along the incline.

**10.** A cart is moving along $+x$ direction with a velocity of $4\ \text{ms}^{-1}$. A person on the cart throws a stone with a velocity of $6\ \text{ms}^{-1}$ with respect to himself. In the frame of reference of the cart the stone is thrown in the $y$-$z$ plane making an angle of $30°$ with the vertical $z$-axis. Then with respect to an observer on the ground
(A) the initial velocity of the stone is $10\ \text{ms}^{-1}$.
(B) the initial velocity of the stone is $2\sqrt{13}\ \text{ms}^{-1}$.
(C) the velocity at the highest point of its motion is zero.
(D) the velocity at the highest point of its motion is $5\ \text{ms}^{-1}$.

**11.** Two shells are fired from a cannon successively with speed $u$ each at angles of projection $\alpha$ and $\beta$, respectively. If the time interval between the firing of shells is $t$ and they collide in mid air after a time $T$ from the firing of the first shell. Then
(A) $T\cos\alpha=(T-t)\cos\beta$
(B) $\alpha>\beta$
(C) $(T-t)\cos\alpha=t\cos\beta$
(D) $(u\sin\alpha)T-\dfrac{1}{2}gT^2=(u\sin\beta)(T-t)-\dfrac{1}{2}g(T-t)^2$

**12.** Choose the correct alternative (s)
(A) A ball is thrown vertically up and another ball is thrown at an angle $\theta$ with the vertical such that both of them remain in air for the same period of time, then the ratio of heights attained by the two balls is $1:1$
(B) The time of flight $T$ and the horizontal range $R$ of a projectile are connected by the equation $gT^2=2R\tan\theta$, where $\theta$ is the angle of projection
(C) For a projectile whose range $R$ is $n$ times its maximum height $H$ the angle of projection is $\tan^{-1}\left(\dfrac{4}{n}\right)$
(D) If the greatest height to which a man can throw a stone is $h$, then the greatest horizontal distance upto which he can throw the stone is $2h$

**13.** A radar observer on the ground is watching an approaching projectile. At a certain instant he has the following information.
(i) The projectile has reached the maximum altitude and is moving with a horizontal velocity $v$;
(ii) The straight line distance of the observer to the projectile is $l$;
(iii) The line of sight to the projectile is at an angle $\theta$ above the horizontal.
Assuming earth to be flat and the observer lying in the plane of the projectile's trajectory then,
(A) the distance between the observer and the point of impact of the projectile is $D=\dfrac{v^2\sin\theta}{g}-l\cos\theta$.
(B) the distance between the observer and the point of impact of the projectile is $D=v\sqrt{\dfrac{2l\sin\theta}{g}}-l\cos\theta$.
(C) the projectile will pass over the observer's head for $l<\dfrac{2v^2\tan\theta\sec\theta}{g}$.
(D) the projectile will pass over the observer's head for $l>\dfrac{2v^2\tan\theta\sec\theta}{g}$.

**14.** A projectile has the same range $R$ for two angles of projections. If $T_1$ and $T_2$ be the times of flight in the two cases and $\theta$ be the angle of projection corresponding to the time $T_1$, then

(A) $T_1T_2 \propto R^2$ (B) $\frac{T_1}{T_2} = \cot\theta$

(C) $\frac{T_1}{T_2} = \tan\theta$ (D) $T_1T_2 \propto R$

**15.** Two guns situated at the top of a hill of height $10\text{ m}$, fire one shot each with the same speed of $5\sqrt{3}\text{ ms}^{-1}$ at some interval of time. One gun fires horizontally and other fires upwards at an angle of $60°$ with the horizontal. The shots collide in mid air at the point $P$. Taking the origin of the coordinate system at the foot of the hill right below the muzzle, trajectories in $x$-$y$ plane and $g = 10\text{ ms}^{-2}$, then

(A) the first shell reaches the point $P$ at $t_1 = 1\text{ s}$ from the start.

(B) the second shell reaches the point $P$ at $t_2 = 2\text{ s}$ from the start.

(C) the first shell is fired $1\text{ s}$ after the firing of the second shell.

(D) they collide at $P$ whose coordinates are given by $(5\sqrt{3}, 5)\text{ m}$.

**16.** A projectile is thrown with an initial velocity $u$, at an angle of projection $\theta$ first from the equator and then from the pole. The fractional decrement in the range of projectile is

(A) $\frac{dR}{R} = -\frac{1}{291}$ (B) $\frac{dR}{R} = \frac{1}{291}$

(C) $\frac{dR}{R} = g\left(\frac{1}{g_p} - \frac{1}{g_e}\right)$ (D) $\frac{dR}{R} = -g\left(\frac{1}{g_p} - \frac{1}{g_e}\right)$

**17.** A boat is moving directly away from a cannon on the shore with a speed $v_1$. The cannon fires a shell with a speed $v_2$ at an angle $\alpha$ and the shell hits the boat. Then,

(A) the shell hits the boat when the time equal to $\frac{2v_2\sin\alpha}{g}$ is lapsed.

(B) the boat travels a distance $\frac{2v_1v_2\sin\alpha}{g}$ from its original position.

(C) the distance of the boat from the cannon at the instant the shell is fired is $\frac{2}{g}(v_2\sin\alpha)(v_2\cos\alpha - v_1)$.

(D) the distance of the boat from the cannon when the shell hits the boat is $\frac{2}{g}(v_2\sin\alpha)(v_2\cos\alpha)$.

**18.** A particle is projected from the ground with a velocity $40\sqrt{2}\text{ ms}^{-1}$ which makes an angle of $45°$ with the horizontal. At time $t = 2\text{ s}$

(A) displacement of particle is 100 m

(B) vertical component of velocity is $20\text{ ms}^{-1}$

(C) velocity makes an angle of $\tan^{-1}(2)$ with the horizontal

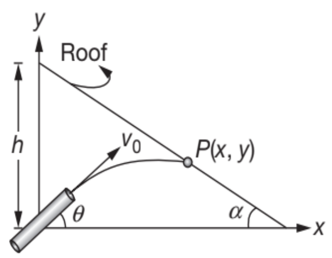
(D) particle is at height of 60 m from ground

**19.** A particle $P$ lying on smooth horizontal $x$-$y$ plane starts from $(6\hat{i} + 8\hat{j})\text{ m}$ with velocity $(2\hat{i})\text{ ms}^{-1}$. Another particle $Q$ is projected (horizontally from origin with velocity $(a\hat{i} + b\hat{j})$ so that is strikes $P$ after $2\text{ s}$. Then

(A) $a = 2$ (B) $a = 5$

(C) $b = 4$ (D) $b = 8$

**20.** A projectile is fired upward with velocity $v_0$ at an angle $\theta$ and strikes a point $P(x, y)$ on the roof of the building (as shown). Then,




(A) the projectile hits the roof in minimum time if $\theta + \alpha = \frac{\pi}{2}$.

