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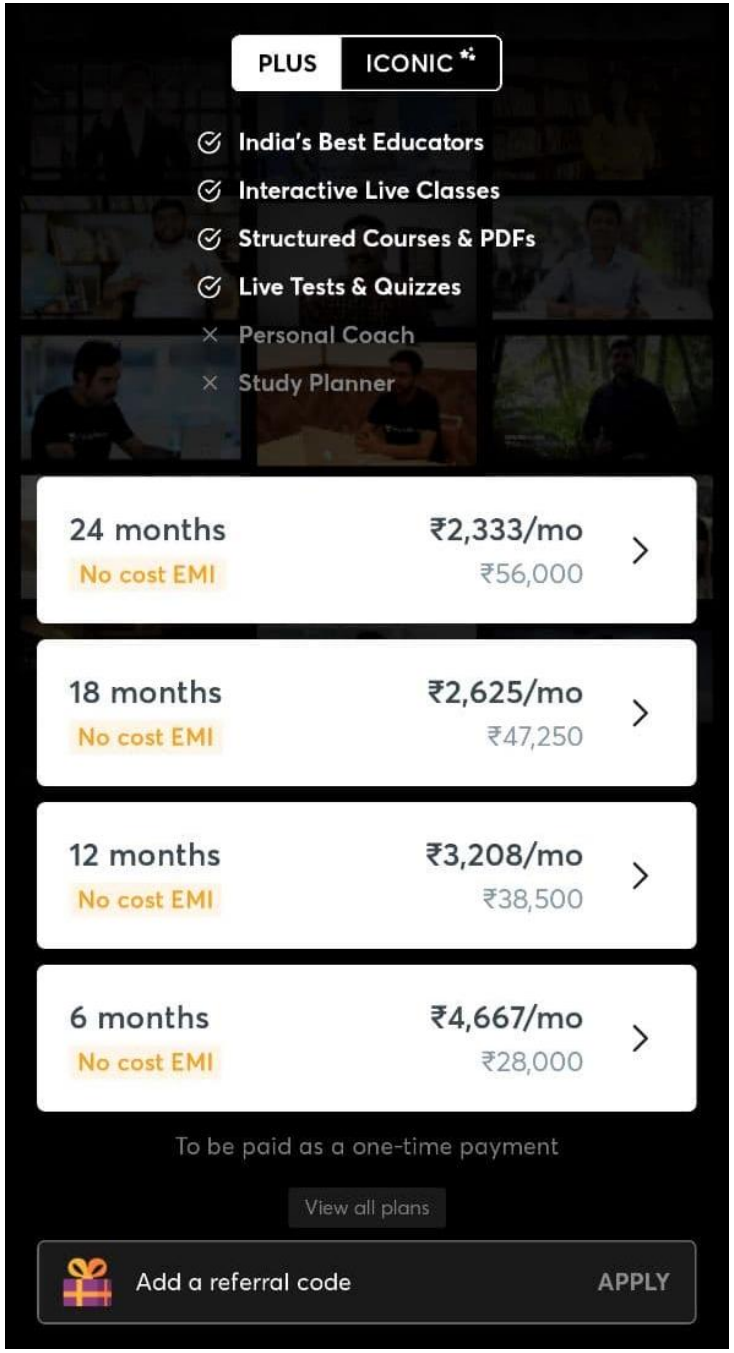

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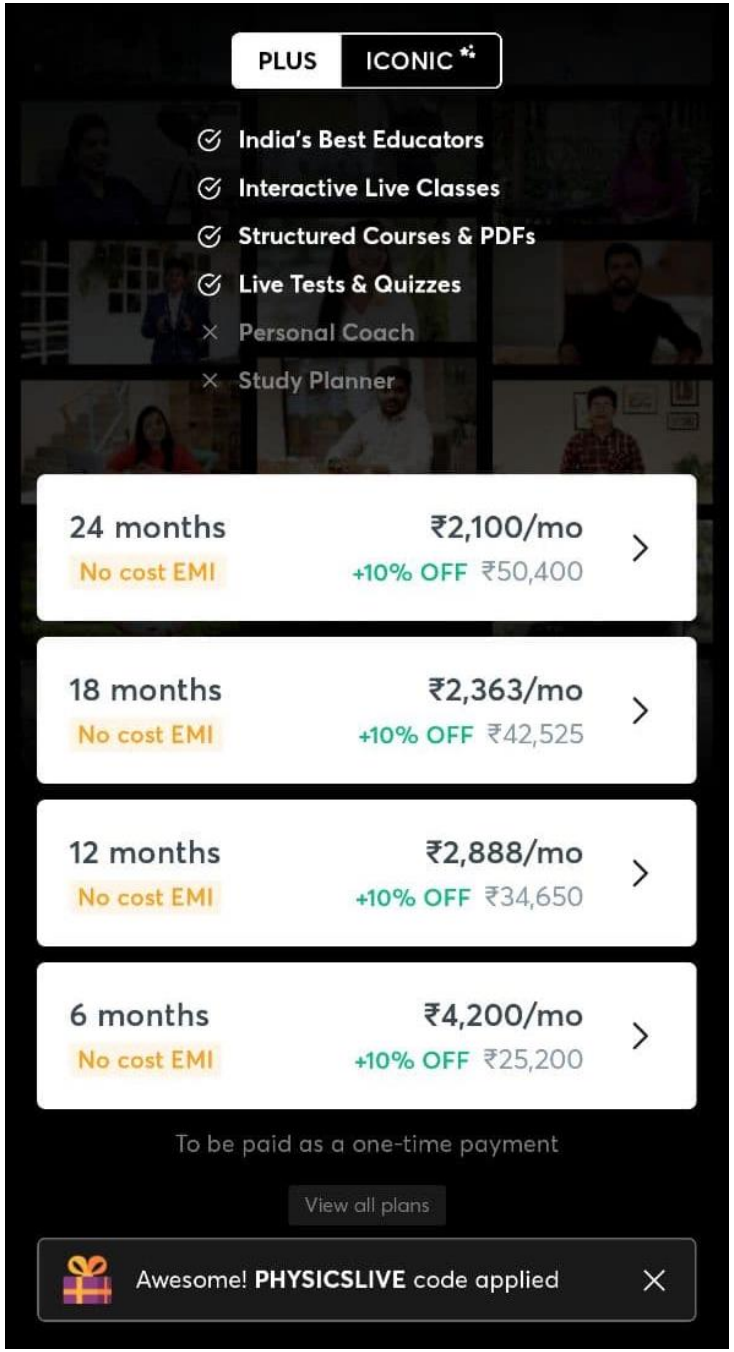

