The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q. 1 **Assertion :** If there were no gravitational force, the path of projectile is always a straight line.

Reason : Gravitational force makes the path of a projectile always parabolic. **[C]**

Q. 2 **Assertion :** The maximum possible height attained by a projectile is $\frac{u^2}{2g}$ if u is projection speed.

Reason : To attain the maximum possible height, body is thrown an angle 45º

[C]

Q. 3 **Assertion:** The range of a projectile thrown on earth with a speed much smaller than escape speed does not depends on mass of earth.

Reason : The time of flight of projectile depends on mass of earth.

Sol. **[D]**

R = $\frac{u^2 \sin 2\theta}{g}$ and $g = \frac{GM_e}{R_e^2}$

Q.4 **Assertion :** Vertical component of velocity of a particle in two dimensional projectile motion at maximum height is equal to zero.

Reason : Horizontal component of velocity remains constant. **[B]**

Q.5 **Assertion :** The maximum possible height attained by a projectile is $\frac{u^2}{2g}$, if u is projection speed.

Reason : To attain maximum possible height, body is thrown on angle 45°. **[C]**

Q.6 **Statement I :** Two balls of different masses are thrown vertically up with same speed. They will pass through their point of projection in downward direction with the same speed.

Statement II : The maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.

Sol. **[A]** Final velocity and maximum height does not depend on mass of body.

Q.7 **Statement I :** For angle of projection $\tan^{-1}(4)$, the horizontal range and maximum height are equal.

Statement II : The maximum range of projectile is directly proportional to square of velocity and inversely proportional to acceleration of gravity. **[B]**

Q.8 **Assertion :** Path of projectile as viewed from other projectile is always straight line as long as both are they are not hitting ground.

Reason : Relative velocity of projectile w.r.t. other projectile is always constant. **[A]**

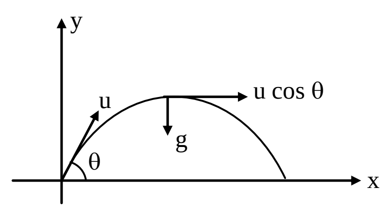
Sol. Both A & R are true & R is correct explanation.

Relative acceleration of projectile w.r.t. to other is zero.

Q.9 **Assertion :** In projectile motion a particle is projected at some angle from horizontal. At heighest point of its path radius of curvature is least.

Reason : At highest point of path normal acceleration of projectile is equal to acceleration due to gravity. **[A]**

Sol.



Normal acceleration : $a_n = \frac{v^2}{r}$

$$r = \frac{v^2}{a_n} = \frac{(u\cos\theta)^2}{g}$$

Q.10 **Assertion :** Two objects of different masses are thrown with same speed and same angle of projection and from same point in the same direction. The time taken by the particle to reach the ground is same. Neglect the air resistance.
Reason : Horizontal range of the bodies are different. **[C]**

Q.11 **Assertion :** Horizontal component of velocity of a projectile is constant throughout the motion.
Reason : There is no force in the horizontal direction. **[A]**

Q.12 **Assertion :** A stone of mass m kg is dropped vertically down from the window of a train which is at rest and then the same stone is dropped from the window of the train accelerating with a ms^{-2}. The net force in air acting on the stone is mg downward in both cases.
Reason : Vertical and horizontal motions are independent of each other in two dimensional projectile motion. **[B]**

Q.13 **Assertion (A) :** In case of projectile motion, the magnitude of rate of change of velocity is variable.
Reason (R) : In projectile motion, magnitude of velocity first decreases and then increases during the motion.

Sol. **[D]** Conceptual

Q. 14 A particle is projected with a velocity v, so that its range on a horizontal plane is twice the greatest height attained. If g is acceleration due to gravity, then its range is –

(A) $\frac{4v^2}{5g}$ (B) $\frac{4g}{5v^2}$

(C) $\frac{4v^2}{5g^2}$ (D) $\frac{4v}{5g^2}$

Sol. **[A]** $\because$ R = 2H

$$\therefore \frac{2u^2\sin\theta\cos\theta}{g} = 2 \cdot \frac{u^2\sin^2\theta}{2g} \Rightarrow \tan\theta = 2$$

$$\Rightarrow R = \frac{2u^2(\sin\theta)(\cos\theta)}{g} = \frac{2u^2\left(\frac{2}{\sqrt{5}}\right)\left(\frac{1}{\sqrt{5}}\right)}{g} = \frac{4u^2}{5g}$$

Q. 15 A ball is projected from the ground at angle θ with the horizontal. After 1 second it is moving at angle 45° with the horizontal and after 2 second it is moving horizontally. What is the velocity of projection of the ball ?

(A) $10\sqrt{3}\ ms^{-1}$ (B) $20\sqrt{3}\ ms^{-1}$

(C) $10\sqrt{5}\ ms^{-1}$ (D) $20\sqrt{2}\ ms^{-1}$

Sol. **[C]** $\because \frac{u\sin\theta}{g} = 2 \Rightarrow u\sin\theta = 20$ ....(1)

$$\therefore \tan\alpha = \frac{u\sin\theta - gt}{u\cos\theta}$$

$\Rightarrow 1 = \frac{20 - g(1)}{4\cos\theta} \Rightarrow u\cos\theta = 10$ ....(2)

By solving them, $u = 10\sqrt{5}$ m/s

Q. 16 Ratio of minimum kinetic energies of two projectiles of same mass in 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

Sol. **[B]** $\frac{\frac{1}{2}mu_1^2}{\frac{1}{2}mu_1^2} = \frac{4}{1} \Rightarrow \frac{u_1^2}{u_2^2} = 4$ ....(1)

$$\because \frac{\mu_1}{\mu_2} = \frac{u_1^2\sin^2\theta_1}{u_1^2\sin^2\theta_2} = \frac{4}{1}$$

$\Rightarrow \sin\theta_2 = \sin\theta_1$

$\Rightarrow \theta_1 = \theta_2$ ....(2)

Thus, $\frac{R_1}{R_2} = \frac{u_1^2}{u_2^2} = \frac{4}{1}$

Q. 17 Two stones are projected with the same speed but making different angles with the horizontal. Their horizontal ranges are equal. The angle of projection of one is $\frac{\pi}{3}$ and the maximum height reached by it is 102 m, Then the maximum height reached by the other in metre is –

(A) 336 (B) 224

(C) 56 (D) 34

Sol. **[D]** $\because$ Both have equal range, thus angle of second projectile is $(90 - \theta)$.

$\therefore \quad \frac{H_1}{H_2} = \tan^2\theta \quad \Rightarrow \quad H_2 = \frac{H_1}{3} = 34m$

PHYSICS

Q.1 Two bodies are projectile from ground at angles 30º and 60º. 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.

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) $\frac{T_1H_1R_1}{T_2H_2R_2}$	(S) $\frac{1}{3\sqrt{3}}$

(A) → Q **(B)** → P **(C)** → R **(D)** → S

Q.2 A body is projected with speed $20\sqrt{2}$ m/s at an angle 45º with horizontal. After 1 sec. of it motion match the following columns. (g= 10m/s^2)

Column I	**Column II**
(A) Average velocity (in magnitude)	(P) $10\sqrt{5}$ m/s
(B) Change in velocity (in magnitude)	(Q) 25 m/s
(C) Instantaneous speed	(R) 10 m/s
(D) change in speed (nearly) (in magnitude)	(S) 6 m/s

Sol. **A → Q ; B → R ; C → P ; D → S**

$\vec{u} = 20\hat{i} + 20\hat{j}$, $\vec{a} = -10\hat{j}$ and t = 1 sec

$\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2 = 20\hat{i} + 15\hat{j}$

$\vec{v} = \vec{u} + \vec{a}t = 20\hat{i} + 10\hat{j}$

$\therefore |\vec{v}_{av}| = \left|\frac{\vec{S}}{t}\right| = \sqrt{(20)^2 + (15)^2} = 25$ m/s

$|\Delta\vec{v}| = |\vec{v} - \vec{u}| = 10$ m/s

$|\vec{v}_{inst}| = |\vec{v}| = \sqrt{(20)^2 + (10)^2} = 10\sqrt{5}$ m/s

$|\Delta v| = |v - u| = 20\sqrt{2} - 10\sqrt{5} = 6$ m/s

Q.3 The path of a projectile moving under gravity is given by $y = x - \frac{x^2}{80}$, where x and y are in meters, use g = 10m/s^2. For this projectile to match the following column.

Column-I	**Column-II**
(A) Angle of projection	(P) 20m
(B) Angle made by instantaneous velocity with horizontal after 4sec	(Q) 80 m
(C) Maximum height attained	(R) 45º
(D) Maximum horizontal distance moved	(S) $\tan^{-1}(1/2)$

Sol. **A → R ; B → R ; C → P ; D → Q**

$y = x - \frac{x^2}{80}$

as $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$\therefore \tan\theta = 1 \Rightarrow \theta = 45º$

and $\frac{1}{80} = \frac{g}{2u^2\cos^2\theta}$

$\therefore u = 20\sqrt{2}$ m/s

$\therefore \vec{V} = u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j} = 20\hat{i} - 20\hat{j}$

for Range put y = 0

Q.4 Two bodies are projected from ground at angles 30º and 60º with same speeds of projection. 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 times of flight.