(B) the projectile hits the roof in minimum time if $\theta + \alpha = \frac{\pi}{4}$.

(C) the minimum time taken by the projectile to hit the roof is $t_{\text{min}} = \frac{v_0 - \sqrt{v_0^2 - 2gh\cos^2\alpha}}{g\cos\alpha}$.

(D) the projectile never reaches the roof for $v_0 < \sqrt{2gh}\cos\alpha$.

**21.** A particle is fired from a point on the ground with speed $u$ making an angle $\theta$ with the horizontal. Then

(A) the radius of curvature of the projectile at the highest point is $\frac{u^2\cos^2\theta}{g}$

(B) the radius of curvature of the projectile at the highest point of launch is $\frac{u^2}{g\cos\theta}$

(C) at the point of projection tangential acceleration is $g\sin\theta$

(D) at the highest point tangential acceleration is zero

22. A shot is fired with a velocity $u$ at an angle $(\alpha+\theta)$ with the horizon from the foot of an incline plane of angle $\alpha$ through the point of projection. If it hits the plane horizontally then

(A) $\tan\theta = \frac{\tan\alpha}{1+2\tan^2\alpha}$ (B) $\tan\theta = 2\tan\alpha$

(C) $\tan\theta = \frac{2\tan\alpha}{1+2\tan^2\alpha}$ (D) $\tan\theta = \frac{\sin\alpha\cos\alpha}{1+\sin^2\alpha}$

23. Two second after projection, a projectile is travelling in a direction inclined at $30°$ to the horizon. After one more second it is travelling horizontally. Then

(A) the velocity of projection is $20\ \text{ms}^{-1}$.

(B) the velocity of projection is $20\sqrt{3}\ \text{ms}^{-1}$.

(C) the angle of projection is $30°$ with vertical.

(D) the angle of projection is $30°$ with horizon.

24. A particle is projected from point $A$ with speed $u$ and angle of projection is $60°$. At some instant, magnitude of velocity of particle is $v$ and it makes an angle $\theta$ with horizontal. If radius of curvature of path of particle at the given instant is $\frac{8}{3\sqrt{3}}$ times minimum radius of curvature during the whole flight, then

(A) $\theta = 37°$ (B) $\theta = 30°$

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

25. Path of a particle moving in $x$-$y$ plane is $y = 3x + 4$. At some instant suppose $x$-component of velocity is $1\ \text{ms}^{-1}$ and it is increasing at a rate of $1\ \text{ms}^{-2}$. Then at this instant

(A) speed of particle is $\sqrt{10}\ \text{ms}^{-1}$

(B) acceleration of particle is $\sqrt{10}\ \text{ms}^{-2}$

(C) velocity-time graph is a straight line

(D) acceleration-time graph is a straight line

26. 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

27. Velocity of a particle moving in a curvilinear path varies with time as $\vec{v} = \left(2t\hat{i} + t^2\hat{j}\right)\ \text{ms}^{-1}$, where, $t$ is in second. At $t = 1\ \text{s}$, the

(A) acceleration of particle is $8\ \text{ms}^{-2}$.

(B) tangential acceleration of particle is $\frac{6}{\sqrt{5}}\ \text{ms}^{-2}$.

(C) radial acceleration of particle is $\frac{2}{\sqrt{5}}\ \text{ms}^{-2}$.

(D) None of these

## REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

**Bubble (A)** If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
**Bubble (B)** If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
**Bubble (C)** If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
**Bubble (D)** If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** For an oblique projectile launched from the ground at an angle $\theta$ with the horizontal, $R = H$ at $\theta = \tan^{-1}(4)$.

**Statement-2:** Maximum range of projectile is proportional to square of initial velocity and inversely proportional to $g$.

2. **Statement-1:** The net acceleration of a particle in circular motion is always directed radially inwards.
**Statement-2:** Whenever a particle moves in a circular path, an acceleration exists which is directed towards the centre.

3. **Statement-1:** In uniform circular motion, acceleration is constant.
**Statement-2:** In uniform circular motion, speed is constant.

4. **Statement-1:** 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-2:** A projectile motion is a two-dimensional motion.

5. **Statement-1:** In uniform circular motion acceleration is constant.

**Statement-2:** In uniform circular motion magnitude of acceleration is $\frac{v^2}{r}$ and direction is always towards the centre.

6. **Statement-1:** A particle is moving on a horizontal surface. Its path will be straight line if initial velocity and acceleration are collinear and/or either of them is zero.
**Statement-2:** Angle between $\vec{u}$ and $\vec{a}$ determine path therefore, it may be accelerated or retarded curvilinear.

7. **Statement-1:** When a particle moves in a circle with a uniform speed, its velocity and acceleration both changes.

**Statement-2:** The centripetal acceleration in circular motion is dependent on angular velocity of the body.

8. **Statement-1:** A coin is allowed to fall in a train moving with constant velocity. Its trajectory is parabola as seen by an observer sitting in the train.
**Statement-2:** An observer on ground will see the path of coin as a parabola.

9. **Statement-1:** A particle is projected with a velocity $u$ making at an angle $\theta < 90^\circ$ with the horizontal. When particle strikes the ground its speed is again $u$.
**Statement-2:** Velocity along horizontal direction remains same but velocity along vertical direction is changed. When particle strikes the ground, magnitude of final vertical velocity is equal to magnitude of initial vertical velocity.

10. **Statement-1:** Two particles of different mass, projected with same velocity at same angles. The maximum height attained by both the particles will be same.
**Statement-2:** The maximum height of projectile is independent of the mass of the particle.

11. **Statement-1:** When speed of projection of a body is made $n$ -times, its time of flight becomes $n$ times
**Statement-2:** This is because range of projectile become $n$ times.

12. **Statement-1:** Horizontal velocity of a particle moving under the influence of gravity remains constant.
**Statement-2:** Acceleration due to gravity acts vertically downwards.

13. **Statement-1:** An oblique projectile is launched from the ground to attain a maximum range. The maximum height attained by the projectile is $25\%$ of range.

**Statement-2:** $R = \frac{u^2 \sin(2\theta)}{g}$ and $H = \frac{u^2 \sin^2\theta}{2g}$

## LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

### *Comprehension I*

A point moves in the plane $x$, $y$ according to the law $x = kt$, $y = kt(1 - \alpha t)$, where $k$ and $\alpha$ are positive constants and $t$ is the time. Based on the above facts, answer the following questions.

