Motion in a Plane

Question1

If the horizontal range of a body projected with a velocity ' u ' is 3 times the maximum height reached by it, then the range of the body is

($g =$ Acceleration due to gravity)

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Options:

A.

$\frac{2u^2}{3g}$

B.

$\frac{4u^2}{5g}$

C.

$\frac{12u^2}{13g}$

D.

$\frac{24u^2}{25g}$

Answer: D

Solution:

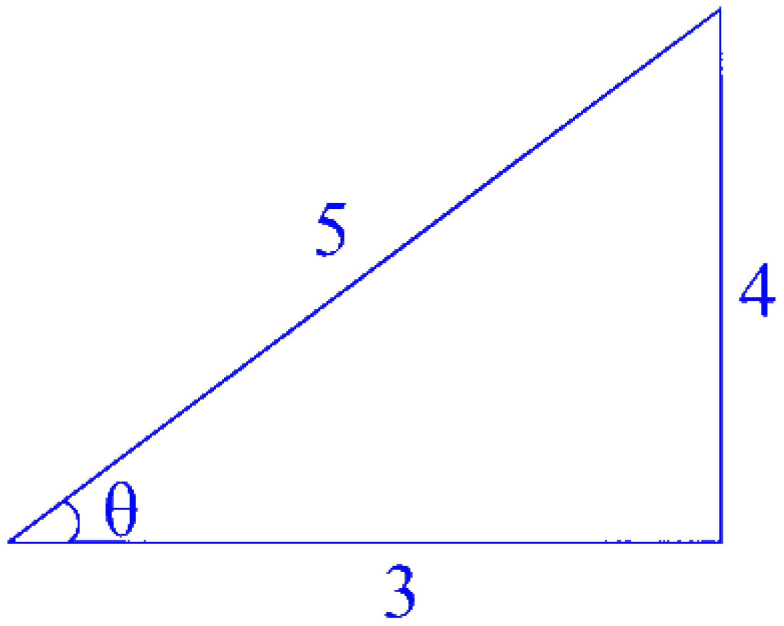
$$R = 3H$$

$$\frac{u^2 \sin 2\theta}{g} = \frac{3u^2 \sin^2 \theta}{2g}$$

$$\Rightarrow \quad 2 \sin \theta \cos \theta = \frac{3}{2} \sin^2 \theta$$

$$\Rightarrow \quad \tan \theta = \frac{4}{3}$$

$$\therefore \quad \sin \theta = \frac{4}{5} \text{ and } \cos \theta = \frac{3}{5}$$



$$\therefore \quad R = \frac{u^2 \sin 2\theta}{g} = \frac{u^2}{g} \times 2 \sin \theta \cos \theta$$

$$= \frac{u^2}{g} \times 2 \times \frac{4}{5} \times \frac{3}{5}$$

$$= \frac{24u^2}{25g}$$

Question2

If the velocity at the maximum height of a projectile projected at an angle of 45° is 20 ms^{-1}, then the maximum height reached by the projectile is (Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

10 m

B.

20 m

C.

30 m

D.

40 m

Answer: B

Solution:

At maximum height

$$\begin{aligned}
&\Rightarrow \quad u\cos\theta = 20\ \mathrm{m/s} \\
&\Rightarrow \quad u\cos 45^\circ = 20 \\
&\Rightarrow \quad u = 20\sqrt{2}\ \mathrm{m/s} \\
&\therefore \quad H = \frac{u^2\sin^2\theta}{2g} = \frac{(20\sqrt{2})^2\sin^2 45^\circ}{2\times 10} \\
&\qquad = 20\ \mathrm{m}
\end{aligned}$$

Question3

If a body of mass 2 kg moving with initial velocity of $4\ \mathrm{ms}^{-1}$ is subjected to a force of 3 N for a time of 2 s normal to the direction of its initial velocity, then the resultant velocity of the body is

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Options:

A.

$7\ \mathrm{ms}^{-1}$

B.

5 ms^{-1}

C.

2 ms^{-1}

D.

7.5 ms^{-1}

Answer: B

Solution:

Acceleration produced in the body due to applied force

$a = \frac{F}{m} = \frac{3}{2} = 1.5 \text{ m/s}^2$

Since, force is applied normal to the direction of its initial velocity, thus, $v_y = 0 + at = 1.5 \times 2 = 3 \text{ m/s}$

$\therefore$ Initial velocity, $v_x = 4 \text{ m/s}$

$\therefore$ Resultant velocity, $v = \sqrt{v_x^2 + v_y^2}$

$= \sqrt{4^2 + 3^2} = 5 \text{ m/s}$

Question4

If the range of a body projected with a velocity of 60 ms^{-1} is $180\sqrt{3} \text{ m}$, then the angle of projection of the body is

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

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Options:

A.

30° or 60°

B.

37° or 53°

C.

20° or 70°

D.

15° or 75°

Answer: A

Solution:

Step 1: Write the formula for range

The formula to find the range R when a body is projected is:

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

Step 2: Put in the given values

Here, $R = 180\sqrt{3}$ m, $u = 60$ m/s, and $g = 10$ m/s^2.

Step 3: Arrange the formula to find $\sin 2\theta$

$\sin 2\theta = \frac{Rg}{u^2}$

Step 4: Substitute the values

$\sin 2\theta = \frac{180\sqrt{3}\times 10}{60\times 60}$

$\sin 2\theta = \frac{1800\sqrt{3}}{3600} = \frac{\sqrt{3}}{2}$

Step 5: Identify the angle for $\sin 2\theta$

We know that $\sin 60^\circ = \frac{\sqrt{3}}{2}$.

So, $2\theta = 60^\circ$

$\theta = 30^\circ$

Step 6: Check for other possible angles

The range at angle θ is the same as at $90^\circ - \theta$.

So, the angle of projection can be 30° or 60°.

Question5

If the height of a projectile at a time of 2 s from the beginning of motion is 60 m , then the time of flight of the projectile is

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

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Options:

A.

12 s

B.

4 s

C.

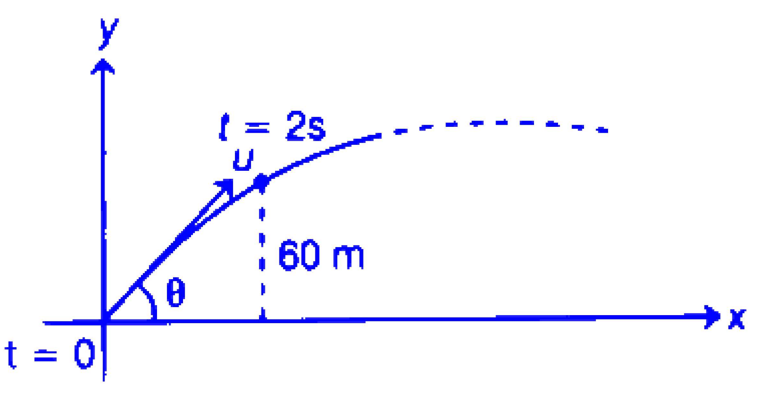
6 s

D.

8 s

Answer: D

Solution:



Considering vertical motion,

$u_y = u \sin \theta, S_y = 60 \text{ m}$
$a_y = -10 \text{ ms}^{-2}, t = 2 \text{ s}$

Using $S_y = u_y t + \frac{1}{2} a_y t^2$

we get,

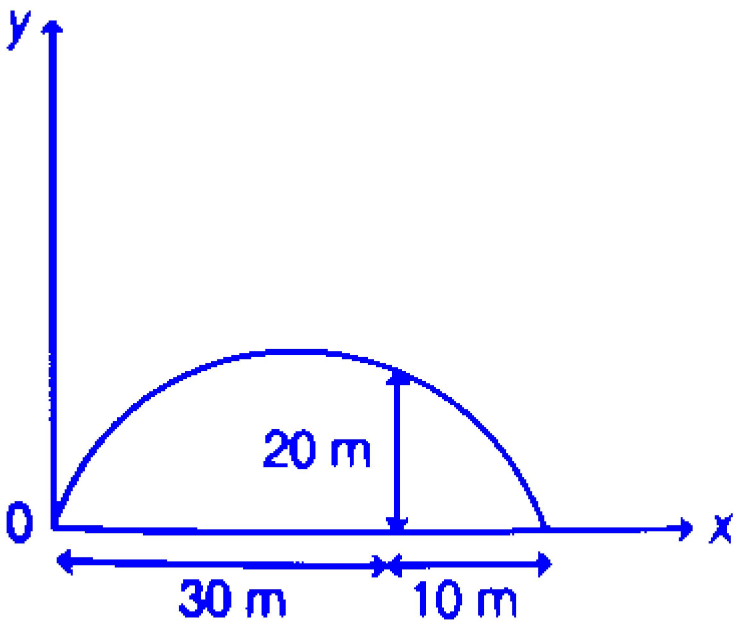
$$60 = u\sin\theta \times 2 - \frac{1}{2} \times 10 \times 2^2$$
$$\Rightarrow u\sin\theta = 40 \qquad \ldots(i)$$

Now, time of flight is

$T = \frac{2n\sin\theta}{g} = \frac{2\times40}{10} = 8\text{ s}$

Question6

The angle of projection of a projectile whose path is shown in the given figure is



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Options:

A.

$\tan^{-1}(1)$

B.