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JEE Main & Advanced, NSEP, INPhO, IPhO
Physics DPP

DPP-6 Projectile Motion on inclined plane

By Physicsaholics Team

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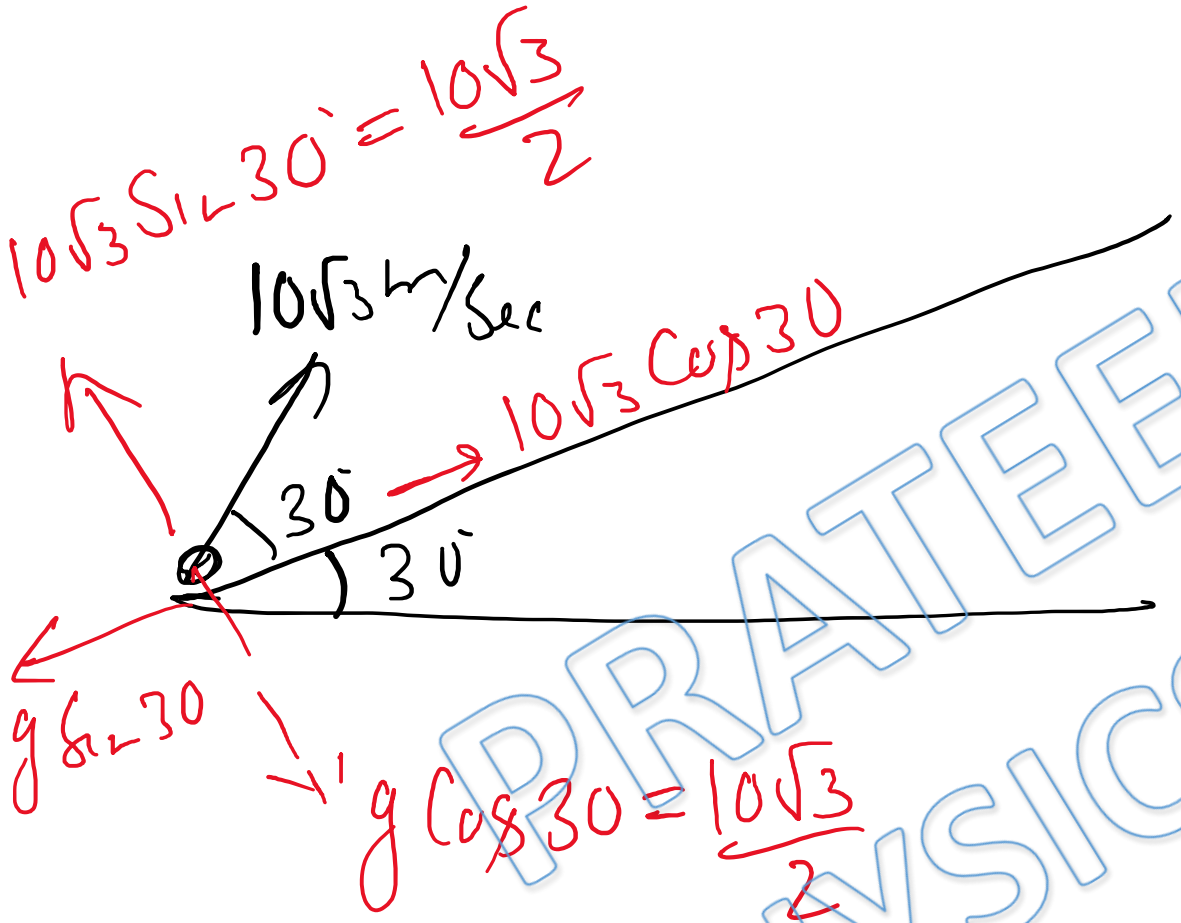
Q) On an inclined plane of inclination 30º, a ball is thrown at an angle of 60º with the horizontal from the foot of the incline with a velocity of $10\sqrt{3}$ m/s. If g = 10 m/s^2, hen find the time in which ball will hit the inclined plane?

(a) 1 s (b) 2 s (c) 3 s (d) 4 s

Ans. b

Solution:



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

$$= \frac{2 \times 10\sqrt{3}/2}{10\sqrt{3}/2}$$

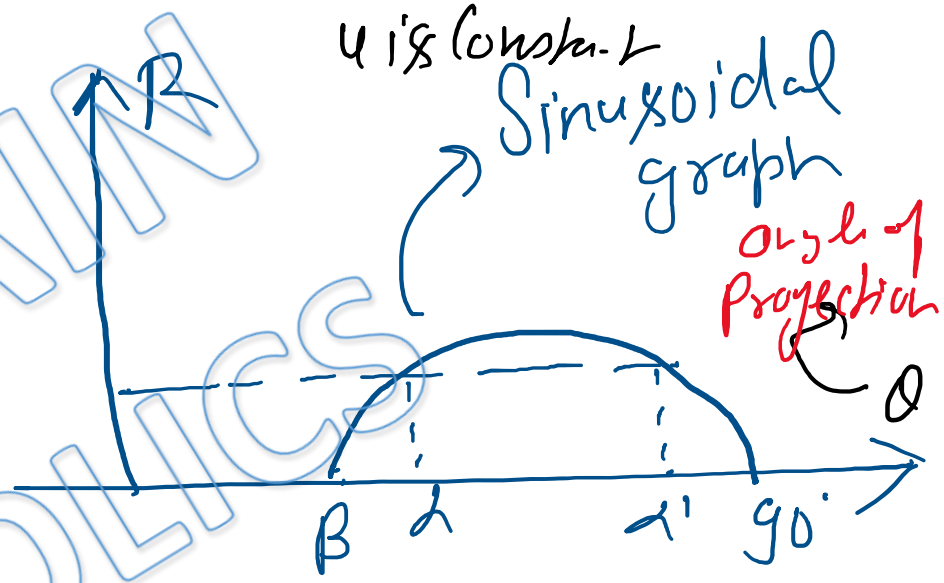
$$= 2 \text{ Sec}$$

Q) Two bodies are projected from the same point with equal speeds in such a directions that they strike on the same point on a plane whose inclination is β. If α the angle of projection of the first, ratio of there times of flight is