1. The trajectory $y(x)$ followed by the particle is a/an

(A) straight line (B) ellipse
(C) parabola (D) cycloid

2. The velocity $v$ of the point is minimum at time

(A) $t = \frac{1}{\alpha}$ (B) $t = \frac{1}{2\alpha}$
(C) $t = \frac{2}{\alpha}$ (D) $t = \frac{1}{3\alpha}$

3. The acceleration of the particle at time when the velocity has a minimum value is

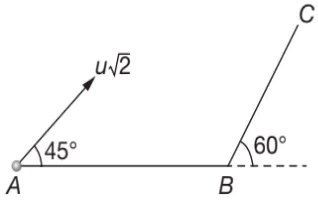
(A) $(2k\alpha)\hat{j}$ (B) $(k\alpha)\hat{j}$
(C) $\left(\frac{k\alpha}{2}\right)\hat{j}$ (D) $-2(k\alpha)\hat{j}$

4. The moment $t_0$ at which the velocity vector forms an angle $\frac{\pi}{4}$ with the acceleration vector is

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

### *Comprehension 2*

A particle is projected from a point $A$ with velocity $u\sqrt{2}$ at an angle of $45^\circ$ with horizontal as shown in figure. It strikes the plane $BC$ at right angles. Based on the above facts, answer the following questions.




5. The velocity of the particle at the time of collision is

(A) $u$ (B) $\frac{u}{2}$

(C) $\frac{\sqrt{3}u}{2}$ (D) $\frac{2u}{\sqrt{3}}$

6. The time after which collision takes place is

(A) $\frac{u}{g}$ (B) $\frac{\sqrt{3}u}{g}$

(C) $\frac{u}{g}\left(\frac{\sqrt{3}+1}{\sqrt{3}}\right)$ (D) $\left(\frac{\sqrt{3}}{\sqrt{3}-1}\right)\frac{u}{g}$

## Comprehension 3

An oblique projectile is launched from a point $O$ with an initial velocity $u$ that makes an angle $\theta$ with the horizontal. It is observed that the projectile attains a maximum height $H$ at the point $\left(\frac{R}{2}, H\right)$, where $R$ is the maximum distance from $O$ at which the projectile strikes the ground. Now, if the velocity of the projectile is $\vec{v}=\left(20\hat{i}+10\hat{j}\right)\ \text{ms}^{-1}$ when it is at a height of 15 m above the ground, then based on this information and taking $g=10\ \text{ms}^{-2}$, answer the following questions.

7. The launch speed in $\text{ms}^{-1}$ is

(A) $20\ \text{ms}^{-1}$ (B) $20\sqrt{2}\ \text{ms}^{-1}$

(C) $40\ \text{ms}^{-1}$ (D) $40\sqrt{2}\ \text{ms}^{-1}$

8. The value of $\theta$ (in radian) is

(A) $\frac{\pi}{6}$ (B) $\frac{\pi}{4}$

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

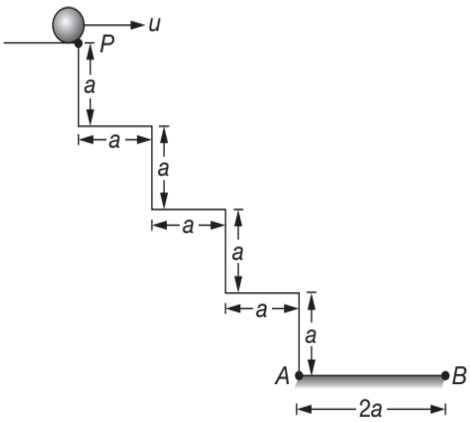
9. The coordinate, where the maximum height is attained is

(A) $(80, 20)$ m (B) $(20, 40)$ m

(C) $(20, 80)$ m (D) $(40, 20)$ m

## Comprehension 4

Consider the situation shown in the figure. A particle has to be projected from point $P$ in horizontal direction. It is required for the particle to strike the plane $AB$ (see figure).




10. The minimum value of horizontal velocity of particle at point $P$ so that particle may strike the plane $AB$ is

(A) $\sqrt{\frac{9}{8}ag}$ (B) $\sqrt{\frac{25}{8}ag}$

(C) $\sqrt{\frac{1}{2}ag}$ (D) $\sqrt{3ag}$

11. The time taken by particle in going from point $P$ to plane $AB$ is

(A) $4\sqrt{\frac{a}{g}}$ (B) $\sqrt{\frac{4a}{g}}$

(C) $\sqrt{\frac{2a}{g}}$ (D) $\sqrt{\frac{8a}{g}}$

12. The maximum value of horizontal velocity of particle at point $P$ so that it may strike the plane $AB$ is

(A) $\sqrt{\frac{9}{8}ag}$ (B) $\sqrt{\frac{25}{8}ag}$

(C) $\sqrt{\frac{1}{2}ag}$ (D) $\sqrt{3ag}$

## Comprehension 5

A ball is projected horizontally from a height of 100 m from the ground with a speed of $20\ \text{ms}^{-1}$. Taking $g=10\ \text{ms}^{-2}$ and based on the information provided, answer the following questions.

13. The time taken to reach the ground is

(A) $\sqrt{5}$ s (B) $2\sqrt{5}$ s

(C) $3\sqrt{5}$ s (D) $4\sqrt{5}$ s

14. The horizontal distance it covers before striking the ground is

(A) $20\sqrt{5}$ m (B) $40\sqrt{5}$ m

(C) $60\sqrt{5}$ m (D) $80\sqrt{5}$ m

15. The angle with the vertical which it strikes the ground is

(A) $\tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (B) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$

(C) $\tan^{-1}\left(\frac{1}{\sqrt{5}}\right)$ (D) $\tan^{-1}\left(\frac{1}{\sqrt{7}}\right)$

## Comprehension 6

For a particle moving in the $x$-$y$ plane the $x$, $y$ coordinates as a function of time are given by $x = 6t$ and $y = 8t - 5t^2$, where $x$ and $y$ are in metre and $t$ is in second. Assume no air drag, answer the following questions. Based on the above facts, answer the following questions.

16. Select the correct statement from the following
    (A) The particle will follow a parabolic path to have a projectile motion with an initial velocity of $5\text{ ms}^{-1}$ and an acceleration of $3\text{ ms}^{-2}$ acting along $-y$ axis
    (B) The particle will follow a parabolic path to have a projectile motion with an initial velocity of $6\text{ ms}^{-1}$ and a constant acceleration of $5\text{ ms}^{-2}$ acting along $-y$ axis
    (C) The particle will follow a parabolic path to have a projectile motion with an initial horizontal velocity of $6\text{ ms}^{-1}$ and a constant acceleration of $10\text{ ms}^{-2}$ acting along $-y$ axis
    (D) None of the above statement seems to be correct

17. The velocity, of the projectile, along $x$-axis after 0.2 second is

(A) $> 6\text{ ms}^{-1}$ (B) $< 6\text{ ms}^{-1}$

(C) $6\text{ ms}^{-1}$ (D) zero

18. The initial vertical velocity is

(A) $6\text{ ms}^{-1}$ (B) $7\text{ ms}^{-1}$

(C) $8\text{ ms}^{-1}$ (D) $10\text{ ms}^{-1}$

19. The velocity of projection of the projectile is

(A) $6\text{ ms}^{-1}$ (B) $7\text{ ms}^{-1}$

(C) $8\text{ ms}^{-1}$ (D) $10\text{ ms}^{-1}$

20. The time of ascent of the projectile is

(A) 0.2 s (B) 0.4 s

(C) 0.6 s (D) 0.8 s

21. The maximum height attained by the projectile is

(A) 0.8 m (B) 1.6 m

(C) 2.9 m (D) 3.2 m

22. The horizontal range of the projectile is

(A) 3.2 m (B) 4.9 m

(C) 8.7 m (D) 9.6 m

## Comprehension 7

The maximum height attained by an oblique projectile is 8 m and the horizontal range is 24 m. Based on the above facts, answer the following questions.