$\tan^{-1}\left(\frac{8}{3}\right)$

C.

$\tan^{-1}\left(\frac{4}{3}\right)$

D.

$\tan^{-1}\left(\frac{5}{3}\right)$

Answer: B

Solution:

Range of projectile $R = 40\text{ m}$

$$R = 40 = \frac{u^2 \sin 2\theta}{g}$$
$$\Rightarrow u^2 = \frac{40g}{\sin 2\theta} \qquad \ldots(i)$$

and from equation of trajectory

$$Y = x\tan\theta - \frac{1}{2}g\frac{x^2}{u^2\cos^2\theta}$$
$$Y = x\tan\theta - \frac{1}{2}\frac{gx^2\sin 2\theta}{40g\times\cos^2\theta}$$
$$20 = 30\tan\theta - \frac{1}{80}\times\frac{900\times 2\sin\theta\cos\theta}{\cos^2\theta}$$
$$20 = 30\tan\theta - \frac{1800}{80}\tan\theta$$
$$20 = 30\tan\theta - \frac{45}{2}\tan\theta$$
$$20 = \frac{15\tan\theta}{2}$$
$$\Rightarrow 15\tan\theta = 40$$
$$\tan\theta = \frac{40}{15} = \frac{8}{3}$$

$\theta = \tan^{-1}\left(\frac{8}{3}\right)$

Question7

If the equation of motion of a projectile is $y = Ax - Bx^2$, then the ratio of the maximum height reached and the range of the projectile is

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Options:

A.

$\frac{A}{4}$

B.

$\frac{A}{B}$

C.

$\frac{B}{4}$

D.

$\frac{A^2}{B}$

Answer: A

Solution:

$y = Ax - Bx^2$

Comparing with equation of trajectory,

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

we get,

$$A = \tan \theta \text{ and } B = \frac{g}{2u^2 \cos^2 \theta}$$

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

$$= \frac{\sin^2 \theta}{4 \sin \theta \cos \theta} = \frac{1}{4} \tan \theta = \frac{A}{4}$$

Question8

The height of ceiling in an auditorium is 30 m . A ball is thrown with a speed of 30 ms^{-1} from the entrance such that it just moves very near to the ceiling without touching it and then it reaches the ground at the end of the auditorium. Then, the length of auditorium is [Acceleration due to gravity $= 10 \mathrm{~ms}^{-2}$]

Options:

A.

$60\sqrt{2}$ m

B.

$30\sqrt{2}$ m

C.

$70\sqrt{2}$ m

D.

$100\sqrt{2}$ m

Answer: A

Solution:

Height of auditorium is 30 m and ball just reaches to this height so this is the maximum height of projectile.

Let angle of projection is θ.

$$\text{So, } H_{\max} = 30 = \frac{u^2 \sin^2\theta}{2g}$$

$$30 = \frac{(30)^2 \sin^2\theta}{2 \times 10}$$

$$\sin^2\theta = \frac{600}{900} = \frac{2}{3}$$

$$\Rightarrow \sin\theta = \sqrt{\frac{2}{3}}$$

$$\text{and } \cos\theta = \frac{1}{\sqrt{3}}$$

Now, length of auditorium will be equal to range of projectile.

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

$$= \frac{u^2(2\sin\theta\cos\theta)}{g}$$

$$R = \frac{(30)^2 \times 2 \times \sqrt{\frac{2}{3}} \times \frac{1}{\sqrt{3}}}{0.10}$$

$$R = \frac{1800\sqrt{2}}{30}$$

$$= 60\sqrt{2}\text{ m}$$

Question9

A particle crossing the origin at time $t=0$ moves in the XY-plane with a constant acceleration ' a ' in y-direction. If the equation of motion of the particle is $y=bx^2$ (where b is a constant), then its velocity component in the x-direction is

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Options:

A.

$\sqrt{\frac{2b}{a}}$

B.

$\sqrt{\frac{a}{2b}}$

C.

$\sqrt{\frac{a}{b}}$

D.

$\sqrt{\frac{b}{a}}$

Answer: B

Solution:

$y = bx^2$

$$\therefore \quad v_y = \frac{dy}{dt} = \frac{d}{dt} \cdot bx^2 = zbx\frac{dx}{dy}$$
$$v_y = zbxv_x$$

differentiating again

$$\frac{dv_y}{dt} = 2b\left(x\frac{dv_x}{dt} + v_x\frac{dx}{dt}\right)$$
$$\Rightarrow \quad a_y = 2b\left[x \cdot a_x + v_x \cdot v_x\right]$$
$$\Rightarrow \quad a_y = 2b\left[xa_x + v_x^2\right]$$

Since, $a_x = 0$ and $a_y = a$

$$\therefore \quad a = 2b\left(0 + v_x^2\right) \Rightarrow a = 2bv_x^2$$
$$\Rightarrow \quad v_x = \sqrt{\frac{a}{2b}}$$

Question10

If a ball projected vertically upwards with certain initial velocity from the ground crosses a point at a height of 25 m twice in a time interval of 4 s , then the initial velocity of the ball is

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

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Options:

A.

20 ms^{-1}

B.

30 ms^{-1}

C.

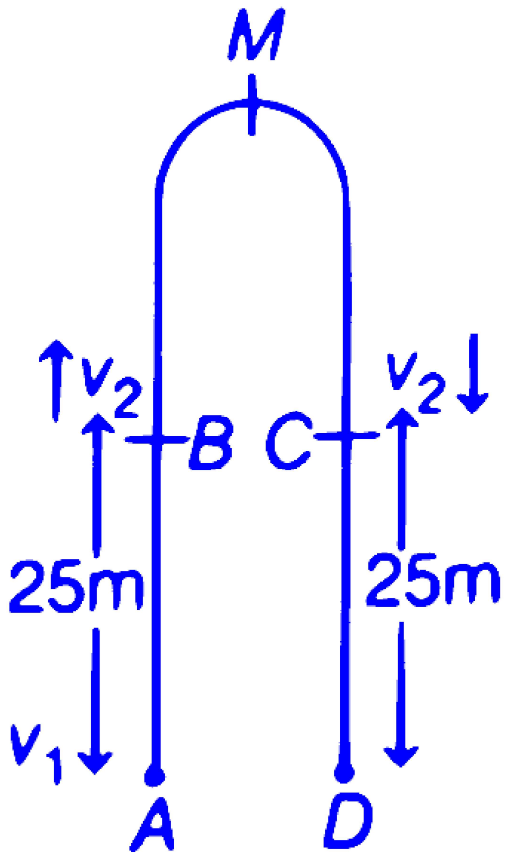
40 ms^{-1}

D.

25 ms^{-1}

Answer: B

Solution:



If v_1 be the velocity at the time of projection and v_2 be the velocity at height 25 m , then

$$v_2^2 = v_1^2 - 2g \times 25 \qquad \ldots (i)$$

If t be the time taken to reach at maximum height H from point B, then

$$0 = v_2 - gt$$
$$v_2 = gt = 10 \times 2 = 20 \text{ m/s}$$

$\therefore$ From eq. (i),

$$20^2 = v_1^2 - 2 \times 10 \times 25$$
$$\Rightarrow \quad 400 + 500 = v_1^2$$
$$\Rightarrow \quad v_1 = \sqrt{900} = 30 \text{ m/s}$$

Question11

A car is moving with a velocity of 4 ms^{-1} towards east. After a time of 4 s , if it is heading north-east with a velocity of $4\sqrt{2} \text{ ms}^{-1}$, then the average velocity of the car is

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Options:

A.

$2\sqrt{5} \text{ ms}^{-1}$

B.

$3\sqrt{5} \text{ ms}^{-1}$

C.

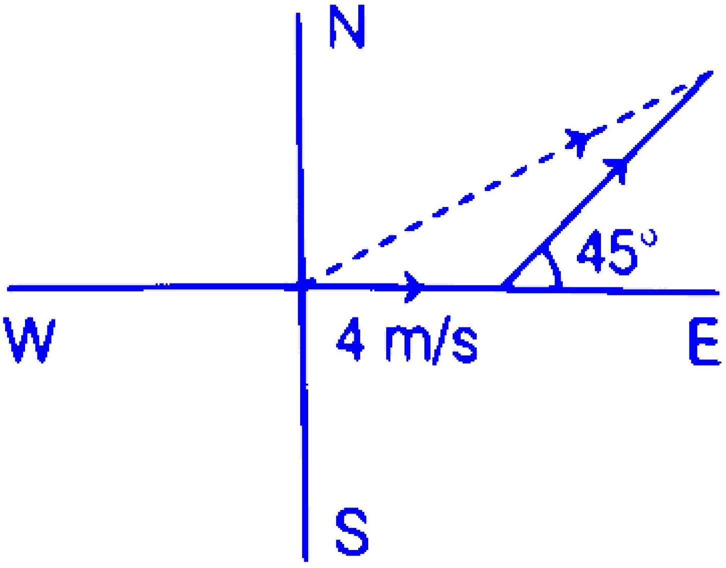
$4\sqrt{3} \text{ ms}^{-1}$

D.

