Question1

Two bodies are projected from the same point with the same initial velocity ' u ' making angles ' θ' and $(90° - \theta)$ with the horizontal in opposite directions. The horizontal distance between their positions when the bodies are at their maximum heights is

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Options:

A.

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

B.
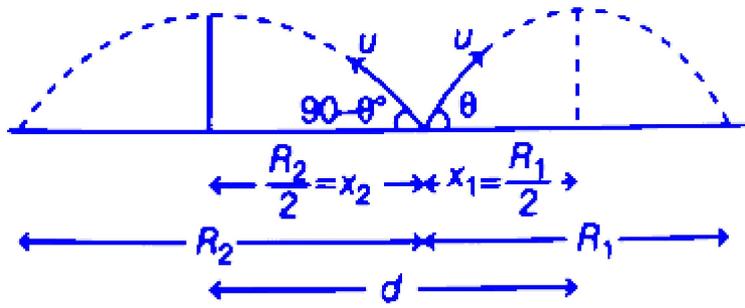
$\frac{u^2 \sin 2\theta}{2g}$

C.

$\frac{u^2}{g}$

D.

$\frac{u^2 \sin 2(90° - \theta)}{g}$

Answer: D

Solution:

The given situation is shown below in figure.

$x_1 = \frac{R_1}{2} = \frac{u^2 \sin 2\theta}{2g}$

and $x_2 = \frac{R_2}{2} = \frac{u^2 \sin 2(90^\circ - \theta)}{2g}$

$\therefore \quad = \frac{u^2 \sin(180^\circ - 2\theta)}{2g} = \frac{u^2 \sin 2\theta}{2g}$

$\therefore d = x_1 + x_2$

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

$= \frac{u^2 \sin(180^\circ - 2\theta)}{g} = \frac{u^2 \sin 2(90^\circ - \theta)}{g}$

Question2

A helicopter flying horizontally with a velocity of 288 km/h drops a bomb. If the line joining the point of dropping the bomb and the point where bomb hits the ground makes an angle 45° with the horizontal, then the height at which the bomb was dropped is (Acceleration due to gravity $= 10$ ms^{-2})

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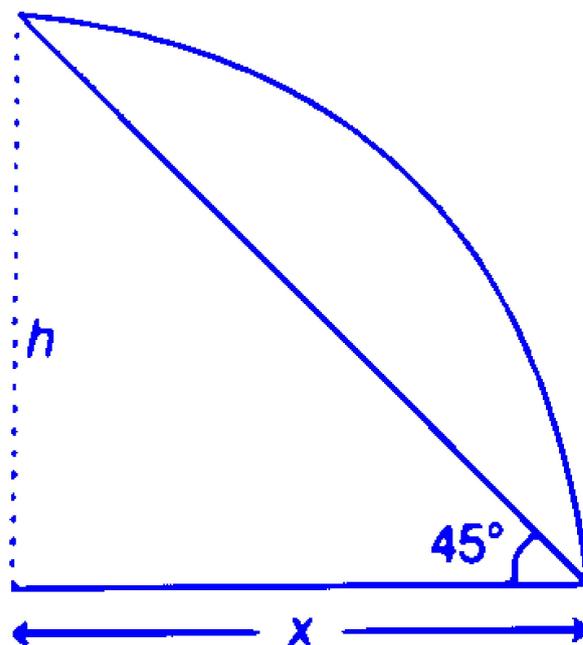**Options:**

A.

1320 m

B.

1280 m

C.

320 m

D.

640 m

Answer: B

Solution:

$u = 288 \text{ km/h}$
$\quad = 288 \times \dfrac{5}{18} = 80 \text{ m/s}$
$h = \dfrac{1}{2}gt^2$
$x = ut$

$\therefore \quad \tan 45° = \dfrac{h}{x}$

$\Rightarrow \quad h = x \Rightarrow \frac{1}{2}gt^2 = ut$

$\Rightarrow \quad t = \frac{2u}{g} = \frac{2 \times 80}{10} \Rightarrow t = 16 \text{ s}$

$\therefore$ Height of bomb, $h = \dfrac{1}{2}gt^2$

$= \dfrac{1}{2} \times 10 \times 16^2 = 1280 \text{ m}$

Question3

The maximum horizontal range of a ball projected from the ground is 32 m . If the ball is thrown with the same speed horizontally from the top of a tower of . height 25 m , the maximum horizontal distance covered by the ball is

(Acceleration due to gravity $= 10 \, \text{ms}^{-2}$)

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Options:

A. 40 m

B. 57 m

C. 60 m

D. 75 m

Answer: A

Solution:

The maximum horizontal range (R) of a projectile launched at an optimal angle $(45°)$ is given by,

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

Given, $R = 32$ m

Then $32 = \frac{u^2 \cdot \sin 2 \cdot 45°}{10}$

$u^2 = 320$

$u = 8\sqrt{5} \, \text{m/s}$

When the ball is thrown horizontally from the top of a tower of height 25 m , the vertical motion is given by,

$y = \frac{1}{2} g t^2$

Given, $y = 25$ m

Then, $25 = \frac{1}{2} \times 10 \times t^2$

$t = \sqrt{5} \, \text{s}$

The horizontal distance x covered by the ball is given by,

$x = ut$

From Eqs. (i) and (ii), we get

$x = 8\sqrt{5} \times \sqrt{5}$

$x = 8 \times 5$

$x = 40$ m

Question4

From a height of h above the ground, a ball is projected up at an angle $30°$ with the horizontal. If the ball strikes the ground with a speed of 1.25 times its initial speed of 40 ms^{-1}, the value of h is (acceleration due to gravity $= 10$ ms^{-2})
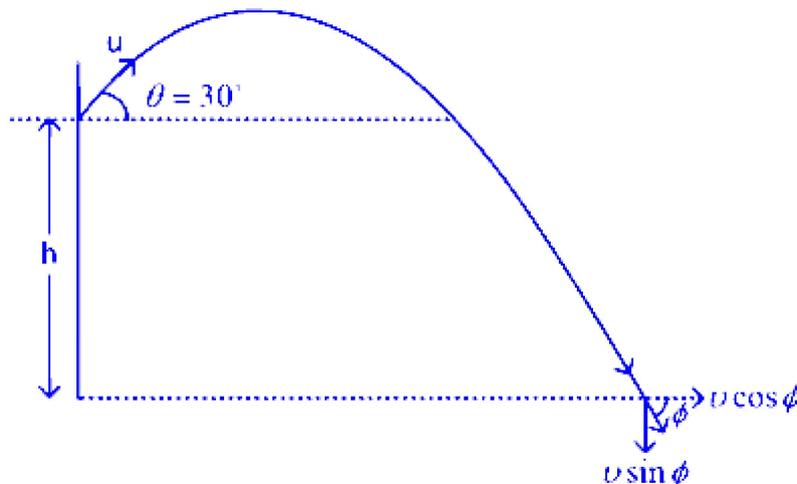
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Options:

A. 75 m

B. 60 m

C. 30 m

D. 45 m

Answer: D

Solution:

Initial speed, $u = 40$ m/s

Final speed, $v = 1.25 \times u$

$v = 50$ m/s

$\because$ Horizontal component is constant

$\Rightarrow \quad 40 \times \frac{\sqrt{3}}{2} = 50 \cos \phi$

$\Rightarrow \quad \cos \phi = \frac{4\sqrt{3}}{10}$

Vertical component

$v_y = v \sin \phi = v\sqrt{1 - \cos^2 \phi}$

$v_y = 50\sqrt{1 - \left(\frac{4\sqrt{3}}{10}\right)^2}$

$\quad = 5\sqrt{52}$

Now using 3rd equation of motion

$\Rightarrow \quad (5\sqrt{52})^2 - (40 \sin 30°)^2 = 2gh$

$\Rightarrow \quad h = \dfrac{1300 - 400}{2 \times 10} = 45$ m

$\quad h = 45$ m

Question5

A body is projected from the ground at an angle of $\tan^{-1}(\sqrt{7})$ with the horizontal. At half of the maximum height, the speed of the body is n times the speed of projection. The value of n is

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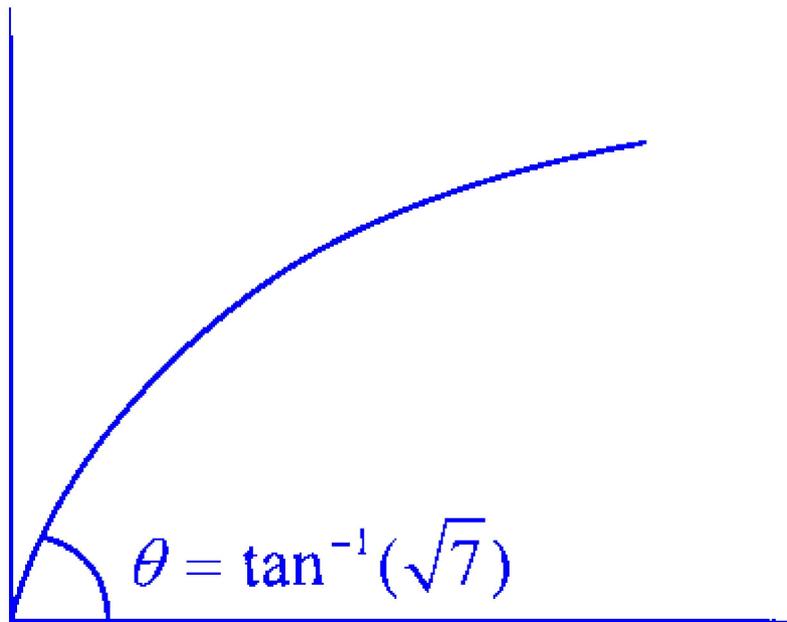
Options:

A. 2

B. $\frac{1}{2}$

C. $\frac{4}{3}$

D. $\frac{3}{4}$

Solution:

Given,

$\theta = \tan^{-1}(\sqrt{7})$

Maximum height

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

[Put $\theta = \tan^{-1}(\sqrt{7})$]

$H_{\max} = \frac{7}{8} \frac{u^2}{2g}$

$\frac{H_{\max}}{2} = \frac{7}{16} \frac{u^2}{2g}$

Using 3rd equation of motion for velocity at $\frac{H_{\max}}{2}$

$v^2 = u^2 - 2gh$

where $v = nu$ (given)

$$h = \frac{H_{\text{max}}}{2}$$

$$n^2 u^2 = u^2 - 2g\frac{H_{\text{max}}}{2}$$

$$\left(n^2 - 1\right)u^2 = -2g \times \frac{7}{16}\frac{u^2}{2g}$$

$$n^2 - 1 = \frac{-7}{16} \Rightarrow n^2 = \frac{-7}{16} + 1$$

$$n^2 = \frac{9}{16}$$

$$n = \frac{3}{4}$$

Question6

A cannon placed on a cliff at a height of 375 m fires a cannon ball with a velocity of 100 ms^{-1} at an angle of $30°$ above the horizontal. The horizontal distance between the cannon and the target is (Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A. $750\sqrt{3}$ m

B. $500\sqrt{3}$ m

C. $250\sqrt{3}$ m

D. 750 m

Answer: A

Solution:

Given, initial height, $y_i = 375$ m

Final height, $y_f = 0$ m

Initial velocity, $v_i = 100$ m/s

Initial horizontal range, $x_i = 0$

Angle of projection, $\theta = 30°$

Now, $y_f = y_i + v_i t - \frac{1}{2}gt^2$

$y_f = y_i + v_i g \sin\theta t - \frac{1}{2}gt^2$

$0 = 375 + (100 \times \sin 30°)t - \frac{1}{2} \times 9.8t^2$

$0 = 375 + 50t - 4.9t^2$

$\Rightarrow 4.9t^2 - 50t - 375 = 0$

On solving, we get

$t_1 = 15.22$ s and $t_2 = -5.02$ s

Now time cannot be negative hence,

$t = 15.22$ s

Thus horizontal rang, $R = v_t \cos\theta t$

$= 100 \times \cos 30° \times 15.22$

$= 100 \times \frac{\sqrt{3}}{2} \times 15.22$

$= 761\sqrt{3}$ m $\approx 750\sqrt{3}$

Question7

A body P is projected at an angle of $30°$ with the horizontal and another body Q is projected at an angle of $30°$ with the vertical. If the ratio of the horizontal ranges of the bodies P and Q is $1 : 2$, then the ratio of the maximum heights reached by the bodies P and Q is

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Options:

A. $1 : 4$

B. $1 : 6$

C. $2 : 3$

D. 1 : 1

Answer: B

Solution:

Given, $\theta_p = 30°$ (Horizontal)

$\theta_Q = 30°$ (Vertical)

$\quad = 90° - 30° = 60°$

thus, $\quad \theta_Q = 60°$ (Horizontal)

Maximum range reached,

$$R = \frac{v_0^2 \sin 2\theta}{g}$$

For body P,

$$R_p = \frac{v_1^2 \sin 60°}{g} \quad \dots \text{ (i)}$$

For body Q

$$R_Q = \frac{v_2^2 \sin 120°}{g} \quad \dots \text{ (ii)}$$

The ratio of $\frac{R_P}{R_Q} = \frac{v_1^2}{v_2^2} = \frac{1}{2}$

$$\frac{H_P}{H_Q} = \frac{v_1^2}{v_2^2} \times \frac{\sin^2 30°}{\sin^2 60°}$$

$$= \frac{1}{2} \times \frac{1}{4} \times \frac{4}{3} = \frac{1}{6}$$

Question8

A person walks in such a way that he covers equal distance in each step. The person takes 2 steps forwards towards east, then takes a right turn and

walks 4 steps towards south, then takes a right turn and walks 6 steps towards west and then takes a right turn and walks further. The direction of his final position after a total of 20 steps walk with respect to his initial position is