23. The vertical component of the velocity of projection is

(A) $\sqrt{g}$ (B) $2\sqrt{g}$

(C) $3\sqrt{g}$ (D) $4\sqrt{g}$

24. The horizontal component of the velocity of projection is

(A) $2\sqrt{g}$ (B) $3\sqrt{g}$

(C) $4\sqrt{g}$ (D) $5\sqrt{g}$

25. The velocity of projection is

(A) $2\sqrt{g}$ (B) $3\sqrt{g}$

(C) $4\sqrt{g}$ (D) $5\sqrt{g}$

26. The angle of projection is

(A) $\cos^{-1}(0.8)$ (B) $\sin^{-1}(0.8)$

(C) $\tan^{-1}(0.6)$ (D) $\cot^{-1}(0.8)$

## Comprehension 8

A particle initially at rest and starting from the origin is moving under the influence of acceleration given by $\vec{a} = \left(6t\hat{i} + 8t\hat{j}\right)\text{ms}^{-2}$. Based on the above facts, answer the following questions.

27. Velocity of particle at $t = 3$ s

(A) $45\text{ ms}^{-1}$ (B) $40\text{ ms}^{-1}$

(C) $35\text{ ms}^{-1}$ (D) $22\text{ ms}^{-1}$

28. Displacement of particle at $t = 3$ s is

(A) 28 m (B) 30 m

(C) 35 m (D) 45 m

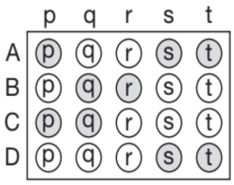
29. Path of particle will be

(A) Straight line (B) Parabola

(C) Circle (D) None of these

## MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:




If the correct matches are A $\rightarrow$ p, s and t; B $\rightarrow$ q and r; C $\rightarrow$ p and q; and D $\rightarrow$ s and t; then the correct darkening of bubbles will look like the following:

**1.** A particle is launched with an initial velocity of $20\sqrt{2}$ ms$^{-1}$ making an angle of $45°$ with the horizontal. Based on this information and $g = 10$ ms$^{-2}$ match the contents of **COLUMN-I** with their counterparts in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Magnitude of average velocity, in ms$^{-1}$, at $t = 1$ s. | (p) $25\sqrt{5}$ |
| (B) Magnitude of average acceleration, in ms$^{-2}$, at $t = 2$ s. | (q) $80\sqrt{2}$ |
| (C) Radius of curvature, in *m*, at $t = 0$ s. | (r) 25 |
| (D) Radius of curvature, in *m*, at $t = 1$ s. | (s) 40 |
| (E) Radius of curvature, in *m*, at $t = 2$ s. | (t) 10 |

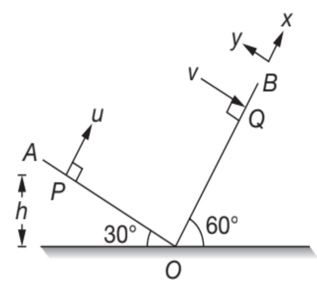
**2.** A particle is moving in a circle such that its speed varies with time $t$ as $v = (2t)$ ms$^{-1}$. The quantities in **COLUMN-I** are at $t = 2$ s against their values mentioned in **COLUMN-II**. Match them correctly.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Distance travelled | (p) 2 |
| (B) Displacement | (q) $\sin(2)$ |
| (C) Average speed | (r) 4 |
| (D) Average velocity | (s) $2\sin(2)$ |
| | (t) None of these |

**3.** A particle is moving in a curvilinear path such that its velocity $\vec{v}$, in ms$^{-1}$, at any instant of time $t$, in second, is given by $\vec{v} = 2t\hat{i} + t^2\hat{j}$. Match the quantities in **COLUMN-I** calculated at $t = 1$ s, with the respective values in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Tangential acceleration, in ms$^{-2}$ | (p) $2\sqrt{2}$ |
| (B) Radial acceleration, in ms$^{-2}$ | (q) $\frac{5\sqrt{5}}{2}$ |
| (C) Acceleration, in ms$^{-2}$ | (r) $\frac{6}{\sqrt{5}}$ |
| (D) Radius of curvature, in *m* | (s) $\frac{2}{\sqrt{5}}$ |
| | (t) None of these |

**4.** Two inclined planes $OA$ and $OB$ having inclinations $30°$ and $60°$ with the horizontal respectively intersect each other at $O$, as shown in figure. A particle is projected from point $P$ with velocity $u = 10\sqrt{3}$ ms$^{-1}$ along a direction perpendicular to plane $OA$. If the particle strikes plane $OB$ normally at $Q$. Based on the information provided and taking $g = 10$ ms$^{-2}$, match the quantities in **COLUMN-I** with the respective values in **COLUMN-II**.



| COLUMN-I | COLUMN-II |
|---|---|
| (A) Time of flight, in s from $P$ to $Q$. | (p) 5 |
| (B) Velocity, in $ms^{-1}$, with which the particle strikes the plane $OB$. | (q) 2 |
| (C) Vertical height, in m, of the point $P$ above $O$ | (r) 20 |
| (D) Separation $PQ$, in m | (s) 10 |
| | (t) None of these |

**5.** A ball launched with some initial velocity from the origin moves in $x$-$y$ plane such that $x$ and $y$ vary with time $t$ as $x = \alpha t$ and $y = \alpha t(1 - \beta t)$ where $\alpha$ and $\beta$ are positive constants. Based on this information match the quantities in **COLUMN-I** with the respective values in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) The maximum horizontal distance travelled, as a multiple of $\frac{\alpha}{2\beta}$ | (p) 1 |
| (B) The maximum vertical displacement attained, as a multiple of $\frac{\alpha}{16\beta}$ | (q) 2 |
| (C) The time taken by the ball to hit the $x$-axis again, as a multiple of $\frac{1}{8\beta}$ | (r) 4 |
| (D) The acceleration of the ball, in magnitude, as a multiple of $\frac{\alpha\beta}{8}$ | (s) 8 |
| (E) The velocity of the ball at half the value of time calculated in (C), as a multiple of $\alpha$ | (t) 16 |