$5\sqrt{3} \text{ ms}^{-1}$

Answer: A

Solution:



Initial velocity, $\mathbf{u} = 4\hat{\mathbf{i}}$

$$\textit{Final velocity,} \mathbf{v} = 4\sqrt{2}\left(\frac{1}{\sqrt{2}}(\hat{\mathbf{i}} + \hat{\mathbf{j}})\right)$$
$$= 4\hat{\mathbf{i}} + 4\hat{\mathbf{j}}$$

$$\textit{Displacement } \mathbf{r} = \mathbf{v}_{\text{avg}} \times t$$
$$\mathbf{r} = \left(\frac{\mathbf{v} + \mathbf{u}}{2}\right) \times t$$
$$= \left(\frac{4\hat{\mathbf{i}} + 4\hat{\mathbf{j}} + 4\hat{\mathbf{i}}}{2}\right) \times 4$$
$$= 4(4\hat{\mathbf{i}} + 2\hat{\mathbf{j}}) = 16\hat{\mathbf{i}} + 8\hat{\mathbf{j}}$$

Average velocity

$$\mathbf{v}_{\text{avg}} = \frac{\text{Displacement covered}}{\text{Time taken}}$$
$$= \frac{16\hat{\mathbf{i}} + 8\hat{\mathbf{j}}}{4} = 4\hat{\mathbf{i}} + 2\hat{\mathbf{j}}$$
$$(\mathbf{v}_{\text{avg}}) = \text{magnitude of average velocity}$$
$$= \sqrt{4^2 + 2^2}$$
$$= \sqrt{20} = 2\sqrt{5}\ \text{m/s}$$

Question12

A body of mass 5 kg starts from the origin with an initial velocity $(30\hat{\mathbf{i}} + 40\hat{\mathbf{j}})\text{ms}^{-1}$. If a constant force $-(\hat{\mathbf{i}} + 5\hat{\mathbf{j}})\text{N}$ acts on the body, then the time in which the y-component of its velocity becomes zero is

Options:

A.

5 s

B.

20 s

C.

40 s

D.

80 s

Answer: C

Solution:

$u = 30\hat{\mathbf{i}} + 40\hat{\mathbf{j}}$

$F = (-\hat{\mathbf{i}} + 5\hat{\mathbf{j}})\mathrm{N}$

$$a = \frac{F}{m} = \left(\frac{-\hat{\mathbf{i}} + 5\hat{\mathbf{j}}}{5}\right) = -\left(\frac{\hat{\mathbf{i}}}{5} + \hat{\mathbf{j}}\right)$$

$u_x = 40\ \mathrm{m/s}, u_y = 40\ \mathrm{m/s}$

In y-direction,

$\therefore \quad a_y = -1\ \mathrm{m/s}^2$

$\therefore \quad v_y = u_y + a_y t$

$0 = 40 - 1t$

$t = 40\ \mathrm{s}$

Question13

If bullets are fired in all possible directions from same point with equal velocity of $10\ \mathrm{ms}^{-1}$ and with an angle of projection 45°, then the area covered by the bullets on the ground is nearly(Acceleration

due to gravity $= 10 \text{ m s}^{-2}$)

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Options:

A.

628 m^2

B.

314 m^2

C.

157 m^2

D.

79 m^2

Answer: B

Solution:

$$
\begin{aligned}
& A=\pi R^2=\pi\left(\frac{u^2 \sin 2 \theta}{g}\right)^2 \\
& =\pi \cdot\left[\frac{10^2 \sin (2 \times 45^{\circ})}{10}\right]^2 \\
& =100 \pi \\
& =100 \times 3.14 \\
& =314 \text{ m}^2
\end{aligned}
$$

Question14

A ball is projected from a point with a speed V_0 at certain angle with the horizontal. From the same point and at the same instant, a person starts running with a constant speed $0.5V_0$ to catch the ball. If the person catches the ball after some time, then the angle of projection of the ball is

Options:

A.

60°

B.

30°

C.

45°

D.

53°

Answer: A

Solution:

Let person catches ball after time ' f '.

Then, $V_0 \cos \theta \cdot t = 0.5 V_0 t$

$$\Rightarrow \cos \theta = 0.5 = \frac{1}{2}$$
$$\Rightarrow \cos \theta = \cos 60^{\circ}$$
$$\Rightarrow \theta = 60^{\circ}$$

Question15

Path of projectile is given by the equation $Y = Px - Qx^2$, match the following accordingly (acceleration due to gravity $= g$)

a.	Range	i	$\frac{P}{Q}$
b.	Maximum height	ii	P
c.	Time of flight	iii	$\frac{P^2}{4Q}$
d.	Tangent of projection	iv	$\left(\sqrt{\frac{2}{gQ}}\right)P$

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Options:

A. a-i,b-iii, c-iv, d-ii

B. a-i, b-iii, c-ii, d-iv

C. a-iii, b-i, c-iv, d-ii

D. a-iv, b-ii, c-iii, d-i

Answer: A

Solution:

The path of the projectile is described by the equation:

$Y = Px - Qx^2$

Comparing this with the traditional equation of projectile motion:

$Y = x\tan\theta - \frac{1}{2}g\frac{x^2}{u^2\cos^2\theta}$

we identify that:

$P = \tan\theta \quad \text{(i)}$

$Q = \frac{g}{2u^2\cos^2\theta} \quad \text{(ii)}$

Using these relationships, we can derive the following:

Range R:

$\frac{P}{Q} = \frac{\tan\theta}{g} = \frac{2u^2\cos^2\theta\cdot\tan\theta}{g} = \frac{u^2\sin 2\theta}{g} = R$

Thus, $a \to$ (i).

Maximum Height (H):

$$\frac{P^2}{4Q} = \frac{\tan^2\theta}{4\cdot\frac{g}{2u^2\cos^2\theta}} = \frac{\tan^2\theta\cdot 2u^2\cos^2\theta}{4g} = \frac{u^2\sin^2\theta}{2g} = H$$

Therefore, $b \rightarrow$ (iii).

Tangent of Projection Angle:

$P = \tan\theta$

Hence, $d \rightarrow$ (ii).

Time of Flight (T):

$$\left(\sqrt{\frac{2}{gQ}}\right)P = \left(\sqrt{\frac{2}{g\cdot\frac{g}{2u^2\cos^2\theta}}}\right)\tan\theta = \frac{2u\cos\theta}{g}\cdot\frac{\sin\theta}{\cos\theta} = \frac{2u\sin\theta}{g} = T$$

Therefore, $c \rightarrow$ (iv).

This analysis establishes a clear correspondence between the projectile motion parameters and the terms given in the equation.

Question16

A bowling machine placed at a height h above the earth surface releases different balls with different angles but with same velocity $10\sqrt{3}\ \mathrm{ms}^{-1}$. All these balls landing velocities make angels 30° or more with horizontal. Then the height h (in metre) (acceleration due to gravity $= 10\ \mathrm{ms}^{-2}$)

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Options:

A. 15

B. 12

C. 10

D. 5

Answer: D

Solution:

To determine the minimum height h from which the bowling machine releases the balls, consider the scenario where the ball is thrown horizontally. The landing velocity should make the smallest possible angle, which is 30°, with the horizontal.

Initial Conditions: At $t = 0$:

Horizontal velocity component: $u_x = 10\sqrt{3}\,\text{ms}^{-1}$

Vertical velocity component: $u_y = 0\,\text{ms}^{-1}$

At time $t = t$:

Horizontal velocity remains constant: $v_x = 10\sqrt{3}$

Vertical velocity due to gravity: $v_y = gt = 10t$

Condition for Minimum Angle:

The tangent of the angle of the landing velocity with respect to the horizontal is given by:

$\tan 30^\circ = \frac{v_y}{v_x}$

Substituting the given values:

$\frac{1}{\sqrt{3}} = \frac{10t}{10\sqrt{3}}$

Solve for t:

$\frac{1}{\sqrt{3}} = \frac{t}{\sqrt{3}} \Rightarrow t = 1\,\text{s}$

Calculate Height h:

Using the formula for vertical displacement under gravity:

$h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 1^2 = 5\,\text{m}$

Thus, the height h from which the balls should be released so that the landing velocity makes the minimum angle of 30° with the horizontal is 5 meters.

Question17

A boy throws a ball with a velocity v_0 at an angle α to the ground. At the same time 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

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Options:

A. $v_0 \cos \alpha$

B. $v_0 \sin \alpha$

C. $v_0 \tan \alpha$

D. $\sqrt{v_0{}^2 \tan \alpha}$

Answer: A

Solution:

Given that a boy throws a ball with an initial velocity v_0 at an angle α to the ground, we need to find the velocity at which the boy should run to catch the ball before it hits the ground.

Initial Components of the Ball's Velocity:

Horizontal Component: $v_0 \cos \alpha$

Vertical Component: $v_0 \sin \alpha$

Total Time of Flight of the Ball:

The formula for the time of flight, T, for a projectile is given by:

$T = \frac{2v_0 \sin \alpha}{g}$

where g is the acceleration due to gravity.