Match the following :

Column I	**Column II**
(A) $\frac{R_1}{R_2}$	(P) $\frac{1}{3}$
(B) $\frac{H_1}{H_2}$	(Q) 1
(C) $\frac{T_1}{T_2}$	(R) $\sqrt{3}$
(D) $\frac{T_1H_1R_1}{T_2H_2R_2}$	(S) $\frac{1}{3\sqrt{3}}$

A → Q, B → P, C → R, D → S

Q.5 Trajectory of particle in a projectile motion is given as $y = x - \frac{x^2}{80}$. Here, x and y are in metres. For this projectile motion match the following with $g = 10\ m/s^2$.

Column-I	**Column-II**
(A) Angle of projection	(P) 20 m
(B) Angle of velocity with horizontal after 4s	(Q) 80 m
(C) Maximum height	(R) 45º
(D) Horizontal range	(S) $\tan^{-1}\left(\frac{1}{2}\right)$

Ans. **A → R ; B → R ; C → P ; D → Q**

Q.6 Trajectory of particle in a projectile motion is given as:

$y = x - \frac{x^2}{80}$. Here, x and y are in metres. For this projectile motion match the following with g = $10\ m/s^2$.

Column I	**Column II**
(A) Angle of projection	(P) 20 m
(B) Angle of velocity with Horizontal after 4s	(Q) 80 m
(C) Maximum height	(R) 45º
(D) Horizontal range	(S) $\tan^{-1}\left(\frac{1}{2}\right)$

Sol. (A) → (R); (B) → (R); (C) → (P); (D) → (Q)

Comparing with the standard equation of projectile,

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

we get, $\theta = 45º$ and $u = 20\sqrt{2}$ m/s

Time period of this projectile is 4s. Hence, after 4 s velocity vector will again make 45º with horizontal.

Q.7 Trajectory of particle in a projectile motion is given as : $y = x - \frac{x^2}{80}$. Here, x and y are in metres. For this projectile motion match the following with $g = 10\ m/s^2$

(A) Angle of projection	(P) 20 m
(B) Angle of velocity with horizontal after 4s	(Q) 80 m
(C) Maximum height	(R) 45º
(D) Horizontal range	(S) $\tan^{-1}\left(\frac{1}{2}\right)$

Ans. **A → R; B → R; C → P; D → Q**

Q.8 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 in to space	(S) $\vec{a}$ may be opposite velocity

Sol. **A → P,R ; B → Q, S ; C → P,Q,R,S; D → P,Q,R,S**

For a particle to move in circular path : $\vec{a} \perp \vec{v}$

For a particle to undergo projectile motion angle between $\vec{a}$ & $\vec{v}$ must be acute.

Q.9 Trajectory of particle in a projectile motion is given as $y = x - \frac{x^2}{80}$. Here, x and y are in metres. For this projectile motion match the following with $g = 10\ m/s^2$. x is in horizontal direction and y is in vertical direction.

Column-I	**Column-II**
(A) Angle of projection	(P) 20 m
(B) Angle of velocity with horizontal after 4s	(Q) 80 m
(C) Maximum height	(R) 45º
(D) Horizontal range	(S) $\tan^{-1}\left(\frac{1}{2}\right)$

Sol. **(A)** → R, **(B)** → R, **(C)** → P, **(D)** → Q

$$y = x - \frac{x^2}{80}$$

Comparing with trajectory equation.

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

$\Rightarrow \tan\theta = 1, \quad \theta = 45º$

$$\frac{2u^2\cos^2\theta}{g} = 8\theta$$

$u^2 = 800$ and $u = 20\sqrt{2}$

$$H = \frac{u^2\sin^2\theta}{2g} = 20\text{ m.}$$

$$R = \frac{u^2\sin^2\theta}{g} = 80\text{ m.}$$

Q.10 A body is projected with velocity v at an angle of projection θ. 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

(A) a → q, b → r, c → s, d → p

(B) a → p, b → r, c → q, d → s

(C) a → q, b → s, c → p, d → r

(D) a → s, b → q, c → r, d → p **[A]**

Sol. a → q, b → r, c → s, d → p

(a) Change in momentum is mgt in time t.

(b) Angle at highest point is 0°.

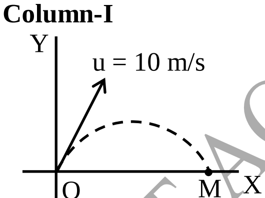
(c) Kinetic energy of body is minimum at highest point.

(d) Horizontal component remains unchanged.

Q.11 A projectile is fixed from point 'O' in horizontal surface and hits the surface at point 'M'. Column I contains different cases of projection and column II contains various parameters of projectile motion. Match then ($g = 10\ m/s^2$) -

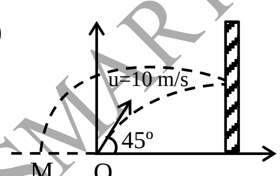
Column-I **Column-II**

(A)



(P) OM = 10 m

(B)



Collision between wall and projectile is elastic.

(Q) Max height reached by projectile = 5 m

(C) Equation of trajectory =

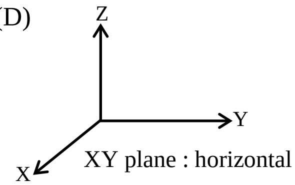
$$z = y - \frac{y^2}{10}$$

(Z axis : vertical
Y axis : horizontal)
where y and z are in metre

of projectile

(R) Time of flight $\sqrt{2}$ sec

(D)



$u = 2\sqrt{3}\,\hat{i} + 6\,\hat{j} + 5\sqrt{2}\,\hat{k}$

(S) Minimum speed of projectile during figh $= 5\sqrt{3}$ m/s

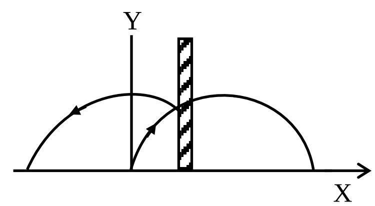
Sol. **A → P,Q,R,S; B → Q,R,S; C → P,Q,R,S; D → Q,R**

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$T = \frac{2u \sin\theta}{g}$$

$$H = \frac{u^2 \sin^2\theta}{2g}$$

B → After collision with wall, return path will be mirror image of actual path beyond wall



Q.12 A projectile of mass m is projected at angle '**θ**' with the horizontal with an initial velocity u from point 'O'. (Neglect air resistance)

Column-I	**Column-II**
(A) K.E. of particle	(P) Increases
(B) Angular momentum about '**O**'	(Q) Decreases
(C) Torque of mg about O	(R) First increases then decreases
(D) Radius of curvature of trajectory of particle	(S) First decreases then increases

Sol. **A → S ; B → P ; C → P ; D → S**

$$K = \frac{1}{2}mv^2 = \frac{1}{2}m(v_x^2 + v_y^2)$$

$|v_y|$ decrease from point of projection to highest point and then increases.

$\tau = |\vec{x} \times \overrightarrow{mg}| = mg.x$

x : horizontal distance travelled by projectile.

Q.13 Two bodies are projected from ground with same speed at angles 30º and 60º. 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.

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) $\frac{T_1H_1R_1}{T_2H_2R_2}$	(S) $\frac{1}{3\sqrt{3}}$

Sol. **A→ Q ; B → P; C → R; D → S**

As angle of projection are complimentary ranges are equal.

$T_1 = \frac{2u\sin 30^\circ}{g}$, $T_2 = \frac{2u\sin 30^\circ}{g}$

$H_1 = \frac{u^2\sin^2 30^\circ}{2g}$, $H_2 = \frac{u^2\sin^2 60^\circ}{2g}$

Q.14 For a particle moving in x-y plane match the following.

Column-I	**Column-II**
(A) Equation of trajectory	(P) r = f(t)
(B) Slope of path of particle	(Q) $\frac{v_y}{v_x}$
(C) Equation of motion	(R) $\vec{v}_x + \vec{v}_y + \vec{v}_z$
(D) Slope of $\vec{r}$ - t curve	(S) y = g(x)
	(T) $\frac{dy}{dx}$

Sol. A → S ; B → Q, T ; C → P ; D → R

Q. 1 A body is thrown from a point with speed 50 m/s and an angle 37º with horizontal in time t it has moved a horizontal distance of 80 m, then its distance from point of projection is d, then – ($g = 10\ m/s^2$)

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

(C) t = 2 sec (D) t = 2.67 sec **[A,B]**

Sol. $y = 80 \times \frac{3}{4} - \frac{10\times80\times80\times25}{2\times50\times50\times16} = 40$ m

$\therefore$ Required distance $= \sqrt{(80)^2+(40)^2}$

$= 40\sqrt{5}$ m

Q. 2 A projectile is thrown from point P on horizontal ground at angle θ with horizontal then-

(A) the projectile moves always away from point P for any value of θ

(B) the projectile moves always away from point P for some values of θ

(C) for some value of θ projectile first moves away from point P then comes closer to point P for some time interval

(D) projectile moves away from point or move closer to point P for some interval of time depends on the speed of projection

[A,C,D]