**6.** Match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Uniform motion | (p) Projectile motion |
| (B) Uniform accelerated motion | (q) Uniform circular motion |
| (C) Non uniform accelerated motion | (r) Motion along a straight line |
| (D) Uniform velocity | (s) Motion along ellipse |

**7.** Two projectiles are launched with same initial speed from ground at angles $30°$ and $60°$. If $R_1$ is range of first and $R_2$ is range of second, similarly $H_1$ and $H_2$ are their maximum heights and $T_1$ and $T_2$ are time of flights, then match the ratios in **COLUMN-I** to the values in **COLUMN-II**.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) $\frac{R_1}{R_2}$ | (p) $\frac{1}{3}$ |
| (B) $\frac{H_1}{H_2}$ | (q) 1 |
| (C) $\frac{T_2}{T_1}$ | (r) $\sqrt{3}$ |
| (D) $\frac{T_1 H_1 R_1}{T_2 H_2 R_2}$ | (s) $\frac{1}{3\sqrt{3}}$ |

**8.** A body is projected with speed $20\sqrt{2}\ ms^{-1}$ at an angle $45°$ with horizontal. After 1 s of it motion match the following columns. $(g = 10\ ms^{-2})$.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Average velocity (in magnitude) | (p) $10\sqrt{5}\ ms^{-1}$ |
| (B) Change in velocity (in magnitude) | (q) $25\ ms^{-1}$ |

*(Continued)*

| COLUMN-I | COLUMN-II |
|---|---|
| (C) Instantaneous speed | (r) $10\ ms^{-1}$ |
| (D) Change in speed (nearly) (in magnitude) | (s) $6\ ms^{-1}$ |

9. Trajectory of particle launched obliquely from the ground is given as $y = x - \frac{x^2}{80}$, where, $x$ and $y$ are in metre. For this projectile motion match the following if $g = 10\ ms^{-2}$.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Angle of projection | (p) 20 m |
| (B) Angle of velocity with horizontal after 4 s | (q) 80 m |
| (C) Maximum height | (r) 45° |
| (D) Horizontal range | (s) $\tan^{-1}\left(\frac{1}{2}\right)$ |

10. Match the following

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Particle moving in circle | (p) $\vec{a}$ may be perpendicular to $\vec{v}$ |
| (B) Particle moving in straight line | (q) $\vec{a}$ may be in the direction of $\vec{v}$ |
| (C) Particle undergoing projectile motion | (r) $\vec{a}$ may make same acute angle with $\vec{v}$ |
| (D) Particle moving into space | (s) $\vec{a}$ may be opposite velocity |

11. A body is projected from the ground with velocity $v$ at an angle of projection $\theta$. Then match the following.

| COLUMN-I | COLUMN-II |
|---|---|
| (A) Change in momentum | (p) Remains unchanged |
| (B) Angle at the highest point | (q) Independent of projected velocity |
| (C) Kinetic energy of body | (r) At highest point is zero |
| (D) Horizontal component of velocity | (s) Minimum at highest point |

## INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

1. A shell is fired from a gun from the bottom of a hill along its slope. The slope of the hill is $30^\circ$ and the angle of the barrel to the horizontal $60^\circ$. The initial velocity of the shell is $21\ ms^{-1}$. Find the distance, in metre, from the gun to the point at which the shell falls.

2. A particle is projected with velocity $2\sqrt{gh}$ so that it just clears two walls of equal height $h$ which are at a distance $2h$ from each other. The time of passing between the walls is $*\sqrt{\frac{h}{g}}$, where $*$ is not readable. Find $*$.

3. On a cricket field, the batsman is at the origin of co-ordinates and a fielder stands in position $(46\hat{i} + 28\hat{j})$ m. The batsman hits the ball so that it rolls along the ground with constant velocity $(7.5\hat{i} + 10\hat{j})\ ms^{-1}$. The fielder can run with a speed of $5\ ms^{-1}$. If he starts to run immediately the ball is hit what is the shortest time, in seconds, in which he could intercept the ball?

4. A particle is projected from a point at the foot of a fixed plane, inclined at an angle of $45^\circ$ to the horizontal, in the vertical plane containing the line of greatest slope through the point. If the particle strikes the plane

horizontally and $\phi(>45^\circ)$ is the angle of launch measured to the horizontal, then find the value of $\tan\phi$.

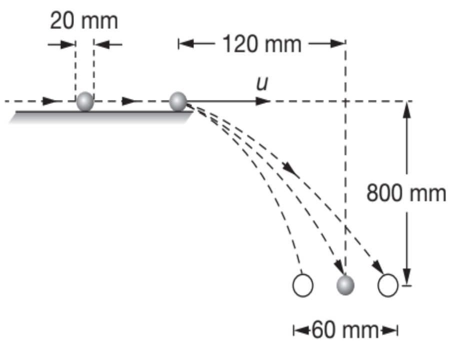
**5.** A particle is moving in a circle of radius $\frac{1}{4}$ m with a linear speed of $2\ \text{ms}^{-1}$. Calculate the angular speed of a particle, in $\text{rads}^{-1}$.

**6.** A boy whirls a stone in a horizontal circle of radius $0.5\ \text{m}$ and at height $20\ \text{m}$ above level ground. The string breaks, and the stone flies off horizontally to strike the ground after travelling a horizontal distance of 10 m. Find the magnitude of the centripetal acceleration, in $\text{ms}^{-2}$, of the stone while in circular motion. $\left(\text{Take } g = 10\ \text{ms}^{-2}\right)$

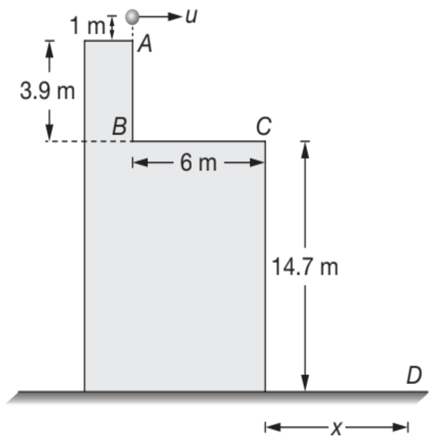
**7.** A highway curve is designed such that the cars travelling at a constant speed of $25\ \text{ms}^{-1}$ must not have an acceleration that exceeds $3\ \text{ms}^{-2}$. Determine the minimum radius of curvature, in metre, of the curve to the nearest integer.