Horizontal Distance Traveled by the Ball (Range R):

The range R is calculated as:

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

Velocity of the Boy:

To catch the ball, the boy must cover the same horizontal distance as the ball in the same amount of time. Thus, the boy's velocity v_b is:

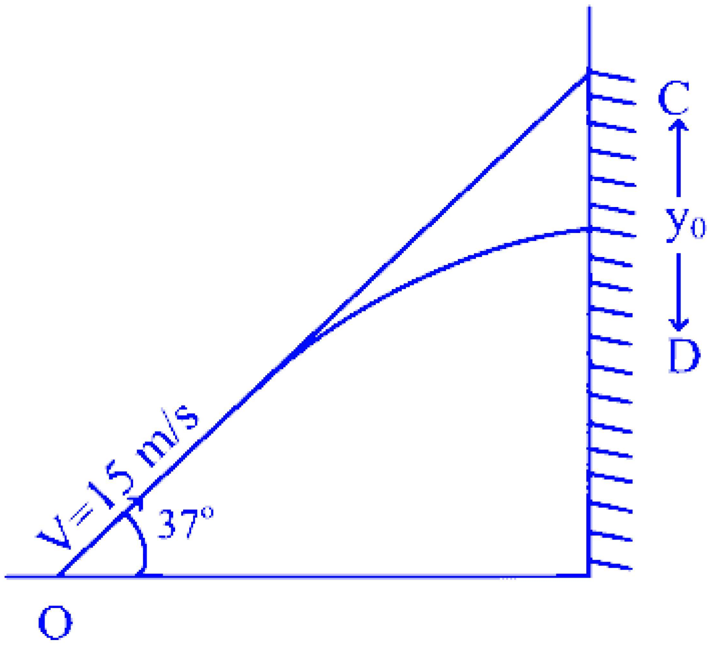
$$\begin{aligned} v_b &= \frac{R}{T} \\ &= \frac{\frac{v_0^2 \sin 2\alpha}{g}}{\frac{2v_0 \sin \alpha}{g}} \\ &= \frac{v_0^2 \cdot 2 \sin \alpha \cos \alpha}{2v_0 \sin \alpha} \\ &= v_0 \cos \alpha \end{aligned}$$

Therefore, the boy should run with a velocity of $v_0 \cos \alpha$ to catch the ball.

Question18

A ball at point O is at a horizontal distance of 7 m from a wall. On the wall a target is set at point C. If the ball is throw from O at an

angle 37° with horizontal aiming the target C. But it hits the wall at point D which is at a vertical distance y_0 below C. If the initial velocity of the ball is $15\ \mathrm{ms}^{-1}$. Find y_0 (given, $\cos 37^{\circ}=\frac{4}{5}$)



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Options:

A. 2 m

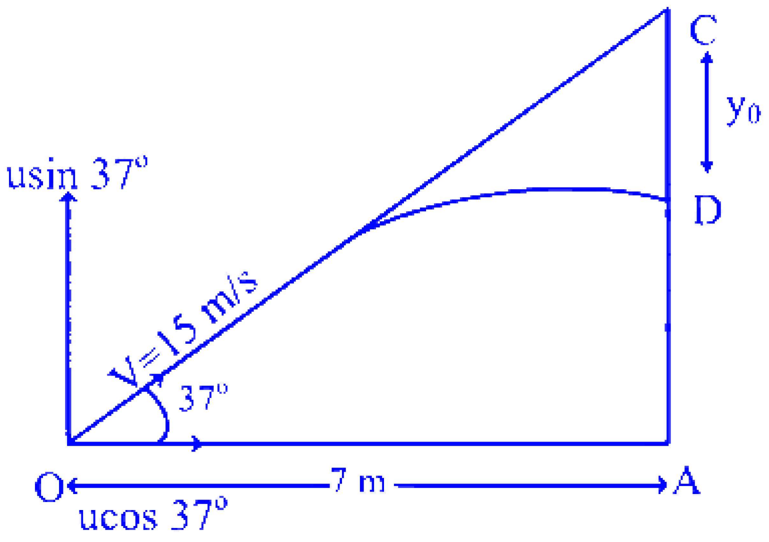
B. 1.5 m

C. 1.7 m

D. 3 m

Answer: C

Solution:



$Given,\ OA = 7\ \text{m}$
$u = 15\ \text{m/s}$

Horizontal component of velocity,

$u_x = u\cos 37^\circ = 15 \times \frac{4}{5} = 12\ \text{m/s}$

Vertical component of velocity,

$v_x = u\sin 37^\circ$
$= 15 \times \dfrac{3}{5} = 9\ \text{m/s}$

From figure, $\tan 37^\circ = \frac{AC}{OA}$

$AC = \tan 37^\circ \times OA$
$= \dfrac{3}{4} \times 7 = \dfrac{21}{4}\ \text{m} \qquad \ldots(i)$

For covering horizontal distance OA, if t is the time taken, then

$u_x t = 7$
$t = \frac{7}{12}$

$$AD = u_y t - \frac{1}{2}at^2 = 9 \times \frac{7}{12} - \frac{1}{2} \times 10 \times \left(\frac{7}{12}\right)^2$$
$$= \frac{21}{4} - 1.70$$

From figure, $AC = AD + DC$

From Eq. (i), $\frac{21}{4} = \frac{21}{4} - 1.70 + y_0$

$y_0 = 1.7\ \text{m}$

Question19

The relation between the horizontal displacement x (in metre) and the vertical displacement y (in metre) of a projectile is $y = 3x - 0.8x^2$. The time of flight of the projectile is (Acceleration due to gravity, $g = 10 \text{ ms}^{-2}$)

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Options:

A. 1.5 s

B. 3 s

C. 2 s

D. 2.5 s

Answer: A

Solution:

Given the equation for the projectile's path:

$y = 3x - 0.8x^2$

where g is the acceleration due to gravity, given as $g = 10 \, \text{m/s}^2$.

The formula for the time of flight T is:

$T = \frac{2u_y}{g}$

Here, u_y is the initial vertical velocity component, and g is the acceleration due to gravity.

Determining the Maximum Height

The vertex form of a parabola $(y = ax^2 + bx + c)$ offers insight into key values, with the vertex given by:

$X_{\text{vertex}} = \frac{-b}{2a}$

For the given trajectory equation, where $a = -0.8$ and $b = 3$:

$X_{\text{vertex}} = -\frac{3}{2 \times (-0.8)} = 1.875 \, \text{m}$

Calculating the maximum height y_{max}:

$y_{\text{max}} = 3 \times 1.875 - 0.8 \times (1.875)^2 = 5.625 - 0.8 \times 3.515 = 2.81 \, \text{m}$

Calculating the Initial Vertical Velocity

Using the equation for maximum height in projectile motion:

$$Y_{\max} = \frac{u_y^2}{2g}$$

Solving for the initial vertical velocity u_y:

$$u_y = \sqrt{2gY_{\max}} = \sqrt{2 \times 10 \times 2.81} = 7.5\,\mathrm{m/s}$$

Calculating the Time of Flight

Finally, the time of flight is:

$$T = \frac{2u_y}{g} = \frac{2\times7.5}{10} = \frac{15}{10} = 1.5\,\mathrm{s}$$

Question20

A boy weighing 50 kg finished long jump at a distance of 8 m . Considering that he moved along a parabolic path and his angle of jump is 45°, his initial KE is

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Options:

A. 960 J

B. 1560 J

C. 2460 J

D. 1960 J

Answer: D

Solution:

Given:

Mass of the boy, $m = 50\,\mathrm{kg}$

Distance of the jump, $d = 8\,\mathrm{m}$

Jump angle, $\theta = 45^\circ$

We know the horizontal range formula in projectile motion is given by:

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

For $\theta = 45^\circ$, the equation simplifies to:

$$d = \frac{v^2}{g}$$

Rearranging for v, the initial velocity:

$$v = \sqrt{d \times g}$$

where g (acceleration due to gravity) is:

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

Substitute the values:

$$v = \sqrt{8 \times 9.8} = 8.86\,\text{m/s}$$

Now, calculate the initial kinetic energy KE:

$$\text{KE} = \frac{1}{2} \times m \times v^2$$

Substitute the known values:

$$\text{KE} = \frac{1}{2} \times 50 \times (8.86)^2 = 25 \times 78.49 = 1962.4\,\text{J}$$

Rounding this to the nearest whole number, the initial kinetic energy is approximately:

$$\text{KE} \approx 1960\,\text{J}$$

Question21

The maximum height attained by projectile is increased by 10% by keeping the angle of projection constant. What is the percentage increase in the time of flight ?

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Options:

A. 5%

B. 10%

C. 20%

D. 40%

Answer: A

Solution:

To find the percentage increase in the time of flight when the maximum height attained by a projectile is increased by 10%, we keep the angle of projection constant.

Initial Conditions:

The initial maximum height is given by the formula:

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

The time of flight is:

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

From these, we derive:

$$t^2 = \frac{4u^2 \sin^2 \theta}{g^2} = \left(\frac{8}{g}\right) h$$

Therefore, $t^2 \propto h$.

With a 10% Increase in Height:

New height, H, is:

$$H = h + \frac{10}{100} h = \frac{11}{10} h$$

Let the new time of flight be T. From our relationships, we have:

$$T^2 \propto H \Rightarrow \frac{T^2}{t^2} = \frac{H}{h} = \frac{11}{10}$$

Simplifying:

$$\frac{T}{t} = \sqrt{\frac{11}{10}} \approx 1.05$$

The percentage increase in time of flight is:

$$\left(\frac{T-t}{t}\right) \times 100 = (1.05 - 1) \times 100 = 5\%$$

Thus, the time of flight increases by 5%.