Q. 3 A projectile is projected with a speed of 40m/s at an angle θ with horizontal such that $\tan\theta = \frac{3}{4}$. After 2 sec, the projectile is moving with speed v at an angle α with horizontal then, ($g = 10\ m/s^2$)

(A) $\tan\alpha = \frac{1}{8}$ (B) $\cot\alpha = \frac{1}{8}$

(C) v = 32.25 m/s (D) 32 m/s

Sol. **[A,C]**

$$\tan\alpha = \frac{u\sin\theta - gt}{u\cos\theta} = \frac{40\times\frac{3}{5}-10\times2}{40\times\frac{4}{5}} = \frac{1}{8}$$

and $v\cos\alpha = u\cos\theta$

$\therefore\ v \times \frac{8}{\sqrt{65}} = 40 \times \frac{4}{5} = 32.25$ m/s

Q.4 A projectile is thrown from point P on horizontal ground at angle θ with horizontal then -

(A) the projectile moves always from point P for any values of θ

(B) the projectile moves always from point P for some values of θ

(C) for some value of θ projectile first moves always from point P then comes closer to point P for some time interval

(D) none of these

Sol. **[B,C]**

Conceptual

Q.5 Two particles A and B start simultaneously from the same point and move in a horizontal plane. A has an initial velocity u_1 due east and acceleration a_1 due north. B has an initial velocity u_2 due north and acceleration a_2 due east. Then –

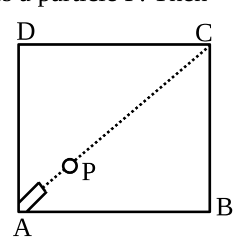
(A) They must collide at some point

(B) They will collide only if $a_1u_1 = a_2u_2$

(C) Their paths must intersect at same point

(D) If $u_1 > u_2$ & $a_1 < a_2$, the particles will have the same speed at some point **[B,C,D]**

Q.6 A large rectangular box falls vertically with acceleration a. A toy gun fixed at A and aimed at C fires a particle P. Then –



(A) P will hit C if a = g

(B) P will hit the roof DC if a > g

(C) P will hit wall BC if a < g

(D) either of A, B & C depending on speed of P.

[A,B,C]

Q.7 A man who can swim at a speed v relative to the water wants to cross a river of width d flowing with a speed u. The point opposite him across the river is A.

(A) He can reach the point A in time d/v

(B) He can reach the point A is time $\frac{d}{\sqrt{v^2 - u^2}}$

(C) The minimum time in which he can cross river is $\frac{d}{v}$

(D) He can not reach A if u > v **[B,C,D]**

Q.8 A train carriage move along the x-axis with a uniform acceleration $\vec{a}$. An observer A in the train sets a ball in motion on the frictionless floor of the carriage with the velocity $\vec{u}$ relative to the carriage. The direction $\vec{u}$ of makes an angle θ with the x-axis. Let B be an observer standing on the ground outside train. The path of ball will be-

(A) A straight line with respect to observer A

(B) A straight line with respect to observer B

(C) A parabola with respect to observer A

(D) A parabola with respect to observer B

[A,D]

Q.9 If two vector are in motion with velocities $\vec{v}_1$ and $\vec{v}_2$ then resultant velocity $\vec{v}_0$ can be–

(A) $|\vec{v}_0| = \sqrt{v_1^2 + v_2^2}$

(B) $|\vec{v}_0| = |v_1 \pm v_2|$

(C) $|\vec{v}_0| = 0$

(D) $v_0 > c$, speed of light **[A,B,C]**

Q.10 Two particles are projected from the same point with the same speed, at different angles θ_1 and θ_2 to the horizontal. Their times of flight are t_1 and t_2 and they have the same horizontal range. Then–

(A) $\frac{t_1}{t_2} = \tan\theta_1$ (B) $\frac{t_1}{t_2} = \tan\theta_2$

(C) $\frac{t_1}{\sin\theta_1} = \frac{t_2}{\sin\theta_2}$ (D) $\theta_1 + \theta_2 = 90^o$

[A,C,D]

Q.11 A cart moves with a constant speed along a horizontal circular path. From the cart a particle is thrown up vertically with respect to earth. Then –

(A) the particle will follow the elliptical path

(B) the particle will follow a parabolic path

(C) the particle will land somewhere on the circular path

(D) the particle will land outside the circular path **[B,D]**

Q.12 An aero plane flies along straight line from A to B with speed v and back again with the same speed. There is a steady wind speed w. The distance between A and B is d. Total time for the round trip –

(A) is $\frac{2vd}{v^2 - w^2}$ if the wind blows along the line AB.

(B) is $\frac{2d}{\sqrt{v^2 - w^2}}$ if the wind blows perpendicular to the line AB.

(C) is always increased by the presence of wind.

(D) depend on the direction of wind.

[All]

Q.13 The coordinates of a particle moving in a plane are given by x(t) = a cos (pt) and y(t) = 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

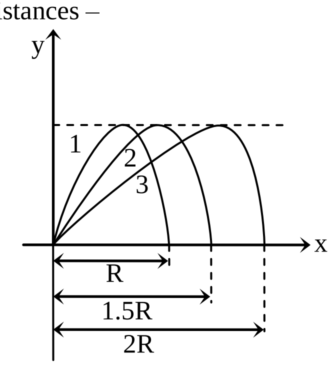
(B) the velocity and acceleration of the particle are normal to each other at t = π/(2p)

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

(D) the distance travelled by the particle in time interval t = 0 to t = π/(2p) is a. **[IIT - 1999]**

[A,B]

Q.14 Path of three projectiles are shown. If T_1, T_2 and T_3 are time of flights and ignoring air resistances –



(A) $T_1 > T_3$ (B) $T_1 < T_3$

(C) $T_2 = \frac{T_1 + T_3}{2}$ (D) $T_1 = T_2 = T_3$ **[C,D]**

Sol. As maximum heights are same therefore their time of flights will be same.

Q.15 Two particles are projected from the same point with the same speed, at different angles θ_1 and θ_2 to the horizontal. They have the same horizontal range. Their times of flight are t_1 and t_2 respectively.

(A) $\theta_1 + \theta_2 = 90^o$ (B) $\frac{t_1}{t_2} = \tan\theta_1$

(C) $\frac{t_1}{t_2} = \tan\theta_2$ (D) $\frac{t_1}{\sin\theta_1} = \frac{t_2}{\sin\theta_2}$

[A,B,D]

Q.16 A man on a moving cart, facing in the direction of motion, throws a ball straight up with respect to himself -

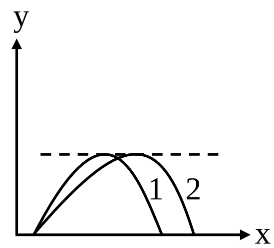
(A) The ball will always return to him

(B) The ball will never return to him

(C) The ball will return to him if the cart moves with a constant velocity

(D) The ball will fall behind him if the cart moves with some acceleration **[C,D]**

Q. 17 Trajectories of two projectiles are shown in figure. Let T_1 and T_2 be the the time periods and u_1 and u_2 their speeds of projection. Then –



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

(C) $u_1 > u_2$ (D) $u_1 < u_2$ **[B, D]**

Q. 18 In a projectile motion let v_x and v_y are the horizontal and vertical components of velocity at any time t and x and y are displacements along horizontal and vertical from the point of projection at any time t. Then -

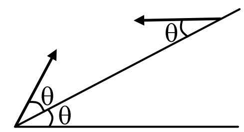
(A) v_y–t graph is a straight line with negative slope and positive intercept

(B) x-t graph is a straight line passing through origin

(C) y-t graph is a straight line passing through origin

(D) v_x-t graph is a straight line **[A, B, D]**

Q. 19 From an inclined plane two particles are projected with same speed at same angle θ, 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) The particles will collide in mid air if projected simultaneously and time of flight of each particle is less than the time of collision **[B, D]**

Q. 20 Two particles are projected from the same point with the same speed, at different angles θ_1 and θ_2 to the horizontal. Their times of flight are t_1 and t_2 and they have the same horizontal range. Then–

(A) $\frac{t_1}{t_2} = \tan\theta_1$ (B) $\frac{t_1}{t_2} = \tan\theta_2$

(C) $\frac{t_1}{\sin\theta_1} = \frac{t_2}{\sin\theta_2}$ (D) $\theta_1 + \theta_2 = 90^o$

[A,C,D]

Sol. For same range, θ_1 and θ_2.

$\theta_2 = (90 - \theta_1) \Rightarrow \theta_1 + \theta_2 = 90^o$

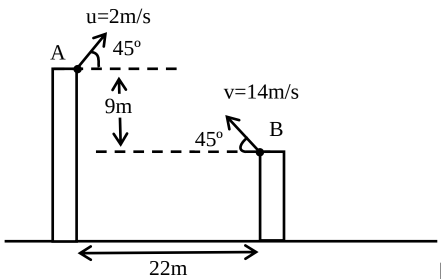
$t_1 = \frac{2u\sin\theta_1}{g}$ and $t_2 = \frac{2u\sin\theta_2}{g}$

$\therefore \frac{t_1}{\sin\theta_1} = \frac{t_2}{\sin\theta_2}$ and $\frac{t_1}{t_2} = \frac{\sin\theta_1}{\sin\theta_2}$

$$\Rightarrow \frac{t_1}{t_2} = \frac{\sin\theta_1}{\sin(90-\theta_1)}$$

$$\frac{t_1}{t_2} = \tan\theta_1$$

Q. 1 Two particles are simultaneously thrown from top of two towers as shown. Their velocities are 2m/s and 14m/s. Horizontal and vertical separation between these particles are 22m and 9m respectively. Then the minimum separation between the particles in process of their motion in meters is.