**8.** At a given instant, a car travels along a circular curved road with a speed of $20\ \text{ms}^{-1}$ while decreasing its speed at the rate of $3\ \text{ms}^{-2}$. If the magnitude of the car's acceleration is $5\ \text{ms}^{-2}$, determine the radius of curvature of the road, in metre.

**9.** Ball bearings of diameter 20 mm leave the horizontal with a velocity of magnitude $u$ and fall through the $60\ \text{mm}$ diameter hole at a depth of $800\ \text{mm}$ as shown. Calculate the permissible range of $u$, in $\text{cms}^{-1}$ which will enable the ball bearings to enter the hole. Take the dotted positions to represent the limiting conditions. $\left(\text{Take } g = 10\ \text{ms}^{-2}\right)$



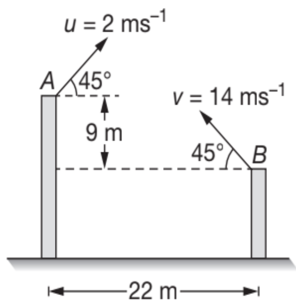

**10.** A ball is launched by a man standing on the top of a building who holds the ball at a distance $1\ \text{m}$ above the edge $A$. Calculate the minimum velocity $u$, in $\text{ms}^{-1}$, along the horizontal such that the ball just clears the edge $C$. Also find $x$, in metre, where the ball strikes the ground. Take $g = 9.8\ \text{ms}^{-2}$.




**11.** A particle is projected from a point at the foot of a fixed plane, inclined at an angle of $45^\circ$ to the horizontal, in the vertical plane containing the line of greatest slope through the point. If the particle strikes the plane at right angles and $\phi(>45^\circ)$ is the angle of launch measured to the horizontal, then find the value of $\tan\phi$.

**12.** The minimum speed in $\text{ms}^{-1}$ with which a projectile must be thrown from origin at ground so that it is able to pass through a point $P(30\ \text{m}, 40\ \text{m})$ is $\left(g = 10\ \text{ms}^{-2}\right)$

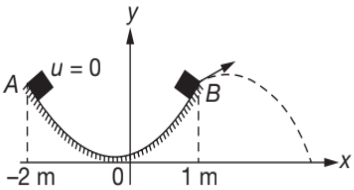
**13.** Two particles are simultaneously thrown from top of two towers as shown. Their velocities are $2\ \text{ms}^{-1}$ and $14\ \text{ms}^{-1}$. Horizontal and vertical separation between these particles are $22\ \text{m}$ and $9\ \text{m}$, respectively. Then the minimum separation between the particles in process of their motion in meters is $\left(g = 10\ \text{ms}^{-2}\right)$.




**14.** A projectile is fixed at an angle $60^\circ$ with horizontal. Ratio of initial and final kinetic energy velocity vector of projectile makes an angle $15^\circ$ with velocity of projection is

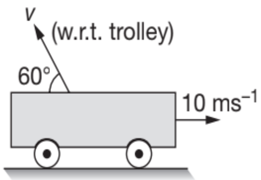
**15.** A particle is projected from the bottom of an inclined plane of inclination $30^\circ$. At what angle $\alpha$ (from the horizontal), in degree, should the particle be projected to get the maximum range on the inclined plane?

16. A small body is released from point $A$ of smooth parabolic path $y = x^2$, where $y$ is vertical axis and $x$ is horizontal axis at ground as shown. The body leaves the surface from point $B$. If $g = 10\ \text{ms}^{-2}$, then total horizontal distance in meters travelled by body before it hits ground is _______



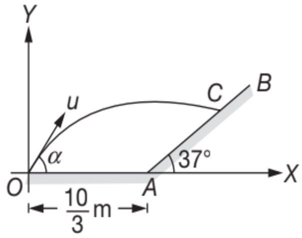

17. A particle is projected towards north with speed $20\ \text{ms}^{-1}$ at an angle $45°$ with horizontal. Ball get horizontal acceleration of $7.5\ \text{ms}^{-2}$ towards east due to wind. Range of ball (in meter) minus $42\ \text{m}$ will be

18. For an observer on trolley, direction of projection of particle is shown in figure, while for observer on ground ball rises vertically. Maximum height (in meter) reached by ball minus $10\ \text{m}$ is ______

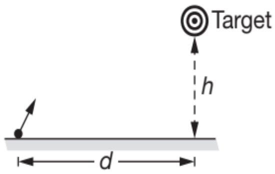



19. Two seconds after projection, a projectile is travelling in a direction inclined at $30°$ with horizontal. After one more second, it is travelling horizontally. One tenth of the angle of projection (in degree) with horizontal is _____

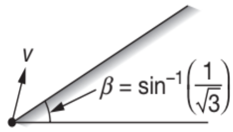
20. A particle is projected from $O$ on the ground with velocity $u = 5\sqrt{5}\ \text{ms}^{-1}$ at angle $\alpha = \tan^{-1}\left(\frac{1}{2}\right)$. It strikes at a point $C$ on a fixed plane $AB$ having inclination of $37°$ with horizontal as shown, then the $x$-coordinate of point $C$ in meters is $\left(g = 10\ \text{ms}^{-2}\right)$




21. A particle is projected from ground with minimum speed required to hit a target at a height $h = 10\ \text{m}$ at a horizontal distance $d = \sqrt{300}\ \text{m}$ as shown. Then find the time taken by particle (in seconds) to hit the target. $\left(g = 10\ \text{ms}^{-2}\right)$



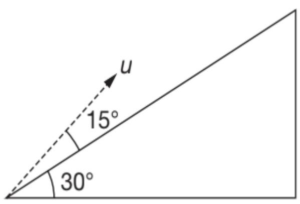

22. A particle is projected with initial velocity $v = 10\sqrt{2}\ \text{ms}^{-1}$ as shown. After elastic collision with the inclined plane, the particle rebounds normally with the plane and retraces its path to come back at its point of projection. Then find the time in seconds in which particle returns to the point of projection. $\left(g = 10\ \text{ms}^{-2}\right)$




23. A football is thrown with a velocity of $10\ \text{ms}^{-1}$ at an angle of $30°$ above the horizontal. What will the time of flight, in seconds? $\left(g = 10\ \text{ms}^{-2}\right)$

## ARCHIVE: JEE MAIN

1. **[Online April 2019]**
A plane is inclined at an angle $30°$ with respect to the horizontal. A particle is projected with a speed $2\ \text{ms}^{-1}$, from the base of the plane, making an angle $15°$ with respect to the plane as shown in the figure. The distance from the base, at which the particle hits the plane is close to (Take $g = 10\ \text{ms}^{-2}$)




(A) 18 cm (B) 20 cm
(C) 14 cm (D) 26 cm

**2. [Online April 2019]**

A shell is fired from a fixed artillery gun with an initial speed $u$ such that it hits the target on the ground at a distance $R$ from it. If $t_1$ and $t_2$ are the values of the time taken by it to hit the target in two possible ways, the product $t_1t_2$ is

(A) $\frac{R}{2g}$ (B) $\frac{2R}{g}$

(C) $\frac{R}{g}$ (D) $\frac{R}{4g}$

**3. [Online April 2019]**

The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle $\theta_0$ with speed $v_0$ then $\left(g = 10 \text{ ms}^{-2}\right)$

(A) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$

(B) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$

(C) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$

(D) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$

**4. [Online April 2019]**

Two particles are projected from the same point with the same speed $u$ such that they have the same range $R$, but different maximum heights, $h_1$ and $h_2$. Which of the following is correct?