Question22

The horizontal range of a projectile projected at an angle of 45° with the horizontal is 50 m . The height of the projectile when its horizontal displacement is 20 m is

Options:

A. 18 m

B. 36 m

C. 12 m

D. 24 m

Answer: C

Solution:

To solve the problem, we're given:

Angle of projection, $\theta = 45^\circ$

Horizontal range, $R = 50\,\mathrm{m}$

First, we determine the initial velocity (u):

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

Plugging the values into the formula:

$50 = \frac{u^2 \times \sin 90^\circ}{10}$

since $\sin 90^\circ = 1$, this becomes:

$u^2 = 500 \quad \Rightarrow \quad u = 10\sqrt{5}\,\mathrm{m/s}$

Next, we calculate the horizontal component of the initial velocity:

$u_{0x} = u \cos 45^\circ = 10\sqrt{5} \times \frac{1}{\sqrt{2}} = 5\sqrt{10}\,\mathrm{m/s}$

The horizontal displacement x at time t is given by:

$x = u_{0x} \cdot t$

Given $x = 20\,\mathrm{m}$:

$20 = 5\sqrt{10} \cdot t$

Solving for t:

$t = \frac{4}{\sqrt{10}}\,\mathrm{s}$

For the vertical component of the initial velocity:

$u_{0y} = u \sin 45^\circ = 5\sqrt{10}\,\mathrm{m/s}$

The vertical displacement y at time t is given by:

$y = u_{0y} \cdot t - \frac{1}{2} g t^2$

Substituting the known values:

$y = 5\sqrt{10} \cdot \frac{4}{\sqrt{10}} - \frac{1}{2} \times 10 \times \left(\frac{4}{\sqrt{10}}\right)^2$

Simplify:

$y = 20 - \frac{16}{2}$

Thus, the vertical displacement is:

$y = 12\,\mathrm{m}$

Question23

A body of mass 1.5 kg is moving towards south with a uniform velocity of $8\ \mathrm{ms}^{-1}$. A force of 6 N is applied to the body towards east. The displacement of the body 3 s after the application of the force is

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Options:

A. 24 m

B. 30 m

C. 18 m

D. 42 m

Answer: B

Solution:

Given:

Mass of the body, $m = 1.5\,\mathrm{kg}$

Initial velocity towards south, $u_s = 8\,\mathrm{m/s}$

Force applied towards east, $F_e = 6\,\mathrm{N}$

Time, $t = 3\,\text{s}$

Calculating Acceleration due to the Force

The acceleration in the eastward direction, a_e, is given by:

$a_e = \frac{F_e}{m} = \frac{6}{1.5} = 4\,\text{m/s}^2$

Since the initial velocity of the body in the eastward direction, $u_e = 0$.

Calculating Displacement

Eastward Displacement (s_e)

Using the formula for displacement with constant acceleration:

$s_e = u_e \cdot t + \frac{1}{2} a_e t^2 = 0 \cdot 3 + \frac{1}{2} \cdot 4 \cdot (3)^2 = 18\,\text{m}$

Southward Displacement (s_s)

Using the formula for displacement with constant velocity:

$s_s = u_s \cdot t = 8 \cdot 3 = 24\,\text{m}$

Resultant Displacement

The resultant displacement, s, is the combination of the eastward and southward displacements, calculated using the Pythagorean theorem:

$s = \sqrt{s_e^2 + s_s^2} = \sqrt{18^2 + 24^2} = \sqrt{324 + 576} = \sqrt{900} = 30\,\text{m}$

Question24

If two stones are projected at angle θ and $(90^\circ - \theta)$ respectively with horizontal with a speed of $20\ \text{ms}^{-1}$. If second stone rises 10 m higher than the first stone then, the angle of projection θ is (acceleration due to gravity $= 10\ \text{ms}^{-2}$)

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Options:

A. 45°

B. 30°

C. 60°

D. 20°

Answer: B

Solution:

The maximum height for a projectile can be calculated using the formula:

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

For the first stone with an angle of projection θ, the maximum height h_1 is:

$h_1=\frac{20^2 \sin^2 \theta}{2 \times 10}$

$h_1=20 \sin^2 \theta \quad \ldots \text{(i)}$

For the second stone projected at an angle $(90^{\circ}-\theta)$, the maximum height h_2 is:

$h_2=\frac{20^2 \sin^2(90^{\circ}-\theta)}{2 \times 10}$

$h_2=20 \cos^2 \theta \quad \ldots \text{(ii)}$

We are given that the second stone rises 10 m higher than the first stone:

$h_2-h_1=10$

Substituting the expressions for h_1 and h_2, we get:

$20 \cos^2 \theta-20 \sin^2 \theta=10$

This simplifies to:

$\cos^2 \theta-\sin^2 \theta=0.5$

Utilizing the trigonometric identity:

$\cos^2 \theta-\sin^2 \theta=\cos 2\theta$

We find:

$\cos 2\theta=0.5$

The angle 2θ for which $\cos 2\theta=0.5$ is 60°. Thus:

$2\theta=60^{\circ}$

$\theta=30^{\circ}$

Question25

An object of mas m is projected with an initial velocity u with angle of θ with the horizontal. The average power delivered by gravity in reaching the highest point

Options:

A. $\frac{mgu \sin^2 \theta}{2}$

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

C. $\frac{mg \sin^2 \theta}{2u}$

D. $\frac{mgu \sin \theta}{2}$

Answer: D

Solution:

Given the following information:

Mass of the object: m

Initial velocity: u

Angle with the horizontal: θ

Let's analyze the situation step-by-step.

Maximum Height of the Projectile

The maximum height H_{max} that the object can reach is given by:

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

Calculation of Power

Power is defined as the work done per unit of time. Therefore, the average power delivered by gravity as the object reaches its highest point can be calculated using:

$$\text{Power} = \frac{|\text{Work done}|}{\text{Time}}$$

Work Done by Gravity:

The work done by gravity is equivalent to the change in potential energy when the object reaches the highest point:

$$W = \Delta U = -mgh_{\text{max}}$$

Substituting for H_{max} :

$$W = -mg\left(\frac{u^2 \sin^2 \theta}{2g}\right) = -\frac{mgu^2 \sin^2 \theta}{2g}$$

Time to Reach Maximum Height:

To determine the time taken to reach the maximum height, you can use the vertical component of the initial velocity:

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

Average Power Delivered by Gravity:

Combine these into the power expression:

$\text{Power} = \frac{\frac{mgu^2 \sin^2 \theta}{2g}}{\frac{u \sin \theta}{g}}$

Simplifying the expression:

$P = \frac{mgu^2 \sin^2 \theta \cdot g}{2g \cdot u \sin \theta} = \frac{mgu \sin \theta}{2}$

Thus, the average power delivered by gravity while the object reaches its maximum height is:

$P = \frac{mgu \sin \theta}{2}$

Question26

A projectile can have the same range R for two angles of projection. Their initial velocities are same. If T_1 and T_2 are times of flight in two cases, then the product of two times of flight is directly proportional to

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Options:

A. $\frac{1}{R}$

B. R^3

C. R^2

D. R

Answer: D

Solution:

When a projectile is launched, it can achieve the same range R with two different angles of projection that are complementary, meaning they add up to 90°. The initial velocities for these two scenarios remain the same.

Consider the angles of projection to be θ and $90^\circ - \theta$.

Time of Flight

For the two complementary angles:

Time of flight for the first angle (θ):

$T_1 = \frac{2u \sin \theta}{g}$

Time of flight for the second angle ($90^\circ - \theta$):

$T_2 = \frac{2u \cos \theta}{g}$

Product of Times of Flight

The product of the times of flight T_1 and T_2 is calculated as follows:

$T_1 \cdot T_2 = \left(\frac{2u \sin \theta}{g}\right) \left(\frac{2u \cos \theta}{g}\right) = \frac{4u^2 \sin \theta \cos \theta}{g^2}$

Using the identity $2 \sin \theta \cos \theta = \sin 2\theta$, we get:

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

Relationship with Range

Given that the range R is:

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

We can substitute for $\sin 2\theta$ in terms of R:

$T_1 \cdot T_2 = \frac{2R}{g}$

Thus, the product of the times of flight $T_1 \cdot T_2$ is directly proportional to the range R:

$T_1 \cdot T_2 \propto R$

Question27

A 2 kg ball thrown vertically upward and another 3 kg ball projected with certain angle $(\theta \neq 90^\circ)$ both will have same time of flight, then this ratio of their maximum heights is

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Options:

A. 3 : 2

B. 3 : 2

C. $\sqrt{3}$: 2

D. 1 : 1

Answer: D

Solution:

The time of flight for any projectile motion is given by the equation:

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

It is important to note that the time of flight does not depend on the mass of the objects involved.

Given that the times of flight for both balls are equal, we have:

$T_1=T_2$

Therefore:

$\frac{2u_1\sin\theta}{g}=\frac{2u_2\sin\theta}{g}$

This simplifies to:

$u_1=u_2$

The maximum height reached by a projectile is defined by:

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

From the equation, we see that:

$H\propto u^2$

Given $u_1=u_2$ from equation (i):

$\frac{H_1}{H_2}=\frac{u_1^2}{u_2^2}=\frac{u_1^2}{u_1^2}=1$

Thus, the ratio of their maximum heights is:

$H_1:H_2=1:1$

Question28

In a sport event, a disc is thrown such that it reaches its maximum range of 80 m , the distance travelled in first 3 s is $\left(g=10\ \mathrm{ms}^{-2}\right)$

Options:

A. 80 m

B. 60 m

C. 72 m

D. 74 m

Answer: B

Solution:

In a sports event, a disc is thrown to achieve a maximum range of 80 meters. Our task is to determine the distance the disc travels in the first 3 seconds, given that the acceleration due to gravity (g) is $10\,\mathrm{m/s}^2$.