[0006]

Sol. $v_x = 8\sqrt{2}$ m/s = relative velocity along x-axis

$\therefore \quad x = (22 - 8\sqrt{2}\,t)$

$v_y = 6\sqrt{2}$ m/s = relative velocity along y-axis

$\therefore \quad y = (9 - 6\sqrt{2}\,t)$

$\therefore \quad r = \sqrt{x^2 + y^2}$

For minimum r,

$$\frac{dr}{dt} = 0 \Rightarrow t = \frac{23}{10\sqrt{2}} \text{ s and } r_{min} = 6.00 \text{ m}$$

Q.2 The minimum speed in m/s with which a projectile must be thrown from origin at ground so that it is able to pass through a point P (30 m, 40 m) is : ($g = 10$ m/s^2) **[0030]**

Sol. As $y = x \tan\theta - \frac{gx^2}{2u^2}(1 + \tan^2\theta)$

for (a, b), $ga^2 \tan^2\theta - 2au^2 \tan\theta + (ga^2 + 2bu^2) = 0$

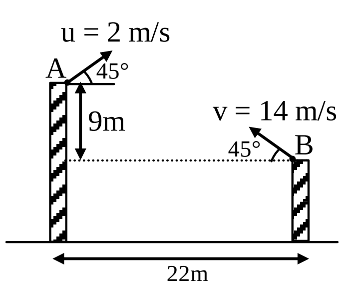
as discriminant must be positive

$$4a^2u^2 - 4ga^2(ga^2 + 2bu^2) \geq 0$$

Solving,

$$u \geq \sqrt{bg + g(a^2 + b^2)^{1/2}}$$

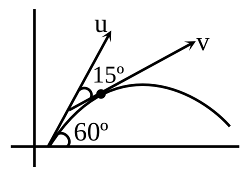
Q.3 Two particles are simultaneously thrown from top of two towers as shown. Their velocities are 2 m/s and 14 m/s. Horizontal and vertical separation between these particles are 22 m and 9 m respectively. Then the minimum separation between the particles in process of their motion in meters is ($g = 10$ m/s^2)



Q.4 A projectile is fixed at an angle 60º with horizontal. Ratio of initial K.E. to K.E when velocity vector of projectile makes an angle 15º with velocity of projection is -

Sol. **[2]**

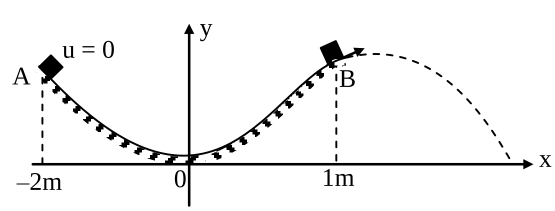
$$v = \frac{u\cos 60^\circ}{\cos 45^\circ}$$



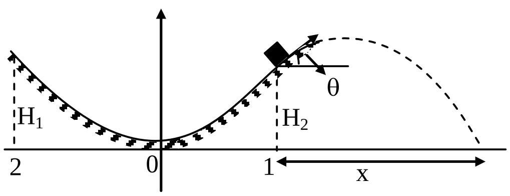
$$\therefore K_f = K_i \frac{\cos^2 60^\circ}{\cos^2 45^\circ}$$

$$\therefore \frac{K_i}{K_f} = 2$$

Q.5 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 $g = 10$ m/s^2 then total horizontal distance in meters travelled by body before it hits ground is. **[0008]**



Sol.



$H_1 = (2)^2 = 4m$

$H_2 = (1)^2 = 1$ m

$\therefore \quad v = \sqrt{2\times g\times(H_2 - H_1)}$

$v = \sqrt{20\times 3}$

$v = \sqrt{60}$

Now $\tan\theta = \left.\frac{dy}{dx}\right|_{x=1} = 2x|_{x=1} = 2$

$-H_2 = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

Q.6 A particle is projected from the bottom of an inclined plane of inclination 30º. At what angle α (from the horizontal) should the particle be projected to get the maximum range on the inclined plane. **[0060]**

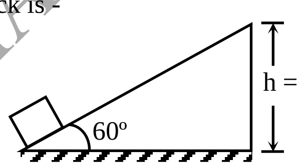
Q.7 A ball is thrown in air making some angle with horizontal. Considering buoyancy due to air which is equal to $\frac{1}{50}$ th weight of the ball, percentage change in range of ball is

Sol. **[2]**

$R \propto \frac{1}{g}$ $\therefore$ % change in R = – (% change in g)

= 2%

Q.8 A block is projected up on smooth inclined plane having angle of inclination 60º with speed $\sqrt{6gh}$. Maximum height (in meter) attained by block is -



Sol. **[5]**

At highest point velocity of block = $\sqrt{gh}$

$\frac{1}{2}m(\sqrt{6gh})^2 = \frac{1}{2}m(\sqrt{gh})^2 + mgh_{max}$

$\Rightarrow h_{max} = 2.5\ h = 5m$

Q.9 A particle is projected towards north with speed 20m/s at an angle 45º with horizontal. Ball get horizontal acceleration of 7.5 m/s^2 towards east due to wind. Range of ball (in meter) minus 42 m will be –

Sol. **[8]**

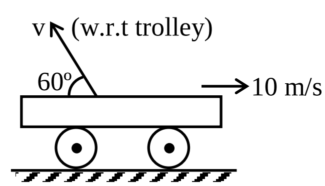
Time of flight : $T = \frac{2u\sin\theta}{g} = 2\sqrt{2}$ sec

Range (along north) = $\frac{u^2\sin 2\theta}{g}$ = 40 m

Range (along east) = $\frac{1}{2}aT^2$ = 30 m

$\therefore$ Range = $\sqrt{30^2 + 40^2}$ = 50 m

Q.10 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 10m is -



Sol. **[5]**

$10 - v\cos 60º = 0$

$\therefore H = \frac{v^2\sin^2 60º}{2g}$ = 15 m

Q.11 Two second after projection a projectile is travelling in a direction inclined at 30º with horizontal, after one more second it is travelling horizontally. Angle of projection (in degree) with horizontal divided by 10 is –

Sol. **[6]**

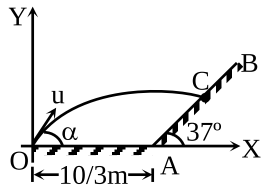
Let angle made by $\vec{V}$ initially and after time t be θ and α respectively.

$\tan 30º = \frac{u\sin\theta - g\times 2}{u\cos\theta}$ …(i)

$\tan 0^\circ = \dfrac{u\sin\theta - g\times 3}{u\cos\theta}$ …(ii)

$\therefore\ \theta = 60^\circ$

Q.12 A particle is projected from O on the ground with velocity u = $5\sqrt{5}$ m/s at angle $\alpha = \tan^{-1}$ (0.5). It strikes at a point C on a fixed plane AB having inclination of 37º with horizontal as shown, then the x-coordinate of point C in meters is (g = 10m/s^2)



Sol. **[5]**

$C(\frac{10}{3} + x, y)$

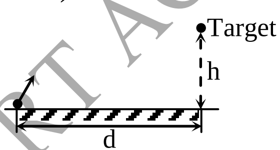
$\frac{y}{x} = \tan 37^\circ \Rightarrow y = \frac{3}{4}x$

$\Rightarrow u_y t - \frac{1}{2}gt^2 = \left[\frac{3}{4}u_x t - \frac{10}{3}\right]$

t = 1.06

so $x = \frac{3}{4} \times 10 \times 1.06 - \frac{10}{3} = 4.64$

Q.13 A particle is projected from ground with minimum speed required to hit a target at a height h = 10 m at a horizontal distance d = $\sqrt{300}$ m as shown. Then find the time taken by particle (in seconds) to hit the target. (g = 10 m/s^2)

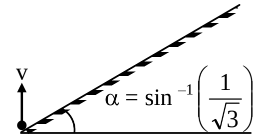


Sol. [2] $u_{min} = \sqrt{g(h+\sqrt{d^2+h^2})} = 10\sqrt{3}$ m/s

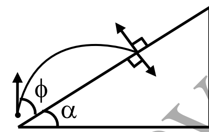
and $\tan\theta = \dfrac{h+\sqrt{d^2+h^2}}{d} \Rightarrow \theta = 60^\circ$

$\therefore\ t = \dfrac{d}{u\cos\theta} = \dfrac{10\sqrt{3}}{10\sqrt{3}\times\frac{1}{2}} = 2$

Q.14 A particle is projected with initial velocity v = $10\sqrt{2}$ m/s 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. (g = 10 m/s^2)