(A) $R^2 = 4h_1h_2$ (B) $R^2 = 16h_1h_2$

(C) $R^2 = 2h_1h_2$ (D) $R^2 = h_1h_2$

**5. [Online January 2019]**

Two guns $A$ and $B$ can fire bullets at speeds $1 \text{ kms}^{-1}$ and $2 \text{ kms}^{-1}$ respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is

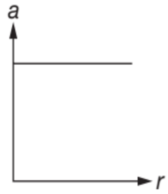
(A) $1:4$ (B) $1:8$

(C) $1:2$ (D) $1:16$

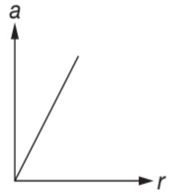
**6. [Online 2015]**

If a body moving in a circular path maintains constant speed of $10 \text{ ms}^{-1}$, then which of the following correctly describes relation between acceleration and radius?

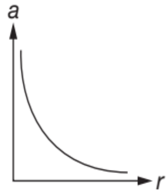
(A)



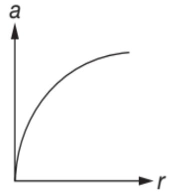

(B)




(C)




(D)




**7. [2013]**

A projectile is given an initial velocity of $\left(\hat{i} + 2\hat{j}\right) \text{ ms}^{-1}$, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If $g = 10 \text{ ms}^{-2}$, the equation of its trajectory is

(A) $4y = 2x - 25x^2$ (B) $y = x - 5x^2$

(C) $y = 2x - 5x^2$ (D) $4y = 2x - 5x^2$

**8. [2012]**

A boy can throw a stone up to a maximum height of $10 \text{ m}$. The maximum horizontal distance that the boy can throw the same stone up to will be

(A) $10 \text{ m}$ (B) $10\sqrt{2} \text{ m}$

(C) $20 \text{ m}$ (D) $20\sqrt{2} \text{ m}$

**9. [2011]**

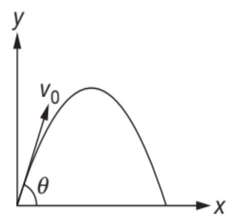
A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is $v$, the total area around the fountain that gets wet is

(A) $\pi\frac{v^2}{g}$ (B) $\pi\frac{v^4}{g^2}$

(C) $\frac{\pi}{2}\frac{v^4}{g^2}$ (D) $\pi\frac{v^2}{g^2}$

**10. [2010]**

A small particle of mass $m$ is projected at an angle $\theta$ with the $x$-axis with an initial velocity $v_0$ in the $x$-$y$ plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is



(A) $\frac{1}{2}mgv_0t^2\cos\theta\hat{i}$ (B) $-mgv_0t^2\cos\theta\hat{j}$

(C) $mgv_0t\cos\theta\hat{k}$ (D) $-\frac{1}{2}mgv_0t^2\cos\theta\hat{k}$

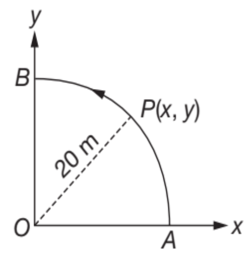
where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along $x$, $y$ and $z$-axis respectively.

**11. [2010]**
For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point $P(R, \theta)$ on the circle of radius $R$ is (Here $\theta$ is measured from the $x$-axis)

(A) $\frac{v^2}{R}\hat{i}+\frac{v^2}{R}\hat{j}$ (B) $-\frac{v^2}{R}\cos\theta\hat{i}+\frac{v^2}{R}\sin\theta\hat{j}$

(C) $-\frac{v^2}{R}\sin\theta\hat{i}+\frac{v^2}{R}\cos\theta\hat{j}$ (D) $-\frac{v^2}{R}\cos\theta\hat{i}-\frac{v^2}{R}\sin\theta\hat{j}$

**12. [2010]**
A point $P$ moves in counter-clockwise direction on a circular path as shown in the figure. The movement of $P$ is such that it sweeps out a length $s = t^3 + 5$, where $s$ is in metres and $t$ is in seconds. The radius of the path is 20 m. The acceleration of $P$ when $t = 2$ s is nearly




(A) 14 $ms^{-2}$ (B) 13 $ms^{-2}$

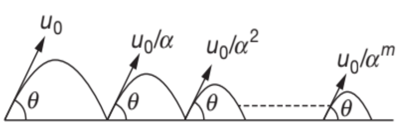
(C) 12 $ms^{-2}$ (D) 7.2 $ms^{-2}$

# ARCHIVE: JEE ADVANCED

## Integer/Numerical Answer Type Questions

In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s).

**1. [JEE (Advanced) 2019]**
A ball is thrown from ground at an angle $\theta$ with horizontal and with an initial speed $u_0$. For the resulting projectile motion, the magnitude of average velocity of the ball up to the point when it hits the ground for the first time is $V_1$. After hitting the ground, the ball rebounds at the same angle $\theta$ but with a reduced speed of $\frac{u_0}{\alpha}$. Its motion continues for a long time as shown in Figure.




If the magnitude of average velocity of the ball for entire duration of motion is 0.8 $V_1$, the value of $\alpha$ is ……..

**2. [JEE (Advanced) 2018]**
A ball is projected from the ground at an angle of 45° with the horizontal surface. It reaches a maximum height of 120 m and returns to the ground. Upon hitting the ground for the first time, it loses half of its kinetic energy. Immediately after the bounce, the velocity of the ball makes an angle of 30° with the horizontal surface. The maximum height it reaches after the bounce, in metres, is ______.