Let's start by understanding the maximum range:

$R_{\max} = 80\,\mathrm{m}$

For maximum range in projectile motion, the launch angle is 45 degrees. The equation for maximum range is:

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

Substituting $\theta = 45^\circ$:

$\frac{u^2 \sin(2 \times 45^\circ)}{g} = 80$

Since $\sin 90^\circ = 1$, we have:

$\frac{u^2}{g} = 80$

Solving for u^2:

$u^2 = 80 \times 10 = 800$

Thus, the initial velocity (u) is:

$u = \sqrt{800} = 20\sqrt{2}\,\mathrm{m/s}$

Next, let's find the horizontal component of the velocity:

$u_x = u \cos 45^\circ = 20\sqrt{2} \times \frac{1}{\sqrt{2}} = 20\,\mathrm{m/s}$

The vertical component of the velocity is:

$u_y = u \sin 45^\circ = 20\sqrt{2} \times \frac{1}{\sqrt{2}} = 20\,\mathrm{m/s}$

Now, calculate the horizontal distance traveled in the first 3 seconds:

$s_x = u_x \times t = 20\,\text{m/s} \times 3\,\text{s} = 60\,\text{m}$

Therefore, the distance traveled by the disc in the first 3 seconds is 60 meters.

Question29

Object is projected such that it has to attain maximum range. Another body is projected to reach maximum heigh. If both the objects reached the same maximum height, then the ratio of initial velocities

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Options:

A. $2 : 1$

B. $\sqrt{2} : 1$

C. $1 : \sqrt{2}$

D. $1 : 2$

Answer: B

Solution:

To analyze the problem, consider two objects:

First Object: Maximizing Range

To achieve maximum range, the object must be projected at a 45° angle.

Using the formula for maximum height H_1 when launched at an angle $\theta_1 = 45^\circ$:

$$H_1 = \frac{u_1^2 \sin^2 \theta_1}{2g} = \frac{u_1^2 \times 1}{2g \times 2} = \frac{u_1^2}{4g} \quad \text{(i)}$$

Second Object: Maximizing Height

To achieve maximum height, the object should be projected vertically at a 90° angle.

The formula for the maximum height H_2 with a launch angle $\theta_2 = 90^\circ$:

$$H_2 = \frac{u_2^2 \sin^2 90^\circ}{2g} = \frac{u_2^2}{2g} \quad \text{(ii)}$$

Equating Heights

Since both objects reach the same maximum height:

$H_1 = H_2$

From equations (i) and (ii):

$\frac{u_1^2}{4g} = \frac{u_2^2}{2g}$

Simplifying, we find:

$u_1^2 = 2u_2^2$

Taking the square root:

$u_1 = \sqrt{2}u_2$

Thus, the ratio of their initial velocities is:

$\frac{u_1}{u_2} = \frac{\sqrt{2}}{1}$

Therefore, the ratio of initial velocities is $\sqrt{2} : 1$.

Question30

Ball is projected at an angle of 45° with the horizontal. It passes through a wall of height h at a horizontal distance d_1 from the point of profection and strikes the ground at a distance $d_1 + d_2$ from the point of projection, then h is :

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Options:

A. $h = \frac{2dd_2}{d_1+d_2}$

B. $h = \frac{dd_2}{d_1+d_2}$

C. $h = \frac{\sqrt{2}dd_2}{d_1+d_2}$

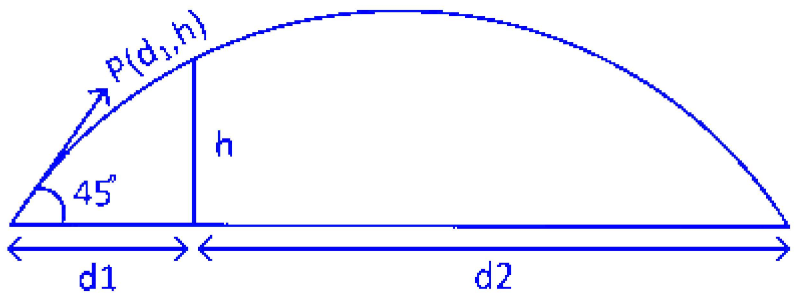
D. $h = \frac{dd_2}{2(d_1+d_2)}$

Answer: B

Solution:

Given.

Angle of projection $= 45^{\circ}$ height of wall $=$ h



We know that.

The equation of trajectory of a projectale,

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$
$$y = x\tan\theta\left(1 - \frac{gx}{2u^2\cos^2\theta \cdot \tan\theta}\right)$$
$$y = x\tan\theta\left(1 - \frac{gx}{2u^2\cos^2\theta \cdot \frac{\sin\theta}{\cos\theta}}\right)$$
$$y = x\tan\theta\left(1 - \frac{x}{R}\right)\left\{\because R = \frac{u^2\sin 2\theta}{g}\right\}$$

Here, $R = d_1 + d_2, x = d_1$ and $y = h$

$$\text{So, } h = d_1\tan 45^{\circ}\left(1 - \frac{d_1}{d_1 + d_2}\right)$$
$$h = d_1\left(\frac{d_2}{d_1 + d_2}\right)$$
$$h = \frac{d_1 d_2}{d_1 + d_2}$$

Question31

second after projection, a projectile is travelling in a direction inclined at 45° to horizontal. After two more seconds, it is travelling horizontally. Then, the magnitude of velocity of the projectile is $\left(g = 10\ \mathrm{ms}^{-2}\right)$

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Options:

A. $10\sqrt{13}\ \mathrm{ms}^{-1}$

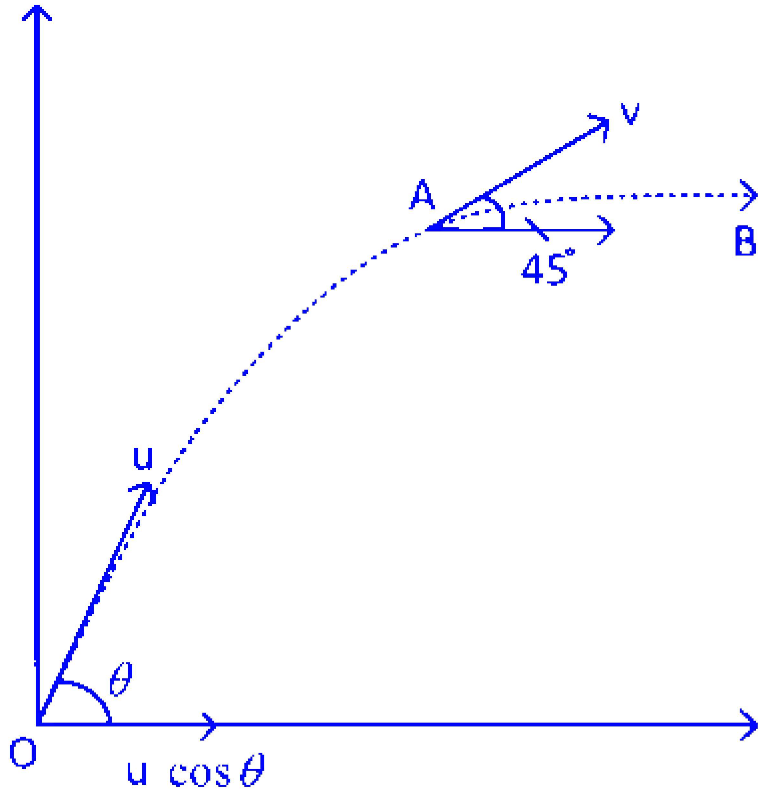
B. 11 ms^{-1}

C. $10\sqrt{2}$ ms^{-1}

D. 20 ms^{-1}

Answer: A

Solution:



Let in is body reaches upto point A and after two more second, it reaches upto point B

Total time of ascent for a body is,

$$t_{\text{ascent}} = 2 + 1 = 3 \text{ s}$$
$$t_{\text{ascent}} = \frac{\text{Time of flight}}{2} = \frac{2u \sin \theta}{2 \times g}$$
$$\frac{u \sin \theta}{g} = 3 \Rightarrow u \sin 45^\circ = 30 \quad \ldots \text{(i)}$$

Horizontal component of velocity remains always constant,

$u \cos 45^\circ = v \cos 45^\circ \quad \ldots$ (ii)

For vertical upward motion between point O and A,

$v_y = u_y - gt$
$v \sin 45^\circ = u \sin 45^\circ - 10 \times 1$
$\frac{v}{\sqrt{2}} = 30 - 10 \quad$ from Eq. (i)
$v = 20\sqrt{2}$ m/s

Putting this value in Eq. (ii),

$u \cos 45^\circ = 20\sqrt{2} \times \frac{1}{\sqrt{2}} = 20 \quad \ldots$ (iii)

From Eq. (i) and Eq. (iii),

$u^2 \sin^2 45^\circ + u^2 \cos^2 45^\circ = (30)^2 + (20)^2$
$u^2 = 1300$
$u = 10\sqrt{13}$ m/s