(a) $\frac{\sin\alpha}{\cos\beta}$ (b) $\frac{\sin\alpha}{\sin\beta}$ (c) $\frac{\sin(\alpha-\beta)}{\cos\beta}$ (d) $\frac{\sin(\alpha-\beta)}{\cos\alpha}$

Ans. d

Solution:



at angle α

$$T_1 = \frac{2u\sin(\alpha-\beta)}{g\cos\beta}$$

at angle α'

$$T_2 = \frac{2u\sin(\alpha'-\beta)}{g\cos\beta}$$

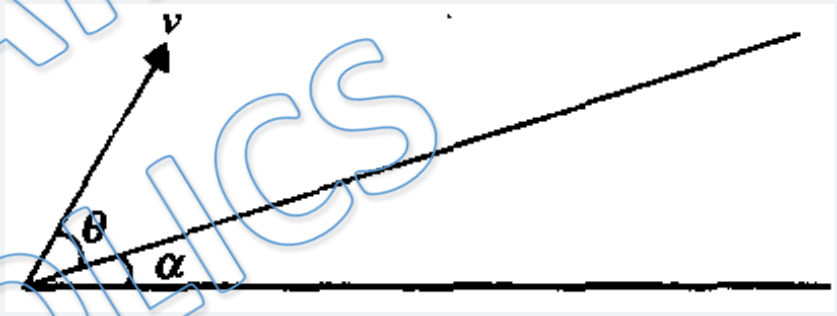
by symmetry

$\alpha - \beta = 90^\circ - \alpha'$

$\alpha' = 90^\circ - (\alpha-\beta)$

$$\frac{T_1}{T_2} = \frac{\sin(\alpha-\beta)}{\sin(90-\alpha)} = \frac{\sin(\alpha-\beta)}{\cos\alpha}$$

Q) A baseball is projected with a velocity v making an angle θ with the incline of indication α as shown in fig. Find the condition that the ball hits the incline at right angle.

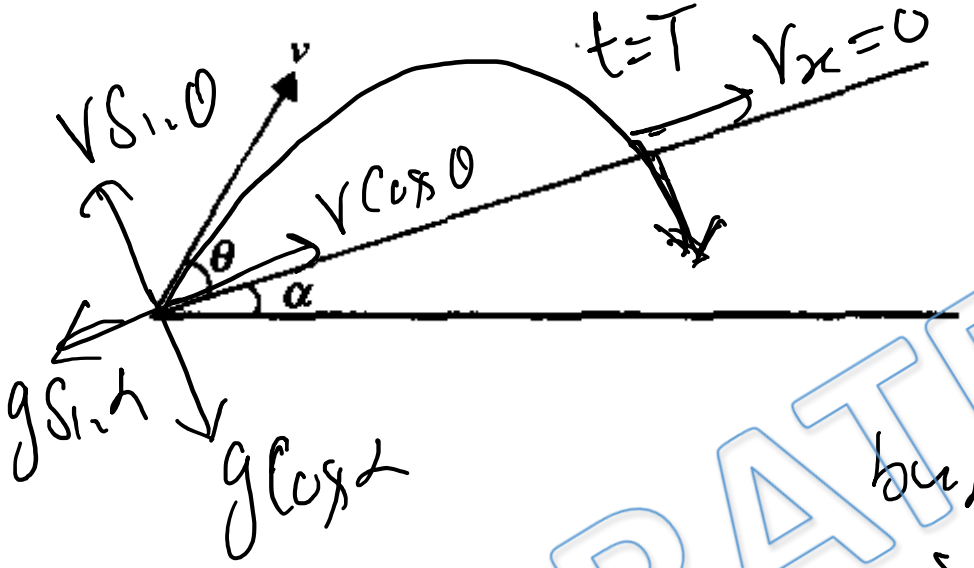


(a) $\cot\theta = 2\tan\alpha$ (b) $\sin\theta = \cos\alpha$

(c) $\tan\theta = \sin\alpha$ (d) $\cot\theta = \cos\alpha$

Ans. a

Solution:



time of flight $T = 2u_y/g_y$

$$T = \frac{2v\sin\theta}{g\cos\alpha}$$

at $t=T$, $v_x = 0$

but $v_x = u_x + a_x t$

$$\Rightarrow 0 = v\cos\theta - g\sin\alpha \times \frac{2v\sin\theta}{g\cos\alpha}$$

$$\Rightarrow \cos\theta = \frac{2\sin\alpha\sin\theta}{\cos\alpha}$$

$$\Rightarrow \cot\theta = 2\tan\alpha$$

Q) A projectile is required to hit a target whose coordinates relative to horizontal and vertical axes through the point of projection are (α, β). If the gun velocity is $\sqrt{2g\alpha}$, it is impossible to hit the target if

(a) $\beta > 3\alpha/4$

(b) $\beta \geq 1\alpha/4$

(c) $\beta \leq 3\alpha/4$

(d) $\beta \geq 3\alpha/4$

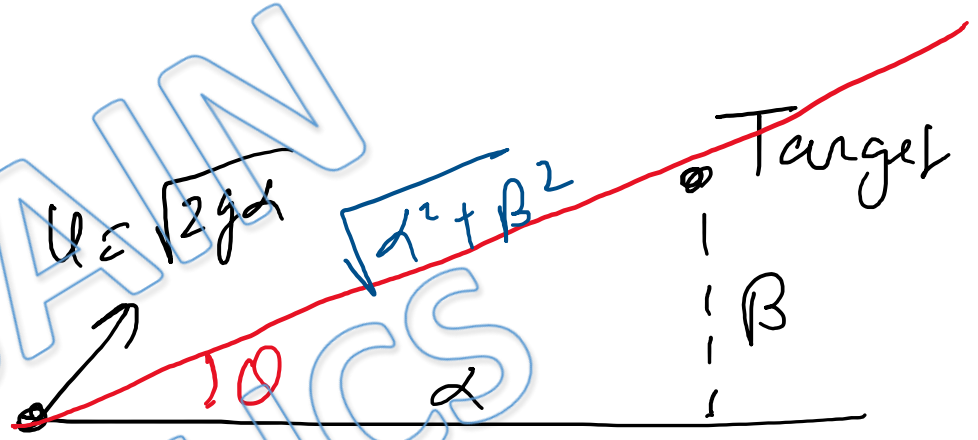
Ans. a

Solution:

Maximum Range on inclined plane

$$R_{max} = \frac{u^2}{g(1+\sin\theta)}$$

$$= \frac{2g\alpha}{g\left(1+\frac{\beta}{\sqrt{\alpha^2+\beta^2}}\right)}$$



If it is not possible to hit target if $R_{max} < \sqrt{\alpha^2+\beta^2}$

$$\frac{2\alpha}{1+\beta/\sqrt{\alpha^2+\beta^2}} < \sqrt{\alpha^2+\beta^2}$$

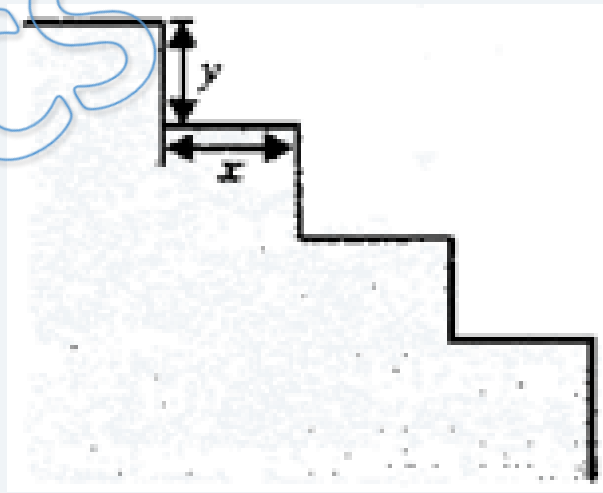
$$\Rightarrow 2\alpha < \sqrt{\alpha^2+\beta^2} + \beta$$

$$\Rightarrow 2\alpha - \beta < \sqrt{\alpha^2+\beta^2}$$

$$\Rightarrow 4\alpha^2 + \beta^2 - 4\alpha\beta < \alpha^2 + \beta^2$$

$$\Rightarrow 3\alpha^2 < 4\alpha\beta \Rightarrow \beta > 3\alpha/4$$

Q) A marble rolls down from top of a staircase with constant horizontal velocity 10 m/s. If each step is y = 1 meter high and x = 1 meter wide. To which step the marble will strike directly? (g = 9.8 m/s^2)



(a) 21st

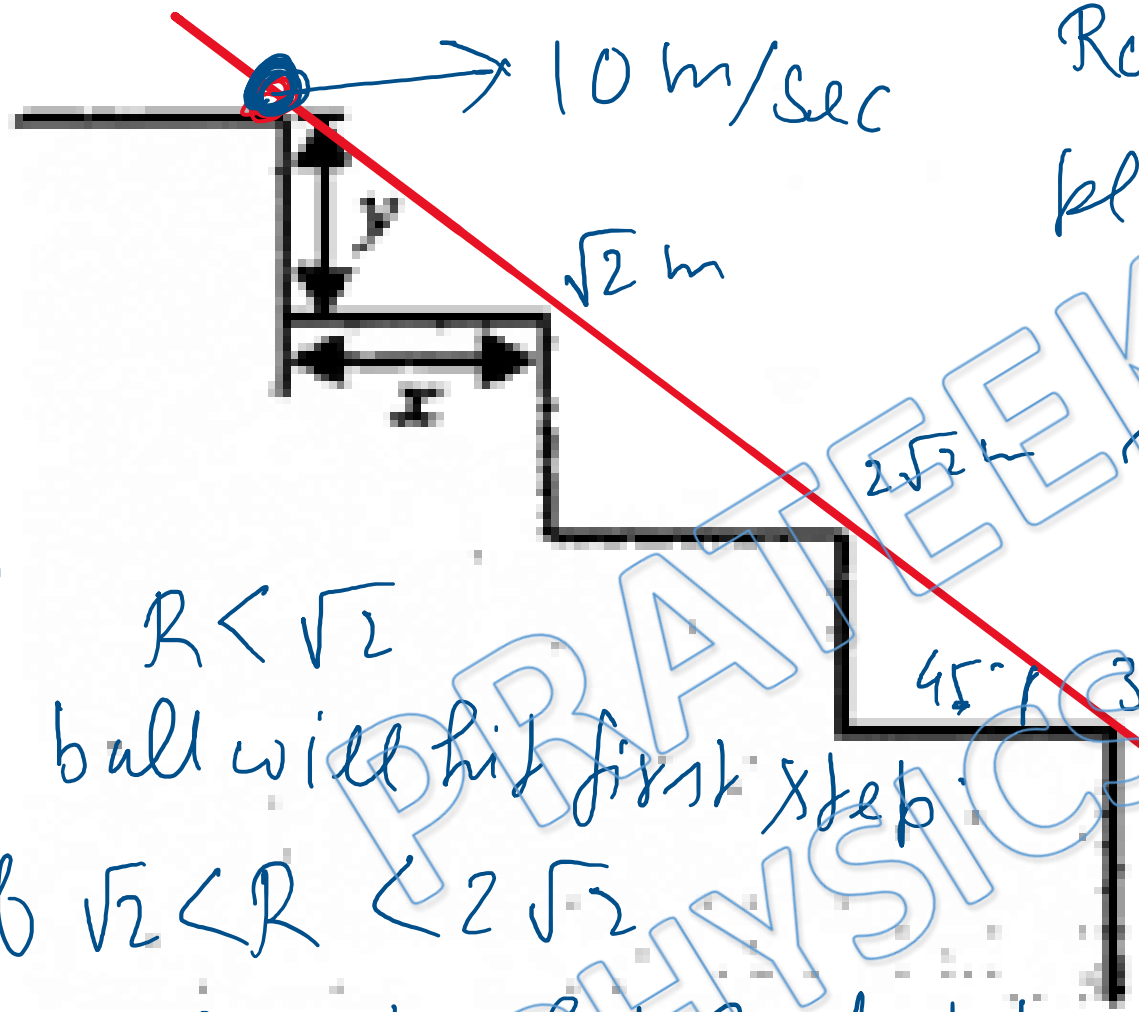
(b) 8th

(c) 10th

(d) 18th

Ans. a

Solution:



Range of ball on inclined plane $R = \frac{2u^2 \cos(45° - 45°) \sin 45°}{g \cos^2 45°}$

$R = \frac{2 \times 100 \times 1 \times 1/\sqrt{2}}{g \times 1/2}$

$= \frac{200\sqrt{2}}{g} = (20.\ldots)\sqrt{2}$

Since $20\sqrt{2} < R < 21\sqrt{2}$

$\Rightarrow$ ball will hit 21st step

If $R < \sqrt{2}$

$\Rightarrow$ ball will hit first step.

If $\sqrt{2} < R < 2\sqrt{2}$

$\Rightarrow$ ball will hit 2nd step

Imaginary inclined plane

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Q) A particle is projected from origin of coordinate system. A target is fixed at point (40m, 30m). Find the minimum velocity of projectile to hit the target? (g = 10 m/s^2)

(a) $10\ m/s$

(b) $17\ m/s$

(c) $20\sqrt{2}\ m/s$

(d) $10\sqrt{5}\ m/s$

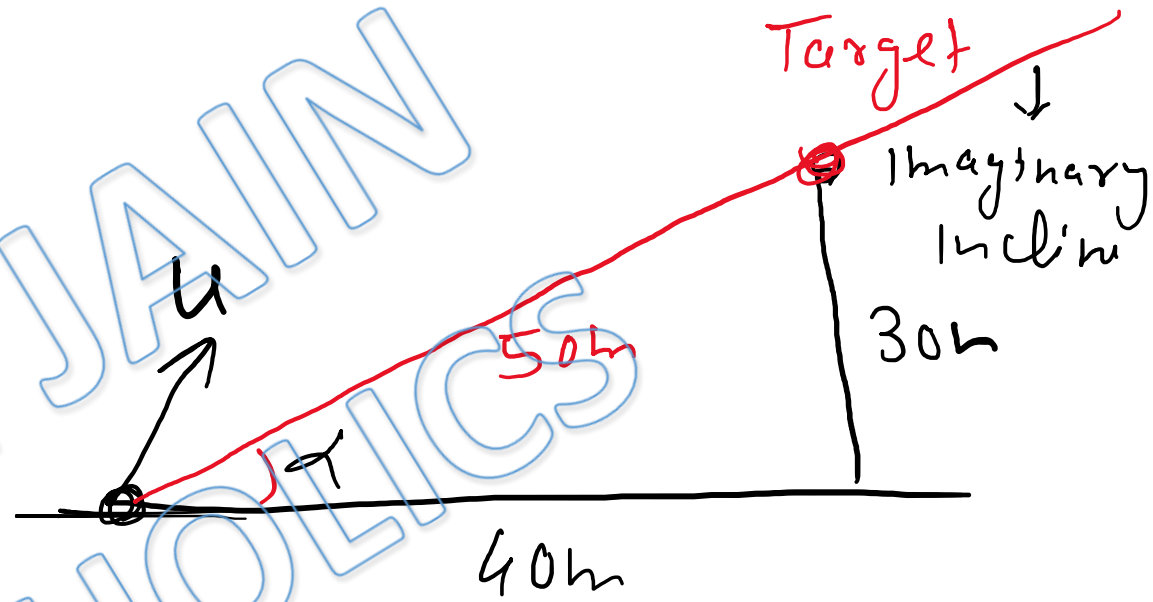
Ans. c

Solution:

$$R_{max} = \frac{u^2}{g(1+\sin\alpha)}$$

$$\Rightarrow 50 = \frac{u^2}{10\left(1+\frac{30}{50}\right)}$$

$$\Rightarrow u^2 = 800 \Rightarrow u = 20\sqrt{2}\ m/sec.$$



✡ at $u = 20\sqrt{2}$ max Range is 50m. means it is just possible to hit target.

If $u < 20\sqrt{2}$ max Range will be less than 50m & particle will not be able to hit target.

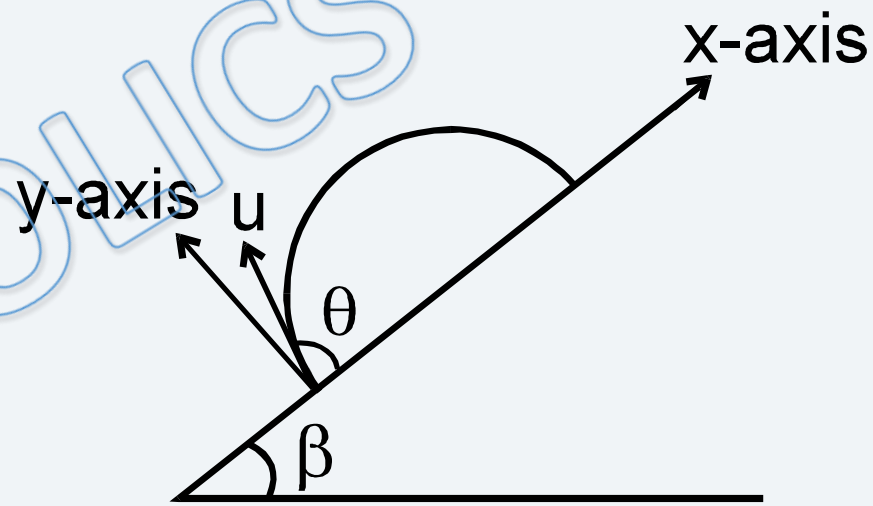
Q) A particle is projected at an angle θ with an inclined plane making an angle β with the horizontal as shown in figure, speed of the particle is u, after time t find y component of velocity when particle is at maximum distance from the incline plane ?