Sol. [6] $\tan\phi = \dfrac{\cot\beta}{2}$ $\therefore\ t = \dfrac{2v}{g\sqrt{1+3\sin^2\beta}}$



Q.15 A football is thrown with a velocity of 10 m/s at an angle of 30° above the horizontal. What will the time of flight be? (g = 10 m/s^2)

Sol. [1] $T = \dfrac{2u\sin\theta}{g} = \dfrac{2\times 10\times\frac{1}{2}}{10\,m/s} = 1s$

Q.16 The minimum speed divided by 10 in m/s with which a projectile must be thrown from origin at ground so that it is able to pass through a point P (30 m, 40 m) is :(g = 10 m/s^2)

Sol.[3] As $y = x\tan\theta - \dfrac{gx^2}{2u^2}(1+\tan^2\theta)$

for (a, b), $ga^2\tan^2\theta - 2au^2\tan\theta + (ga^2 + 2bu^2) = 0$

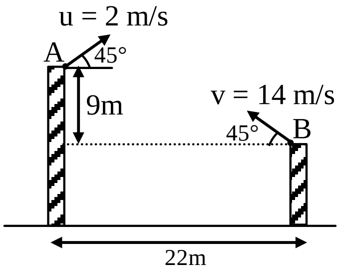
as discriminant must be positive

$4a^2u^2 - 4ga^2(ga^2 + 2bu^2) \geq 0$

Solving,

$u \geq \sqrt{bg + g(a^2+b^2)^{1/2}}$

Q.17 Two particles are simultaneously thrown from top of two towers as shown. Their velocities are 2 m/s and 14 m/s. Horizontal and vertical separation between these particles are 22 m and 9 m respectively. Then the minimum separation between the particles in process of their motion in meters is (g = 10 m/s^2)



Sol.[6] $v_x = 8\sqrt{2}$ m/s = relative velocity along x-axis

$\therefore \quad x = (22 - 8\sqrt{2}\,t)$

$v_y = 6\sqrt{2}$ m/s = relative velocity along y-axis

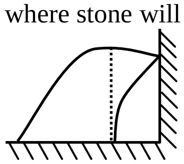
$\therefore \quad y = (9 - 6\sqrt{2}\,t)$

$\therefore \quad r = \sqrt{x^2 + y^2}$

For minimum r,

$\frac{dr}{dt} = 0 \Rightarrow t = \frac{23}{10\sqrt{2}}$ s and $r_{min} = 6.00$ m

Q.1 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) H/2 (B) H/4
(C) 3H/4 (D) None of these **[C]**

Sol. $H = \frac{1}{2} g (2t)^2 = 2gt^2$ ···· (1)

$h = H - \frac{1}{2} gt^2$ ···· (2)

By (1) and (2)

$h = H - \frac{H}{4} = \frac{3H}{4}$

Q.2 A ball is projected with velocity u at an angle α with horizontal plane. Its speed when it makes an angle β with the horizontal is -

(A) $u \cos \alpha$ (B) $\frac{u}{\cos\beta}$

(C) $u \cos \alpha \; \cos \beta$ (D) $\frac{u\cos\alpha}{\cos\beta}$ **[D]**

Sol. $V \cos \beta = u \cos \alpha$

$V = \frac{u\cos\alpha}{\cos\beta}$

Q. 3 The range of a projectile when launched at an angle 15º with the horizontal is 1.5 km. What will be the range of that projectile when launched with the same velocity at an angle 45º to the horizontal ?

(A) 0.75 km (B) 1.5 km
(C) 3.0 km (D) 6.0 km **[C]**

Sol. At $\theta = 15^o$,

$R = \frac{u^2 \sin 30^o}{g} = 1.5$ km

$\Rightarrow \frac{u^2}{g} = 3$ km

AT $\theta = 45^o$, $R' = \frac{u^2 \sin 90^o}{g} = \frac{u^2}{g} = 3$ km

Q. 4 A projectile is fired at an angle of 30º to the horizontal such that the vertical component of its initial velocity is 80 m/s. Its time of flight is T. Its velocity at t = T/4 has a magnitude of nearly :

(A) 200 m/s (B) 300 m/s
(C) 140 m/s (D) 100 m/s **[C]**

Sol. $\frac{u_x}{u_y} = \cot 30^o = \sqrt{3}$ $\therefore$ $u_x = 80\sqrt{3}$ m/s

$T = \frac{2u_y}{g}$ $\therefore$ T = 16 s

At $t = \frac{T}{4} = 4$s, $v_x = 80\sqrt{3}$ m/s

$v_y = 80 - 10 \times 4 = 40$ m/s

$\therefore$ $v = \sqrt{(80\sqrt{3})^2 + (40)^2} = 140$ m/s

Q.5 The range of projectile at an angle θ is equal to half of the maximum range if thrown at the same speed. The angle of projection θ is given by -

(A) 15º (B) 30º
(C) 60º (D) insufficient data **[A]**

Sol. $R_{max} = \frac{u^2}{g}$

$\frac{u^2 \sin_2 \theta}{g} = \frac{1}{2} \frac{u^2}{g}$

$\theta = 15^o$

Q.6 A projectile is thrown at angle β 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) $\sqrt{\frac{2H}{g\cos\beta}}$ **[B]**

Sol. $H = \frac{u^2 \cos^2 \beta}{2g} \Rightarrow u \cos \beta = \sqrt{2gH}$

$t = \frac{u\cos\beta}{g} = \sqrt{\frac{2H}{g}}$

Q.7 A stone thrown with the velocity $V_0 = 14$ m/s at an angle 45° to the horizontal, dropped to the ground at a distance 'S' from the point where it was thrown. From what height should the stone be thrown in horizontal direction with the same initial velocity so that it fall at the same spot -

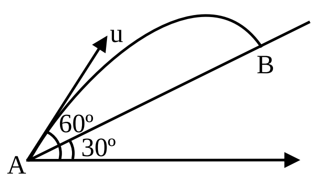
(A) 14.2 m (B) 16.9 m
(C) 10.0 m (D) 9.6 m **[C]**

Sol. $\frac{u^2 \sin 2\theta}{g} = u\sqrt{\frac{2h}{g}}$

$\frac{(14)^2 \sin 2(45)}{9.8} = 14\sqrt{\frac{2(h)}{9.8}}$

h = 10 m

Q.8 Time taken by the projectile to reach from A to B is t. Then the distance AB is equal to :



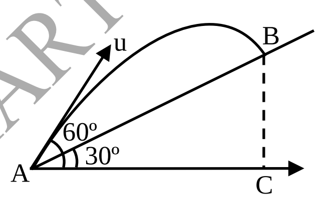
(A) $\frac{ut}{\sqrt{3}}$ (B) $\frac{\sqrt{3}ut}{2}$

(C) $\sqrt{3}$ ut (D) 2 ut **[A]**

Sol. Horizontal component of velocity

$u_H = u \cos 60^o = \frac{u}{2}$

$\therefore$ AC = $(u_H)t = \frac{ut}{2}$



and AB = AC sec 30° $= \left(\frac{ut}{2}\right) = \left(\frac{2}{\sqrt{3}}\right) = \frac{ut}{\sqrt{3}}$ **]**

Q. 9 A circular disc of radius r = 5m 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 m/s 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) None of these

[B]

Sol. [B] $R = u\sqrt{\frac{2h}{g}} = 12\sqrt{\frac{10}{10}} = 12$ m

$\therefore S = \sqrt{R^2 + r^2} = 13$ m

Q. 10 If T_1 and T_2 are the times of flight for two complementary angles, then the range of projectile R is given by -

(A) $R = 4g\, T_1T_2$ (B) $R = 2g\, T_1T_2$

(C) $R = \frac{1}{4} g\, T_1T_2$ (D) $R = \frac{1}{2} g\, T_1T_2$

[D]

Sol. For complimentary angles range is same

$T_1 = \frac{2u \sin\theta}{g}$ and $T_2 = \frac{2u \sin(90-\theta)}{g}$

$T_1 T_2 = \frac{4u^2 \sin\theta\cos\theta}{g^2}$

and $R = \frac{2u^2 \sin\theta\cos\theta}{g}$

$\frac{R}{T_1T_2} = \frac{g}{2} \Rightarrow R = \frac{1}{2} g\, T_1T_2$

Q.11 A person can throw a stone to a maximum distance of R meter. The greatest height to which he can throw the stone is -

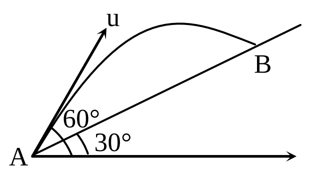
(A) R/2 (B) R
(C) 3R/2 (D) 2R **[A]**

Sol. $H_{max} = \frac{u^2}{2g}$ [θ = 90°]

but $\frac{u^2}{g} = R$

$\therefore H_{max} = \frac{R}{2}$

Q. 12 Time taken by the projectile to reach A to B is t. Then the distance AB is equal to –



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

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

Sol. **[A]**

Horizontal component of velocity

$u_H = u\cos 60° = \frac{u}{2}$

$\therefore$ AC = $(u_H)t = \frac{ut}{2}$

Q. 13 Two bullets are thrown simultaneously in the same vertical plane from same point with different speeds u_1 and u_2 at angles of projection θ_1 and θ_2 with horizontal such that $u_1\cos\theta_1 = u_2\cos\theta_2$ then the path followed by one as seen from other is a -