Question32

A projectile is launched from the ground, such that it hits a target on the ground which is 90 m away. The minimum velocity of projectile to hit the target is (acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A. 10 ms^{-1}

B. 16 ms^{-1}

C. 60 ms^{-1}

D. 30 ms^{-1}

Answer: D

Solution:

To solve this problem, we will use the kinematic equations for projectile motion. Let's assume the projectile is launched at an angle θ with an initial velocity v_0. The range of the projectile, which is the horizontal distance it covers, is given by:

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

where:

- R is the range (90 meters in this case)
- v_0 is the initial velocity
- g is the acceleration due to gravity ($10 \ \mathrm{ms}^{-2}$)
- θ is the angle of projection

To hit the target at the minimum velocity, the projectile should be launched at the optimum angle, which is 45 degrees ($\sin 2\theta = \sin 90^{\circ} = 1$). Thus, the equation simplifies to:

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

Now, rearrange the equation to solve for v_0:

$v_0^2 = R \cdot g$

Substitute the values of R and g:

$v_0^2 = 90 \, \mathrm{m} \cdot 10 \, \mathrm{ms}^{-2}$

$v_0^2 = 900 \, \mathrm{m}^2 \mathrm{s}^{-2}$

Take the square root of both sides to find v_0:

$v_0 = \sqrt{900} \, \mathrm{ms}^{-1}$

$v_0 = 30 \, \mathrm{ms}^{-1}$

Therefore, the minimum velocity of the projectile to hit the target is:

Option D: $30 \ \mathrm{ms}^{-1}$

Question33

A force $\mathbf{F}_1$ of magnitude 4 N acts on an object of mass 1 kg , at origin in a direction 30° above the positive X-axis. A second F_2 of magnitude 4 N acts on the same object in the direction of the positive Y-axis. The magnitude of the acceleration of the object is nearly.

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Options:

A. $6.9 \ \mathrm{ms}^{-2}$

B. $7.6 \ \mathrm{ms}^{-2}$

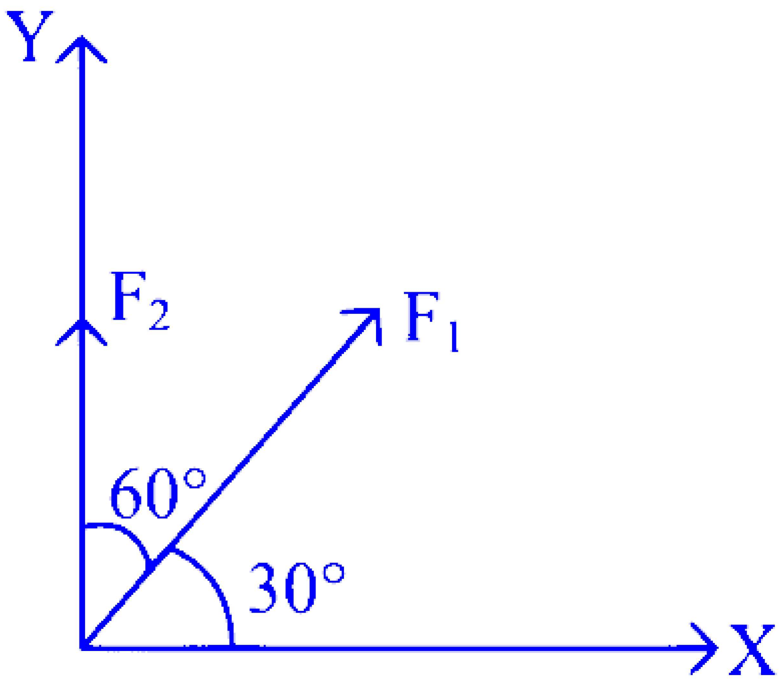
C. 4.3 ms^{-2}

D. 8.0 ms^{-2}

Answer: A

Solution:

The given situation is shown below



Given, $m = 1$ kg

$|F_1| = 4$ N
$|F_2| = 4$ N

From the figure, angle between force, F_1 and $F_2, \theta = 60^\circ$

$\because$ Magnitude of resultant force,

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$
$$= \sqrt{4^2 + 4^2 + 2 \times 4 \times 4 \times \cos 60^\circ}$$
$$= \sqrt{16 + 16 + 16} = 4\sqrt{3}\text{ N}$$

Magnitude of acceleration of the object

$$\mathbf{a} = \frac{F}{m} = \frac{4\sqrt{3}}{1} = 4\sqrt{3}$$
$$= 6.9\text{ m/s}^2$$

Question34

A car travels with a speed of $40 \mathrm{~km} \mathrm{~h}^{-1}$. Rain drops are falling at a constant speed vertically. The traces of the rain on the side windows of the car make an angle of 30° with the vertical. The magnitude of the velocity of the rain with respect to the car is

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Options:

A. $40 \sqrt{3} \mathrm{~km} \mathrm{~h}^{-1}$

B. $\frac{40}{\sqrt{3}} \mathrm{~km} \mathrm{~h}^{-1}$

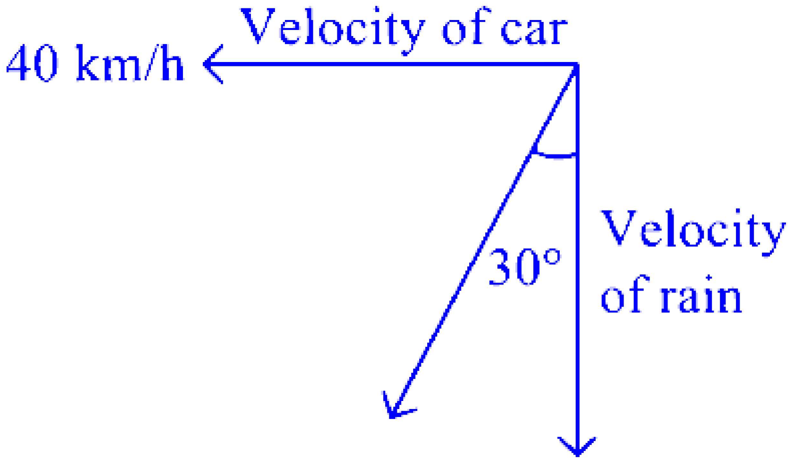
C. $80 \mathrm{~km} \mathrm{~h}^{-1}$

D. $\frac{80}{\sqrt{3}} \mathrm{~km} \mathrm{~h}^{-1}$

Answer: C

Solution:

The given situation can be described by the figure given below



$$\text{Thus, } \sin \theta=\frac{40}{\text{Velocity of rain w.r.t car}}$$

$$\Rightarrow \text{ velocity of rain }=\frac{40}{\sin \theta}$$

$$=\frac{40}{\frac{1}{2}} \quad\left[\because \theta=30^{\circ}\right]$$

$$=40 \times 2=80 \mathrm{kmh}^{-1}$$

Question35

A projectile with speed $50 \mathrm{~ms}^{-1}$ is thrown at an angle of 60° with the horizontal. The maximum height that can be reached is (acceleration due to gravity $=10 \mathrm{~ms}^{-2}$)

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Options:

A. 90.75 m

B. 70.00 m

C. 85.00 m

D. 93.75 m

Answer: D

Solution:

Speed of projectile, $u=50 \mathrm{~ms}^{-1}$

Angle of projection,

$\theta=60^{\circ}$
$g=10 \mathrm{~ms}^{-2}$

Maximum height attained by projectile,

$$H=\frac{u^2 \sin ^2 \theta}{2 g}$$
$$=\frac{50^2 \times \sin ^2 60^{\circ}}{2 \times 10}=\frac{2500 \times\left(\frac{\sqrt{3}}{2}\right)^2}{20}$$
$$=125 \times \frac{3}{4}=\frac{375}{4}$$
$$=93.75 \mathrm{~m}$$

Question36

A hiker stands on the edge of a cliff $490 \mathrm{~m}$ above the ground and throws a stone horizontally with an initial speed of $15 \mathrm{~ms}^{-1}$. The speed with which it hits the ground is

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Options:

A. $99 \mathrm{~ms}^{-1}$

B. $101 \mathrm{~ms}^{-1}$

C. $103 \mathrm{~ms}^{-1}$

D. $105 \mathrm{~ms}^{-1}$

Answer: A

Solution:

Given, height of cliff, $H=490 \mathrm{~m}$

Initial speed along X-axis, $u_x=15 \mathrm{~ms}^{-1}$

and initial speed along Y-axis, $u_y=0 \mathrm{~ms}^{-1}$

Acceleration due to gravity $g=10 \mathrm{~ms}^{-2}$

As we know that, for motion along Y-axis,

$$
\begin{aligned}
& v_y^2-u_y^2=2 g H \\
\Rightarrow \quad & v_y=\sqrt{2 g H} \\
& =\sqrt{2 \times 10 \times 490}=70 \sqrt{2} \mathrm{~ms}^{-1} \\
& =99 \mathrm{~ms}^{-1}
\end{aligned}
$$

Question37

Two paper screens A and B are separated by $150 \mathrm{~m}$. A bullet pierces A and than B. The hole in B is $15 \mathrm{~cm}$ below the hole in A. If the

bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is $\left(g = 10 \text{ ms}^{-2}\right)$

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Options:

A. $100\sqrt{3} \text{ ms}^{-1}$

B. $200\sqrt{3} \text{ ms}^{-1}$

C. $300\sqrt{3} \text{ ms}^{-1}$

D. $500\sqrt{3} \text{ ms}^{-1}$

Answer: D

Solution:

Given, separation between two papers A and B, $s = 150$ m

Height between hole A and B, $H = 15$ cm

$= 15 \times 10^{-2}$ m

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

Let, time taken to go from A to B be t.