**3. [JEE (Advanced) 2011]**
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 $ms^{-1}$, 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 $ms^{-2}$, is

## ANSWER KEYS–TEST YOUR CONCEPTS AND PRACTICE EXERCISES

### Test Your Concepts-I (Based on Curvilinear Motion)

3. 8 $rads^{-1}$
4. 2 $rads^{-2}$
5. 9.5 $ms^{-2}$
6. 50 $ms^{-2}$
7. 20 s, 0.32 $ms^{-2}$
8. 1.8 $ms^{-1}$, 1.2 $ms^{-2}$
9. 38.7 $ms^{-1}$
10. 63 $ms^{-1}$
11. 0.488 $ms^{-2}$
12. 208 m
13. 100 m
14. 3.2 m

### Test Your Concepts-II (Based on Horizontal Projectile)

1. 44.1 m, 29.4 $ms^{-1}$
2. 20 $ms^{-1}$
3. 0.7 s, 7 m
4. 14 $ms^{-1}$, 2.4 m
5. 34 $ms^{-1}$
6. 6 $ms^{-1}$, $(1+3.9+14.7)=\frac{1}{2}(9.8)t^2$, 6 m
7. $u_{MIN}=25$ $cms^{-1}$ and $u_{MAX}=35$ $cms^{-1}$

### Test Your Concepts-III (Based on Oblique Projectile)

1. 76°
6. (a) 11 m
   (b) 23 m
   (c) 17 $ms^{-1}$, 63° with horizontal
7. 3.16 $ms^{-1}$
9. (a) 5 s
   (b) 130 m
   (c) 43.6 $ms^{-1}$
12. $t=\frac{uv\sin(\alpha-\beta)}{(v\cos\beta-u\cos\alpha)}$
13. 4.5 m, 2.75 m
15. 68.2°, 1.253 $ms^{-1}$
16. 28 $ms^{-1}$
17. $\frac{gt\cos\beta}{2\sin(\alpha-\beta)}$
21. $\tan\alpha=\frac{g(R_1-R_2)^2}{4v^2(R_1+R_2)}$

### Test Your Concepts-IV (Based on Projectile on an Inclined Plane)

1. (a) 2
   (b) 3
3. $\frac{2u^2\tan\theta\sec\theta}{g}$
4. $\sqrt{\frac{2gh}{2+\cot^2\theta}}$
5. $\sqrt{\frac{gR(1+3\sin^2\beta)}{2\sin\beta}}$
6. $\alpha+\beta=\frac{\pi}{2}$

### Single Correct Choice Type Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. D | 2. D | 3. D | 4. D | 5. D | 6. B | 7. A | 8. C | 9. A | 10. D |
| 11. A | 12. A | 13. C | 14. B | 15. C | 16. D | 17. B | 18. B | 19. A | 20. D |
| 21. C | 22. D | 23. D | 24. D | 25. D | 26. C | 27. A | 28. A | 29. D | 30. B |
| 31. C | 32. D | 33. B | 34. A | 35. D | 36. D | 37. B | 38. A | 39. D | 40. A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 41. B | 42. C | 43. C | 44. D | 45. C | 46. C | 47. B | 48. A | 49. C | 50. C |
| 51. D | 52. D | 53. C | 54. D | 55. B | 56. C | 57. B | 58. D | 59. B | 60. B |
| 61. A | 62. D | 63. C | 64. C | 65. D | 66. C | 67. B | 68. C | 69. D | 70. D |
| 71. B | 72. B | 73. C | 74. A | 75. D | 76. C | 77. D | 78. A | 79. C | 80. C |
| 81. A | 82. D | 83. D | 84. B | 85. C | 86. C | 87. B | 88. C | 89. A | 90. B |
| 91. C | 92. B | 93. B | 94. C | 95. A | 96. C | 97. B | 98. D | 99. D | 100. C |
| 101. C | 102. A | 103. D | 104. B | 105. D | 106. C | 107. B | 108. C | 109. C | 110. D |
| 111. B | 112. B | 113. A | 114. A | 115. D | 116. C | 117. B | 118. B | 119. B | 120. D |
| 121. C | 122. C | 123. B | 124. C | 125. D | 126. D | | | | |

## Multiple Correct Choice Type Questions

| | | | | |
|---|---|---|---|---|
| 1. B, C, D | 2. A, C | 3. C, D | 4. A, D | 5. A, D |
| 6. C, D | 7. A, B, C, D | 8. A, B, C | 9. A, D | 10. B, D |
| 11. A, B, D | 12. A, B, C, D | 13. B, C | 14. C, D | 15. A, B, C, D |
| 16. B, D | 17. A, B, C, D | 18. A, B, D | 19. B, C | 20. A, C, D |
| 21. A, B, C, D | 22. A, D | 23. B, C | 24. B, C | 25. A, B |
| 26. A, B | 27. B, C | | | |

## Reasoning Based Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. B | 2. D | 3. D | 4. D | 5. D | 6. A | 7. B | 8. D | 9. A | 10. A |
| 11. C | 12. A | 13. A | | | | | | | |

## Linked Comprehension Type Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. C | 2. B | 3. D | 4. A | 5. D | 6. C | 7. B | 8. B | 9. D | 10. A |
| 11. D | 12. B | 13. B | 14. B | 15. C | 16. C | 17. C | 18. C | 19. D | 20. D |
| 21. D | 22. D | 23. D | 24. B | 25. D | 26. B | | | | |

## Matrix Match/Column Match Type Questions

| | | | | |
|---|---|---|---|---|
| 1. A → (r) | B → (t) | C → (q) | D → (p) | E → (s) |
| 2. A → (r) | B → (s) | C → (p) | D → (q) | |
| 3. A → (r) | B → (s) | C → (p) | D → (q) | |
| 4. A → (q) | B → (s) | C → (p) | D → (r) | |
| 5. A → (q) | B → (r) | C → (s) | D → (t) | E → (p) |
| 6. A → (q, r) | B → (p, r) | C → (q, r, s) | D → (r) | |
| 7. A → (q) | B → (p) | C → (r) | D → (s) | |
| 8. A → (q) | B → (r) | C → (p) | D → (s) | |
| 9. A → (r) | B → (r) | C → (p) | D → (q) | |
| 10. A → (p, r) | B → (q, s) | C → (p, q, r, s) | D → (p, q, r, s) | |
| 11. A → (q) | B → (r) | C → (s) | D → (p) | |

## Integer/Numerical Answer Type Questions

| | | | | |
|---|---|---|---|---|
| **1.** 30 | **2.** 2 | **3.** 4 | **4.** 2 | **5.** 8 |
| **6.** 50 | **7.** 208 | **8.** 100 | **9.** Min. 25 & Max. 35 | **10.** 6, 6 |
| **11.** 3 | **12.** 30 | **13.** 6 | **14.** 2 | **15.** 60 |
| **16.** 8 | **17.** 8 | **18.** 5 | **19.** 6 | **20.** 5 |
| **21.** 2 | **22.** 6 | **23.** 1 | | |

## ARCHIVE: JEE MAIN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** B | **2.** B | **3.** C | **4.** B | **5.** D | **6.** C | **7.** C | **8.** C | **9.** B | **10.** D |
| **11.** D | **12.** A | | | | | | | | |

## ARCHIVE: JEE ADVANCED

### Integer/Numerical Answer Type Questions

| | | |
|---|---|---|
| **1.** 4.00 | **2.** 30 | **3.** 5 |