(A) vertical straight line

(B) horizontal straight line

(C) parabola

(D) any straight line

Sol. **[A]**

$\vec{V}_1 = u_1\cos\theta_1\,\hat{i} + (u_1\sin\theta_1 - gt)\,\hat{j}$

$\vec{V}_2 = u_2\cos\theta_2\,\hat{i} + (u_2\sin\theta_2 - gt)\,\hat{j}$

$\vec{V}_{rel.} = (u_1\cos\theta_1 - u_2\cos\theta_2)\,\hat{i} + (u_1\sin\theta_1 - u_2\sin\theta_2)\,\hat{j}$

as $u_1\cos\theta_1 = u_2\cos\theta_2$ given

$\vec{V}_{rel.} = (u_1\sin\theta_1 - u_2\sin\theta_2)\,\hat{j}$

Q.14 A stone is thrown form a cliff of height h in a given direction then the speed with which it hits ground -

(A) must depends on speed of projection

(B) must be larger than the speed of projection

(C) must be independent of angle of projection

(D) All of of above

Sol. **[D]**

$V = \sqrt{u^2 + 2gh}$

Q.15 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

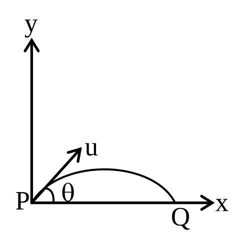
(C) $\frac{7\pi}{36}$ radians (D) $\frac{13\pi}{36}$ radians

Sol. **[D]**

For two angles of projection ranges are same.

i.e. for $\alpha + \beta = \frac{\pi}{2}$

Q.16 Average torque on a projectile of mass m, initial speed u and angle of projection θ between initial and final positions P and Q as shown in figure about the point of projection is –



(A) $\frac{mu^2\sin 2\theta}{2}$ (B) $mu^2\cos\theta$

(C) $mu^2\sin\theta$ (D) $\frac{mu^2\cos\theta}{2}$

Sol. **[A]**

$L_i = 0$, $L_f = m \times u\sin\theta \times R$

$\therefore \Delta L = L_f$

Now,

$$\tau_{av} = \frac{\Delta L}{\Delta t} = \frac{L_f}{T} = \frac{mu\sin\theta R}{\frac{2u\sin\theta}{g}} = \frac{mu^2\sin 2\theta}{2}$$

Q.17 A projectile thrown with initial velocity $(a\hat{i} + b\hat{j})$ and its range is twice the maximum height attained by it then -

(A) $b = \frac{a}{2}$

(B) b = a

(C) b = 2a

(D) b = 4a

Sol. **[C]**

$\tan\theta = \frac{b}{a} = \frac{4H}{R}$

Q.18 A body is thrown with speed of 30 m/s at angle 30º 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 sec. (B) 3 sec.

(C) 1.5 sec. (D) never

Sol. **[D]**

As θ < 45º body never moves perpendicular to its initial direction of motion.

Q.19 A body is thrown from a point with speed 50 m/s at an angle 37º 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

Sol. **[C]**

As $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$y = 80 \times \frac{3}{4} - \frac{10\times80\times80\times25}{2\times50\times50\times16} = 40$ m

∴ distance from point of projection

$= \sqrt{(80)^2 + (40)^2}$ m

Q.20 A hunter aims his gun and fires a bullet directly at a monkey on a tree. At the instant bullet leaves the gun, monkey drops, the bullet -

(A) hits the monkey

(B) misses to hit the monkey

(C) can not be said

(D) None of these **[A]**

Q.21 Two projectile thrown from the same point at angles 60° and 30° with the horizontal attain the same height. The ratio of their initial velocities is -

(A) 1 (B) 2

(C) $\sqrt{3}$ (D) $\frac{1}{\sqrt{3}}$ **[D]**

Sol. $\frac{u_1^2\sin^2\theta_1}{2g} = \frac{u_2^2\sin^2\theta_2}{2g}$

$u_1\sin\theta_1 = u_2\sin\theta_2$

$\frac{u_1}{u_2} = \frac{\sin 30°}{\sin 60°} = \frac{1}{\sqrt{3}}$

Q.22 Two stones are projected with the same speed but making different angles with the horizontal. Their ranges are equal. If the angle of projection of one is π/3 and its maximum height is y_1 then the maximum height of the other will be –

(A) $3y_1$ (B) $2y_1$

(C) $y_1/2$ (D) $y_1/3$ **[D]**

Sol. For same range θ and 90 – θ are angles of projection. 60º and 30º

$y_1 = \frac{u^2\sin^2 60}{2g}$ and $y_2 = \frac{u^2\sin^2 30}{2g}$

$\frac{y_2}{y_1} = \frac{1}{3} \Rightarrow y_2 = \frac{y_1}{3}$

Q.23 A body is projected horizontally with speed 20 m/s. What will be its speed nearly after 5 sec ?

(A) 54 m/s (B) 20 m/s

(C) 50 m/s (D) 70 m/s

Sol. **[A]**

$v_x = u = 20$ m/s

$v_y = u_y + gt = 0 + 10 \times 5 = 50$ m/s

$v = \sqrt{u_x^2 + u_y^2} = \sqrt{(20)^2 + (50)^2}$

Q.24 A particle projected with the speed u at an angle α with the horizontal acquires a velocity v when it is at an angle β with the horizontal. Then -

(A) $v = \frac{u}{\cos\beta}$ (B) $v = u\cos\beta$

(C) $v = \frac{u\cos\beta}{\cos\alpha}$ (D) $v = \frac{u\cos\alpha}{\cos\beta}$ **[D]**

Sol. $v\cos\beta = u\cos\alpha$

$$v = \frac{u\cos\alpha}{\cos\beta}$$

Q.25 The ceiling of a tunnel is of 5m high. What is the maximum horizontal distance that a ball thrown with a speed of 20 m/s, can go without hitting the ceiling of the tunnel ? (Take g = 10 m/s^2)

(A) 30 m (B) 40 m

(C) $30\sqrt{2}$ m (D) $20\sqrt{3}$ m **[D]**

Sol. $\because \quad \frac{u^2\sin^2\theta}{2g} = 5$ m

$\Rightarrow \quad \frac{(20)^2\sin^2\theta}{20} = 5$

$\Rightarrow \quad \sin\theta = \frac{1}{2} \quad \Rightarrow \quad \theta = 30^\circ$

$\therefore \quad R = \frac{u^2\sin 2\theta}{g} = \frac{(20)^2\sin 60^\circ}{10} = 20\sqrt{3}$

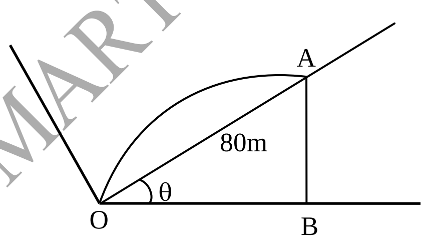
Q.26 A particle is projected up the inclined such that its component of velocity along the incline is 20 m/s. Time of flight is 4 sec. Horizontal displacement of the particle in 4 sec is 64 m. The angle made by the incline with the horizontal is –

(A) 30º (B) 37º

(C) 53º (D) Data is insufficient

[B]

Sol.



OA = 20 m/s × 4 s = 80 m

OB = 64 m

$\cos\theta = \frac{OB}{OA} = \frac{64}{80} = \frac{4}{5}$

$\theta = 37^\circ$

Q.27 During a projectile motion if the maximum height equals the horizontal range, then the angle of projection with the horizontal is:

(A) $\tan^{-1}(1)$ (B) $\tan^{-1}(2)$

(C) $\tan^{-1}(3)$ (D) $\tan^{-1}(4)$

Sol. **[D]** Given that

H = R

i.e. $\frac{u_y^2}{2g} = \frac{2.u_x u_y}{g}$

or $\frac{u_y}{u_x} = 4$ or $\tan\theta = 4$ or $\theta = \tan^{-1}(4)$

Q.28 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

Sol. **[B]** $\frac{\frac{1}{2}mu_1^2\cos^2\theta_1}{\frac{1}{2}mu_2^2\cos^2\theta_2} = \frac{4}{1}$

$\Rightarrow \frac{u_1\cos\theta_1}{u_2\cos\theta_2} = 2$ …(1)

and $\frac{u_1^2\sin^2\theta_1}{u_2^2\sin^2\theta_2} = \frac{4}{1}$

or $\frac{u_1\sin\theta_1}{u_2\sin\theta_2} = \frac{2}{1}$ …(2)

from equation no. (1) and (2)

$\frac{u_1\sin\theta_1.u_1\cos\theta_1}{u_2\sin\theta_2.u_2\cos\theta_2} = \frac{4}{1}$

$\frac{gR_1/2}{gR_2/2} = \frac{4}{1} \quad \Rightarrow \frac{R_1}{R_2} = \frac{4}{1}$