(a) $\frac{u}{\sqrt{2}}$

(b) $\frac{2u}{\sqrt{3}}$

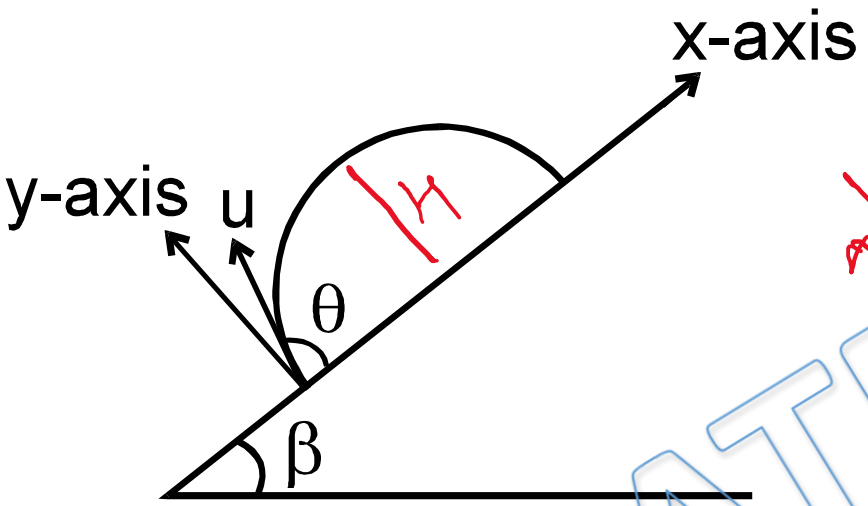
(c) $\frac{\sqrt{2}u}{3}$

(d) zero



Ans. d

Solution:



Projection of motion on y axis →

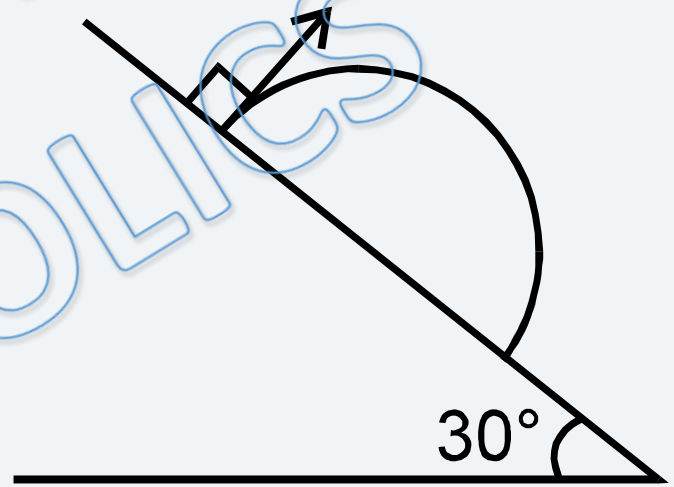
$V_y = 0$

H

u_y

at maximum distance from incline $V_y = 0$

Q) A ball is projected from point A with a velocity 10 m/s perpendicular to the inclined plane as shown in figure. Range of the ball on the inclined plane is :



(a) $\frac{40}{3}$ m

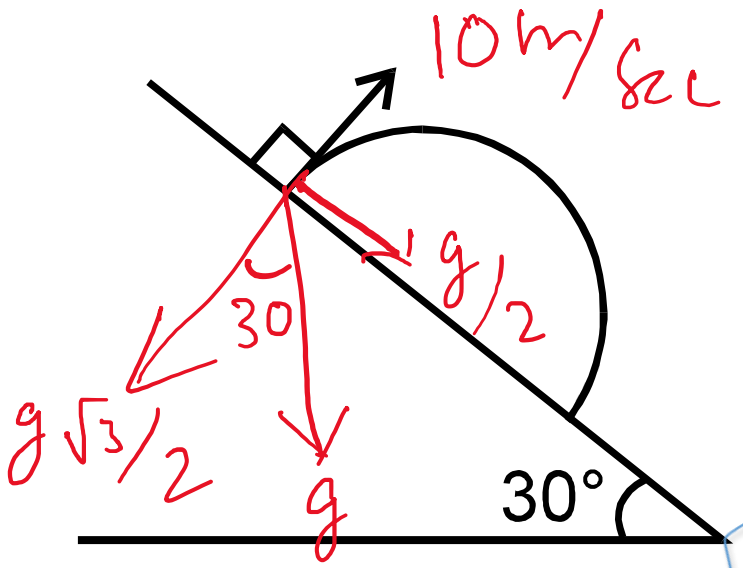
(b) $\frac{20}{13}$ m

(c) $\frac{13}{20}$ m

(d) $\frac{13}{40}$ m

Ans. a

Solution:



$$T = \frac{2u_y}{g_y} = \frac{2 \times 10}{g\sqrt{3}/2} = \frac{4}{\sqrt{3}}$$

$$R = u_x T + \frac{1}{2} a_x T^2$$

$$= 0 + \frac{1}{2} \times \frac{g}{2} \times \frac{16}{3}$$

$$= \frac{40}{3} \text{ m}$$

Q) A plane surface is inclined making an angle θ with the horizontal. From the bottom of this inclined plane, a bullet is fired with velocity v. The maximum possible range of the bullet on the inclined plane is