Velocity of bullet at point A be v.

Since, $H = (1/2)gt^2$

$\Rightarrow \quad t = \sqrt{\frac{2H}{g}}$ [for accelerated motion]

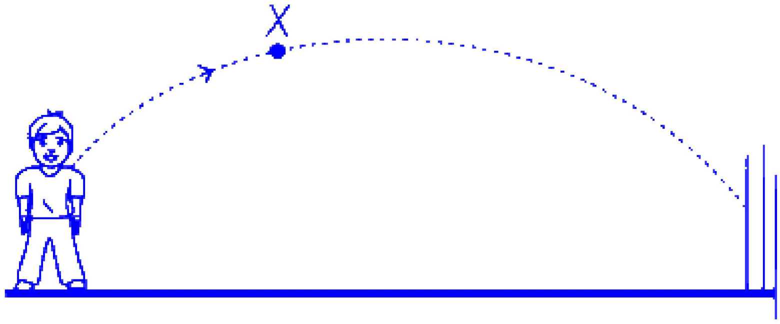
$\Rightarrow \quad t = \sqrt{\frac{2\times15}{100\times10}} = 10^{-1}\sqrt{3}$ s

and $v = \frac{s}{t}$[for non-accelerated motion]$\therefore \quad v = \frac{150}{10^{-1}\sqrt{3}} = 500\sqrt{3} \text{ ms}^{-1}$

Question38

A boy throws a cricket ball from theboundary to the wicket keeper. If thefrictional force due to air (f_a) cannot beignored, the forces

acting on the ball at theposition X are represented by



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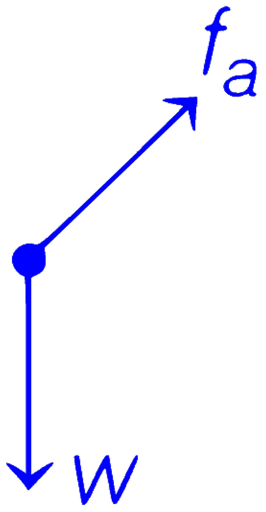
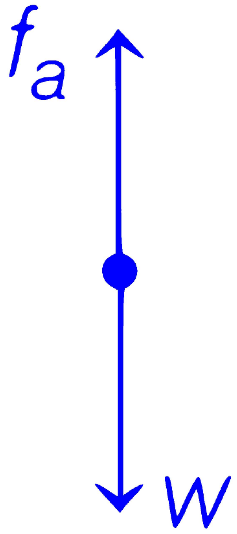
Options:

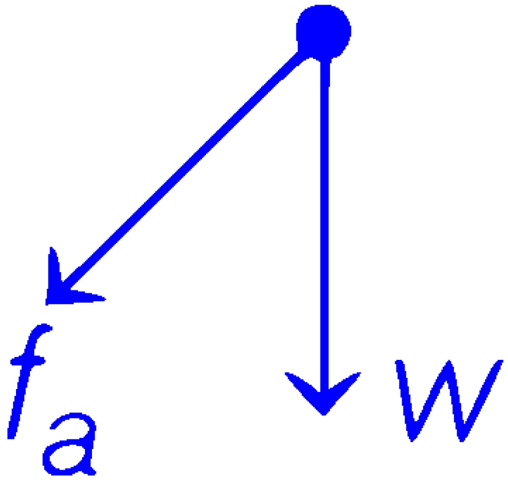
A.



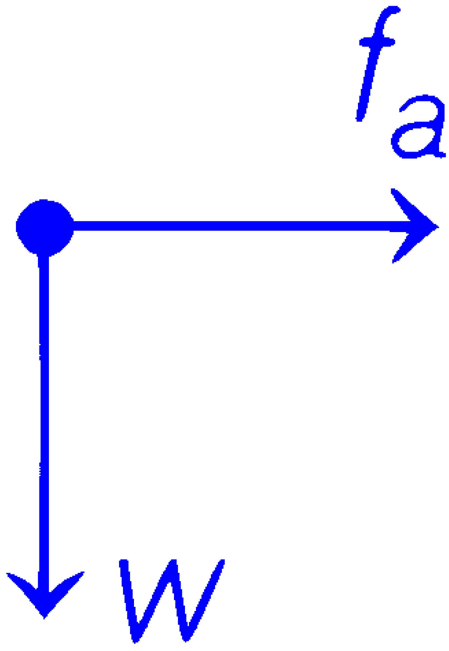
B.



C.



D.

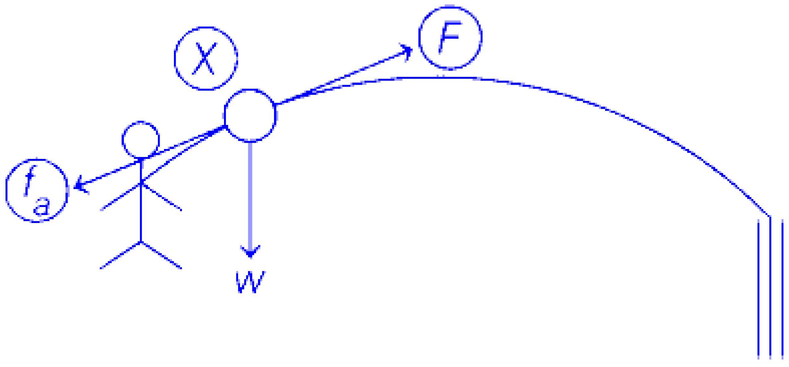


Answer: C

Solution:

Given, friction force due to air = f_a

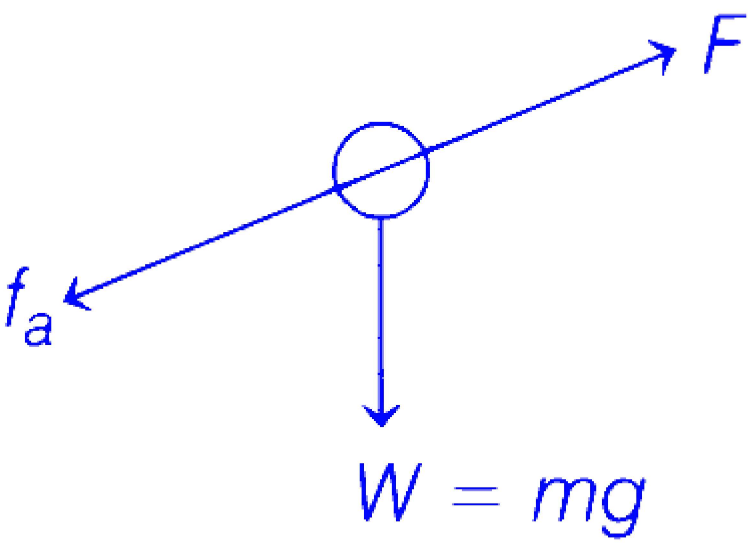
According to given diagram



Let W be the weight of ball.

As, we know that, weight W is always perpendicular towards earth and friction force f_a is always in opposite direction of net force.

$\therefore$ Free body diagram of ball will be



Question39

A particle of mass m is projected with avelocity u making an angle θ with thehorizontal. The magnitude of angularmomentum of the projectile about the pointof projection when the particle is at itsmaximum height is

Options:

A. 0

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

C. $\frac{2mu^2\cos^2\theta\sin\theta}{g}$

D. $\frac{mu^3\sin^2\theta\cos\theta}{2g}$

Answer: D

Solution:

Given, mass of particle $= m$

Velocity $= u$

Angle of projection $= \theta$

Let angular momentum, $L = mvr$

Maximum height $= H$

As we know that,

$$H = \frac{u^2\sin^2\theta}{2g} = r$$
$$\therefore \quad L = m \cdot u\cos\theta \cdot r$$
$$\Rightarrow \quad L = mu\cos\theta\left(\frac{u^2\sin^2\theta}{2g}\right)$$
$$\Rightarrow \quad L = \frac{mu^3\sin^2\theta\cos\theta}{2g}$$

Question40

When a ball is thrown with a velocity of 50 ms^{-1} at an angle 30ϒ with the horizontal, it remains in the air for .... s.

(Take, g = 10 ms^{-2})

Options:

A. 5

B. 2.5

C. 1.25

D. 0.625

Answer: A

Solution:

The time of flight of a projectile is the time it takes for the projectile to return to the same vertical position from which it was launched. The time of flight can be calculated using the following equation:

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

where:

T = time of flight

u = initial velocity

θ = angle of projection

g = acceleration due to gravity

In this case, the initial velocity is 50 ms^{-1}, the angle of projection is 30ϒ, and the acceleration due to gravity is 10 ms^{-2}. Plugging these values into the equation, we get:

$T = \frac{2\times50\times\sin30}{10}$

$T = \frac{2\times50\times0.5}{10}$

$T = \frac{50}{10}$

$T = 5s$

Therefore, the ball remains in the air for **5 s**.

So the answer is **Option A**.