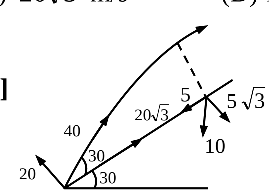
Q.29 A particle is projected from the bottom of an inclined plane & inclination 30° (with the horizontal) with speed 40 m/s at an angle 60° with the horizontal. The speed of the particle when its velocity vector is parallel to inclined plane is

($g = 10\ m/s^2$)

(A) $\frac{40}{\sqrt{3}}$ m/s (B) 20 m/s

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

Sol. **[A]**



$V_y = u_y + a_y t$ or $0 = 20 - 5\sqrt{3}\ t$ or $t = 4/\sqrt{3}$

$V_x = u_x + a_xt$ =

$20\sqrt{3} - 5\times\frac{4}{\sqrt{3}} = \frac{40}{\sqrt{3}}$ m/s

Q.30 A projectile is thrown with an initial velocity of $(v_x\hat{i} + v_y\hat{j})$ m s^{-1}. If the range of the projectile is double the maximum height, then v_y =

(A) v_x (B) $2v_x$

(C) $3v_x$ (D) $4v_x$ **[B]**

Sol. $\tan\theta = \frac{v_y}{v_x}$ …..(1)

R = 2 H

$\tan\theta = 2$ …...(2)

$\frac{v_y}{v_x} = 2 \Rightarrow v_y = 2v_x$

Q.31 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) $\sqrt{281}$ m/sec (B) $\sqrt{812}$ m/sec

(C) $\sqrt{182}$ m /sec (D) None of the above

[C]

Q.32 Two stones are projected with the same speed but making different angles with the horizontal. Their ranges are equal. If the angle of projection of one is $\pi/3$ and its maximum height is y_1 then the maximum height of the other will be –

(A) $3y_1$ (B) $2y_1$

(C) $y_1/2$ (D) $y_1/3$ **[D]**

Q.33 An object is thrown at an angle α 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 the above **[A]**

Q.34 A shell is fired from a cannon at a velocity of 300 m/s to hit a target 3km away. At what angle above the horizontal should the cannon be aimed –

(A) Nearly 9.5º (B) Nearly 19º

(C) Nearly(1/3)º (D) Nearly(1/6)º **[A]**

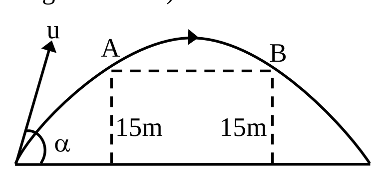
Q.35 A projectile is thrown with a velocity of 20 m/s, at an angle of 60º with the horizontal. After how much time the velocity vector will make an angle of 45º with the horizontal –

(take $g = 10 m/s^2$)

(A) $\sqrt{3}$ sec (B) $1/\sqrt{3}$ sec

(C) ($\sqrt{3}$ + 1) sec (D) ($\sqrt{3}$ – 1) sec **[D]**

Q.36 A golfer standing on level ground hits a ball with a velocity of u = 52 m/s at an angle α above the horizontal. If $\tan\alpha = 5/12$, then the time for which the ball is at least 15m above the ground (i.e. between A and B) will be (take $g = 10 m/s^2$) –



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

[B]

Q.37 Two balls are projected from the same point in direction inclined at 60º and 30º to the horizontal. If they attain the same maximum height, what is the ratio of their velocities of projection ?

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

(C) 1 : 1 (D) 1 : 2 **[A]**

Q.38 An aeroplane is flying horizontally with a velocity of 720 km/h at an altitude of 490 m.

When it is just vertically above the target a bomb is dropped from it. How far horizontally it missed the target ?

(A) 1000 m (B) 2000 m

(C) 100 m (D) 200 m **[B]**

Q.39 An aeroplane is moving with a horizontal velocity u at a height h above the ground, if a packet is dropped from it; the speed of the packet when it reaches the ground will be –

(A) $\sqrt{u^2+2gh}$ (B) $\sqrt{2gh}$

(C) $\sqrt{u^2-2gh}$ (D) 2gh **[A]**

Q.40 From the top of a tower of height h a body of mass m is projected in the horizontal direction with a velocity v, it falls on the ground at a distance x from the tower. If a body of mass 2m is projected from the top of another tower of height 2h in the horizontal direction so that it falls on the ground at a distance 2x from the tower, the horizontal velocity of the second body is -

(A) 2v (B) $\sqrt{2}$ V

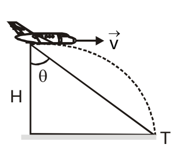
(C) $\frac{V}{2}$ (D) $\frac{V}{\sqrt{2}}$ **[B]**

Q.41 A stone is thrown from a bridge at an angle of 30º down with the horizontal with a velocity of 25 m/s if the stone strikes the water after 2.5 sec then calculate the height of the bridge from the water surface –

(A) 61.9 m (B) 35 m

(C) 70 m (D) None **[A]**

Q.42 A bomber is moving with a velocity v (m/s) above H meter from the ground. The bomber releases a bomb to hit a target T when the sighting angle is θ. Then the relation between θ, H and v is –

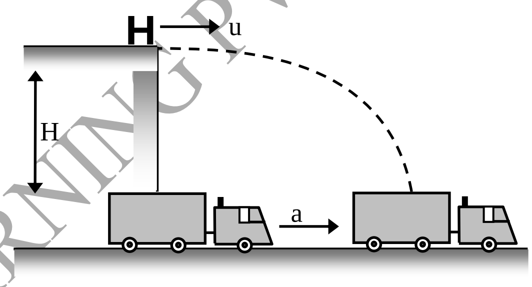


(A) $\theta = \tan^{-1} v\sqrt{2Hg}$ (B) $\theta = \tan^{-1} v\sqrt{2/gH}$

(C) $\theta = \tan^{-1} v\sqrt{H/2g}$ (D) None of the above

[B]

Q.43 A stunt performer is to run and dive off a tall platform and land in a net in the back of a truck below. Originally the truck is directly under the platform, it starts forward with a constant acceleration a at the same instant the performer leaves the platform. If the platform is H above the net in the truck, then the horizontal velocity u that the performer must have as he leaves the platform is –



(A) $a\sqrt{2H/g}$ (B) $a\sqrt{H/2g}$

(C) $\sqrt{g/2H}$ (D) None of these **[B]**

Q.44 A shell is fired from a gun from the bottom of a hill along its slope. The slope of the hill is α = 30º, and the angle of the barrel to the horizontal β = 60º. The initial velocity v of the shell is 21 m/sec. Then distance of point from the gun at which shell will fall –

(A) 10 m (B) 20 m

(C) 30 m (D) 40 m **[C]**

Q.45 An aircraft drives towards a stationary target which is at sea level and when it is at a height of 1390m above sea level it launches a missile towards the target. The initial velocity of the missile is 410 m/s in a direction making an angle θ below the horizontal where tanθ = 9/40. Then the time of flight of the missile from the instant it was launched until it reaches sea level is nearly –

(A) 10 sec (B) 15 sec

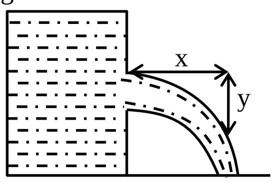
(C) 20 sec (D) 25 sec **[A]**

Q.46 A bomber is flying horizontally with a constant speed of 150 m/s at a height of 78.4m. The pilot has to drop a bomb at the enemy target. At what horizontal distance from the target should he release the bomb -

(A) Zero (B) 300 m

(C) 600 m (D) 750 m **[C]**

Q.47 A jet of water is issued horizontal from a small vertical opening of a tank. If a point on the centre line of the jet is at a horizontal distance x and at a depth 'y' below the centre of the opening, find the velocity of the jet through the opening ?



(A) $x\sqrt{\frac{g}{2y}}$ (B) 2gy (C) $\sqrt{\frac{xg}{2y}}$ (D) $\frac{xg}{\sqrt{2y}}$

[A]

Q.48 To an observer moving along East, the wind appears to blow from North. If he doubles his speed , the air would appear to come from -

(A) North (B) East

(C) North-East (D) North-West **[C]**

Q.49 A car A is going north-east at 80km/hr. and another car B is going south-east at 60km/hr. Then the direction of the velocity of A relative to B makes with the north an angle α such that $\tan\alpha$ is –

(A) 1/7 (B) 3/4

(C) 4/3 (D) 3/5 **[A]**

Q.50 A boat man could row his boat with a speed 10m/sec. He wants to take his boat from P to a point Q just opposite on the other bank of the river flowing at a speed 4m/sec. He should row his boat –

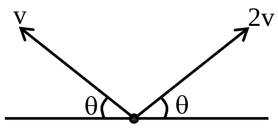
(A) at right angle to the stream

(B) at an angle of $\sin^{-1}$ (2/5) with PQ up the stream

(C) at an angle of $\sin^{-1}$ (2/5) with PQ down the stream

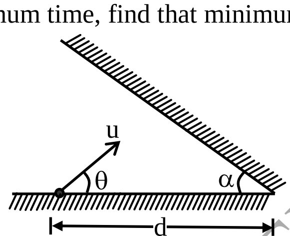
(D) at an angle $\cos^{-1}$ (2/5) with PQ down the stream **[B]**

Q.1 Two particles are projected from the same point with velocities v and 2v making equal angle $\theta = 30^\circ$ with the horizontal in opposite directions as shown in the figure. Find the separation between them when their velocity vectors become mutually perpendicular. The acceleration due to gravity is g.