(a) $\frac{V^2}{g}$

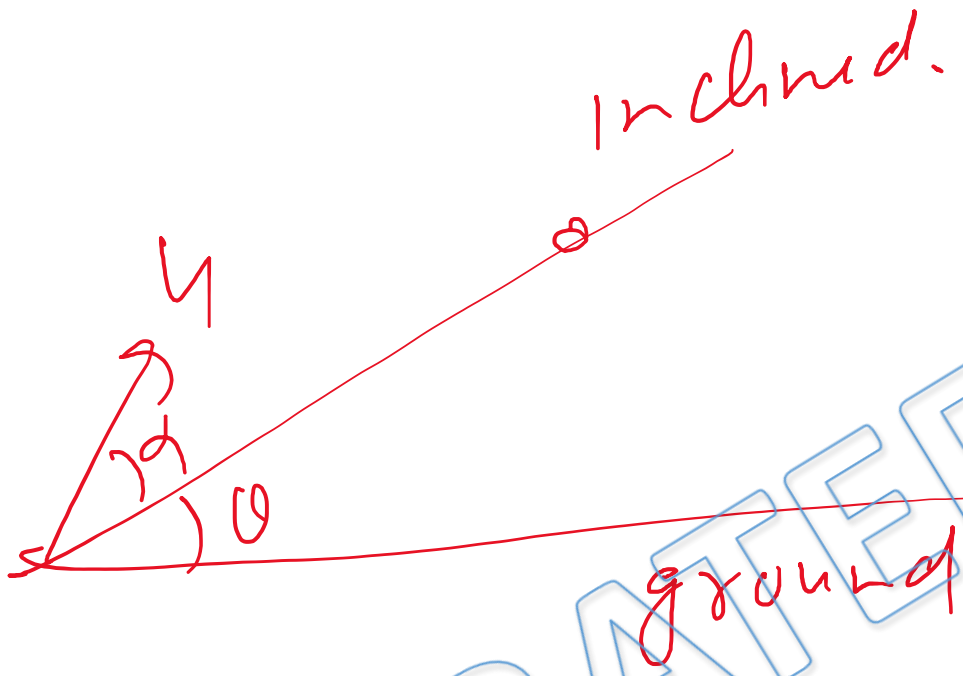
(b) $\frac{V^2}{g(1+\sin\theta)}$

(c) $\frac{V^2}{g(1-\sin\theta)}$

(d) $\frac{V^2}{g(1+\cos\theta)}$

Ans. b

Solution:



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

$$R = \frac{u^2[\sin(2\theta+\alpha)-\sin\theta]}{g(1-\sin^2\theta)}$$

$$R_{max} = \frac{u^2(1-\sin\theta)}{g(1-\sin\theta)(1+\sin\theta)}$$

$$= \frac{u^2}{g(1+\sin\theta)}$$

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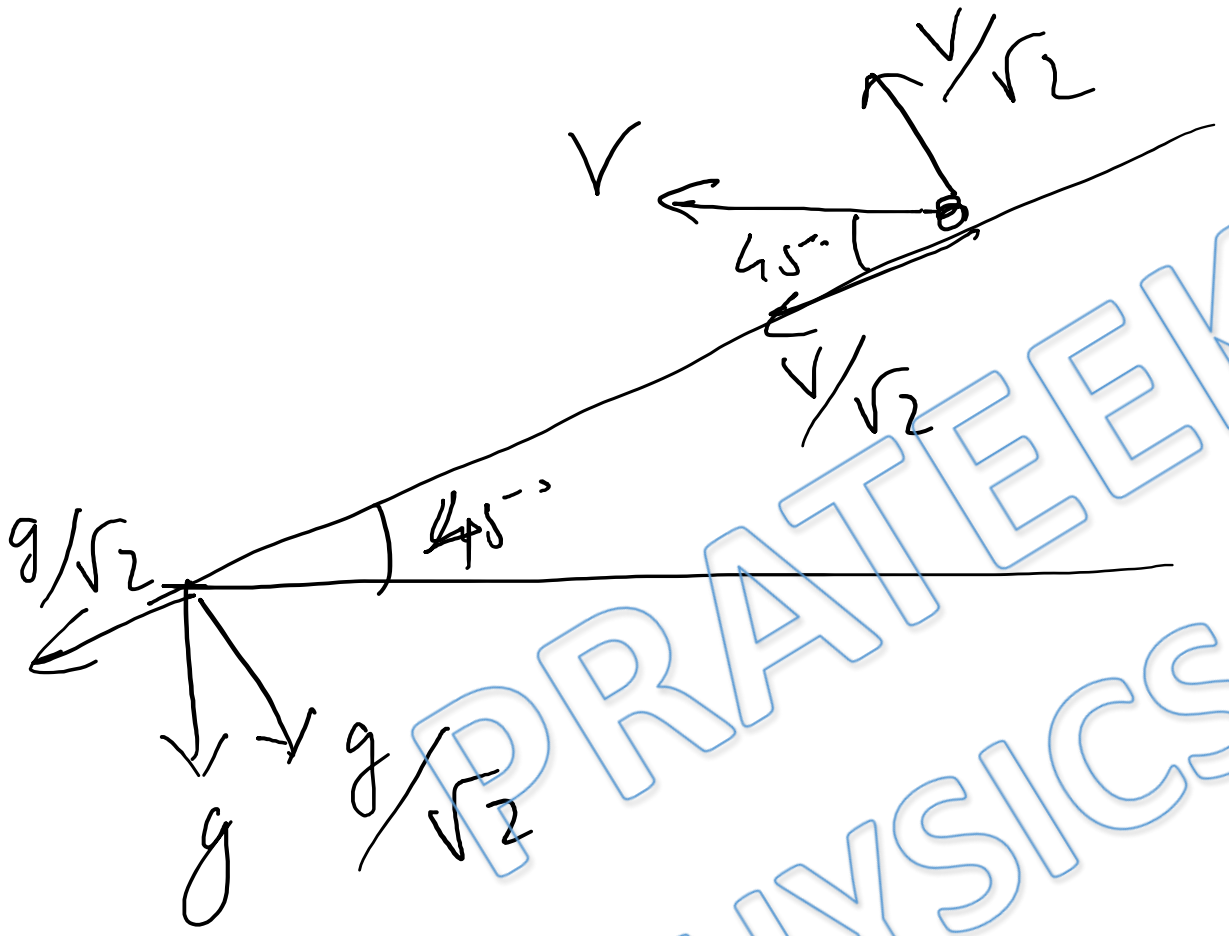
Q) A ball is projected horizontal with a speed v from the top of a plane inclined at an angle 45° with the horizontal. How far from the point of projection with the ball strike the plane?