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Options:

A. North-West

B. $60°$ West of South

C. $60°$ South of West

D. South-East

Answer: A

Solution:

Given,

Each step distance is equal.
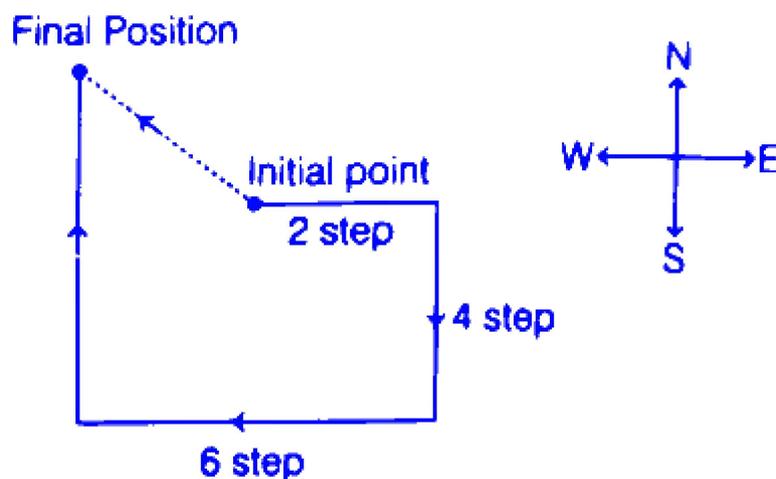
1st $\rightarrow$ 2 step towards east.

2nd $\rightarrow$ take right and walks 4 steps south

3rd $\rightarrow$ take right and walks 6 steps towards west.

4th $\rightarrow$ take right and walks.

Total steps $= 20$.

Draw the given data,

At last turn, person travels

$= 20 - 6 + 4 + 2 = 8$ steps

Thus, final direction is north west.

Question9

A bomb is dropped on an enemy post on the ground by an aeroplane flying horizontally with a velocity of 60kmh^{-1} at a height of 490 m . At the time of dropping the bomb, the horizontal distance of the aeroplane from the enemy post, so that the bomb hits the target is

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Options:

A. $\left(\frac{400}{3}\right)\text{m}$

B. $\left(\frac{500}{3}\right)\text{m}$

C. $\left(\frac{1700}{3}\right)\text{m}$

D. 498 m

Answer: B

Solution:

Given,

Initial speed of plane $= 60$ km/h
$$= \frac{50}{3} \text{ m/s}$$

Vertical height ∓ 490 mHorizontal distance
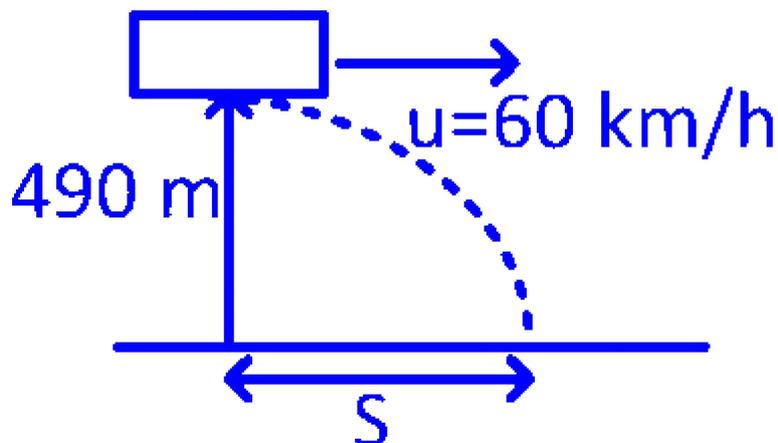
…(i)

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

$(a = 0) \qquad (s)$

For vertical component of motion,

$u = 0$

using equation of motion,

$s = ut + \frac{1}{2}at^2 (a = g)$

$t = \sqrt{\dfrac{2s}{g}} \Rightarrow t = \sqrt{\dfrac{2 \times 490}{9.8}}$

$t = 10 \text{ s}$

Put this in Eq. (i)

$s = \dfrac{50}{3} \times 10$

$s = \dfrac{500}{3} \text{ m}$