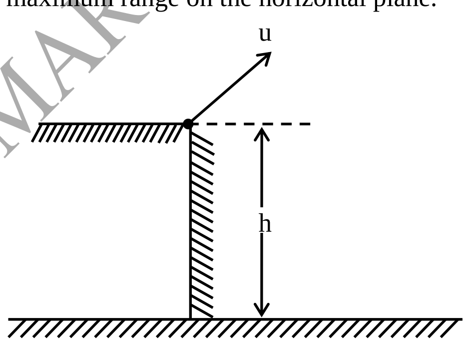
Ans. $d = \frac{(2\sqrt{7})v^2}{g}$

Q.2 A projectile is fired with velocity u at an angle θ so as to strike a point on the inclined plane inclined at an angle α with the horizontal. The point of projection is at a distance d from the inclined plane on the ground as shown in the figure. The angle θ is adjusted in such a way that the projecile can strike the inclined plane in minimum time, find that minimum time.



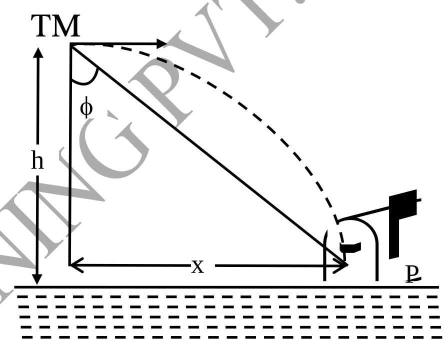
Ans. $t = \frac{u - \sqrt{u^2 - gd\sin 2\alpha}}{g\cos\alpha}$

Q.3 A particle is projected with an initial speed u from a point at height h above the horizontal plane as shown in the figure. Find the maximum range on the horizontal plane.



Ans. $R_{max} = \frac{u\sqrt{u^2 + 2gh}}{g}$

Q.4 A relief aeroplane is flying at a constant height of 1960 m with speed 600 km/hr above the ground towards a point directly over a person struggling in flood water (see figure). At what angle of sight, should the pilot release a survival kit if it is to reach the person in water. ($g = 9.8\ m/s^2$)



Ans. $\phi = \tan^{-1}1.7$

Q.5 If R is the horizontal range and h, the greatest height of a projectile, prove that its initial speed is $5\sqrt{\frac{(16h^2 + R^2)}{4h}}$ [$g = 10\ m/s^2$]

Q.6 Show that a given gun will shoot three time as high when elevated at an of angle 60º as when fired at an angle of 30º but will carry the same distance on a horizontal plane ?

Q.7 A bomb is dropped from a plane flying horizontally with uniform speed. Show that the bomb will explode vertically below the plane. Is the statement true if the plane flies with uniform speed but not horizontally ?

Q.8 A stone is thrown horizontally. In 0.5 second after the stone began to move, the numerical value of its velocity was 1.5 times its initial velocity. Find the initial velocity of stone.

Ans. 4.4 m/s

Q.9 A shell is fired from a point O at an angle of 60º with a speed of 40 m/s & it strikes a horizontal plane through O, at a point A. The gun is fired a second time with the same angle of elevation but a different speed v. If it hits the target which starts to rise vertically from A with a constant speed $9\sqrt{3}$ m/s at the same instant as the shell is fired, find v. (Take g = 10 m/s^2)

Ans. 50 m/s

Q.10 A cricket ball thrown from a height of 1.8 m at an angle of 30º with the horizontal at a speed of 18 m/s is caught by another field's man at a height of 0.6 m from the ground. How far were the two men apart ?

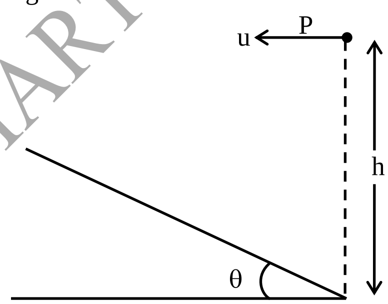
Ans. 30.55 m

Q.11 A batsman hits the ball at a height 4.0 ft from the ground at projection angle of 45° and the horizontal range is 350 ft. Ball falls on left boundary line, where a 24 ft height fence is situated at a distance of 320 ft. Will the ball clear the fence ?

Ans. 27.43 m

Q.12 **(a)** A particle is projected with a velocity of 29.4 m/s at an angle of 60º to the horizontal. Find the range on a plane inclined at 30º to the horizontal when projected from a point of the plane up the plane.

(b) Determine the velocity with which a stone must be projected horizontally from a point P, so that it may hit the inclined plane perpendicularly. The inclination of the plane with the horizontal is θ and P is h metre above the foot of the incline as shown in the figure.



Ans. **(a)** 58.8 m **(b)** $\sqrt{\dfrac{2gh}{2+\cot^2\theta}}$

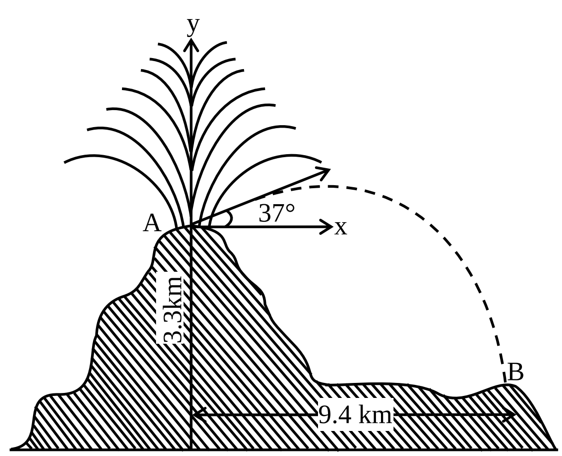
Q.13 A dive bomber, diving at an angle of 53º with the vertical, releases a bomb at an altitude of 2400 ft. The bomb hits the ground 5.0 s after being released. (a) What is the speed of the bomber ? (b) How far did the bomb travel horizontally during its flight? (c) What were the horizontal and vertical components of its velocity just before striking the ground ?

Ans. (a) v_0 = 667 ft/s (b) 2667 ft (c) v_x = 534 ft/s, v_y = 560 ft/s

Q.14 A boy throws a ball so as to clear a wall of height 'h' at a distance 'x' from him. Find minimum speed of the ball to clear the wall.

Ans. $\sqrt{g\left[h+\sqrt{h^2+x^2}\right]}$

Q.15 During the volcanic eruption chunks of solid rock are blasted out of the volcano.



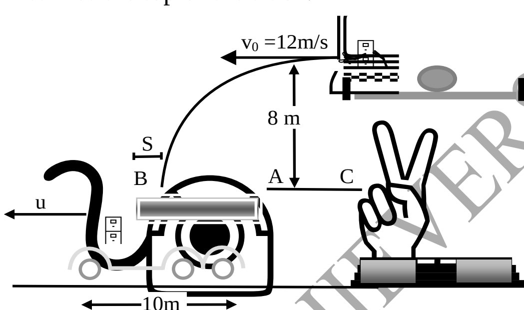
(a) At what initial speed would a volcanic object have to be ejected at 37º to the horizontal from the vent A in order to fall at B as shown in figure. (b) What is the time of flight. (g = 9.8 m/s^2)

Ans. (a) u = 255 m/s (b) 46 s.

Q.16 At a harbour enemy ship is at a distance $180\sqrt{3}$ m from the security cannon having a muzzle velocity of 60 m/s (a) To what angle must the cannon be elevated to hit the ship? (b) What is the time of flight ? (c) How far should the ship be moved away from its initial position so that it becomes beyond the range of the cannon ($g = 10$ m/s^2) ?

Ans. (a) $\theta = 30^\circ$ or 60°, (b) $t_1 = 6$ s, $t_2 = 10.4$ s , (c) 48.2 m

Q.17 A boy throws a ball horizontally with a speed of $v_0 = 12$ m/s from the Gandhi Setu bridge C of Patna in an effort to hit the top surface AB of a truck travelling directly underneath the boy on the bridge. If the truck maintains a constant speed $u = 15$ m/s, and the ball is projected at the instant B on the top of the truck appears at point C, determine the position s where the ball strikes the top of the truck.



Ans. 3.84 m

Q.18 A projectile is projected with an initial velocity of $(6\hat{i} + 8\hat{j})$ ms^{-1} then calculate its horizontal range, maximum height and time of flight.

Ans. 9.8 m, 3.3 m, 1.6s.

Q.19 An aeroplane is flying at a height of 1960 metre in a horizontal direction with a velocity of 100 m/s, when it is vertically above an object M on the ground it drops a bomb. If the bomb reaches the ground at the point N, then calculate the time taken by the bomb to reach the ground and also find the distance MN.

Ans. 20 s, 2000 m

Q.20 Two balls are projected from the same point in the direction inclined at 60º and 30º to horizontal. If they attain the same height what is the ratio of their velocities of projection ? What is the ratio if they have the same horizontal range ?

Ans. $1 : \sqrt{3}$, 1 : 1