(a) $\frac{V^2}{g}$ (b) $\sqrt{2}\frac{V^2}{g}$ (c) $\frac{2V^2}{g}$ (d) $\sqrt{2}\left[\frac{2V^2}{g}\right]$

Ans. d

Solution:



$$T = \frac{2u_y}{g_y} = \frac{2V/\sqrt{2}}{g/\sqrt{2}} = \frac{2V}{g}$$

$$R = u_x T + \frac{1}{2} a_x T^2$$

$$= \frac{V}{\sqrt{2}} \times \frac{2V}{g} + \frac{1}{2} \times \frac{g}{\sqrt{2}} \frac{4V^2}{g^2}$$

$$= \frac{4V^2}{g\sqrt{2}} = \frac{2\sqrt{2}V^2}{g}$$

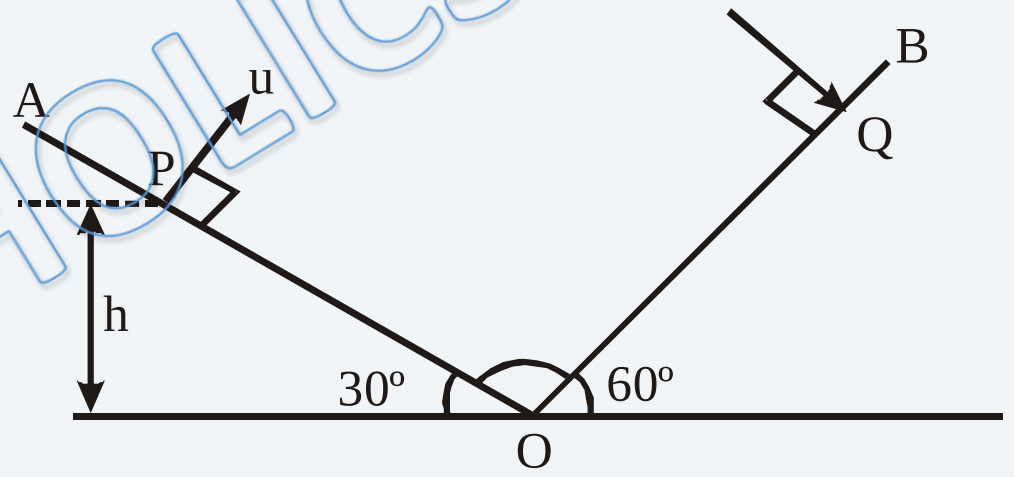
Q) Two inclined planes OA and OB having inclination with horizontal) 30º and 60º respectively, intersect each other at O as shown in figure. A particle is projected from point P with velocity $u = 10\sqrt{3}$ m/s Along a direction perpendicular to plane OA. If the particle strikes plane OB perpendicularly at Q, calculate Velocity with which particle strikes the plane OB? (g = 10 m/s^2)

(a) 10 m/s

(b) $10\sqrt{3}$ m/s

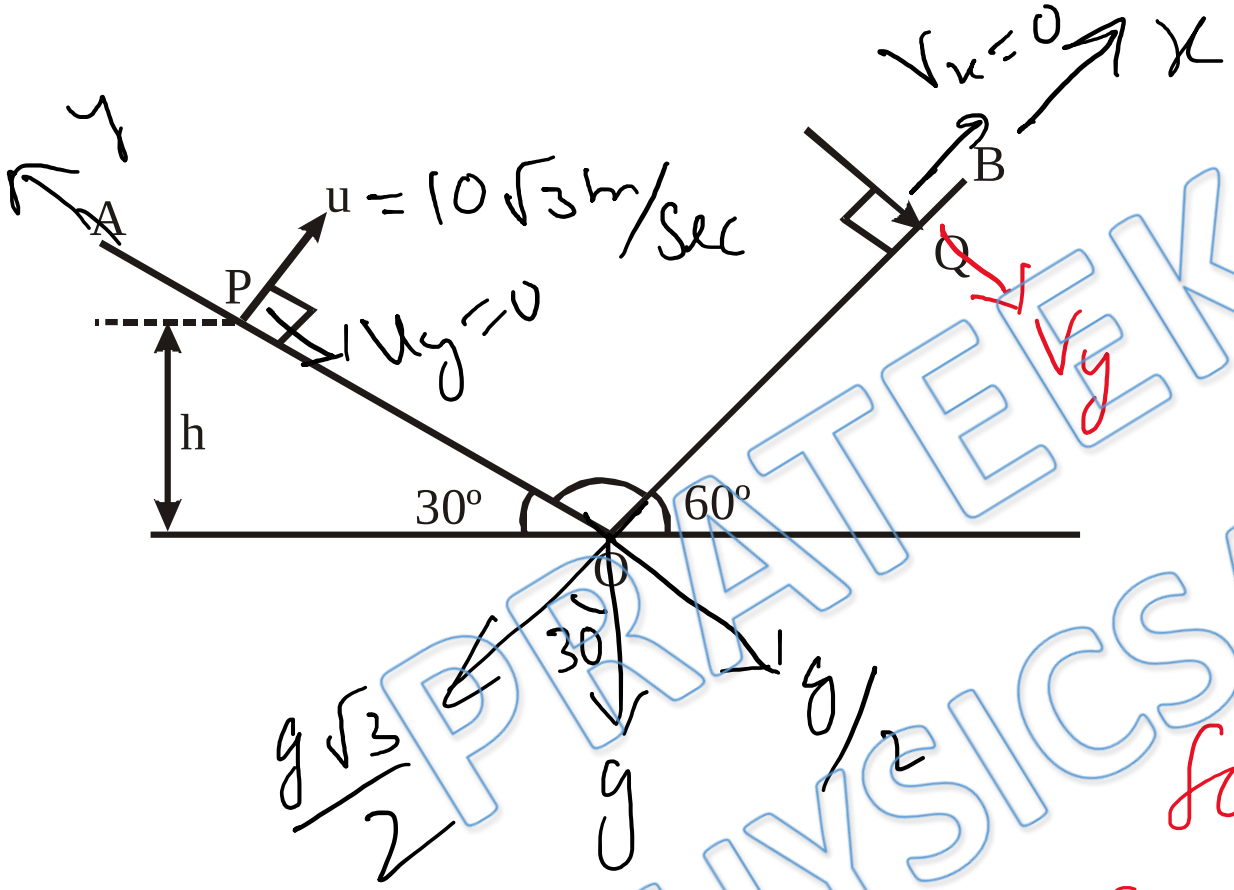
(c) $\sqrt{3}$ m/s

(d) $5\sqrt{3}$ m/s



Ans. a

Solution:



for motion along x axis

$v_x = u_x + a_x t$

$0 = 10\sqrt{3} - \frac{g\sqrt{3}}{2} t$

$t = 2$ Sec

for motion along y axis

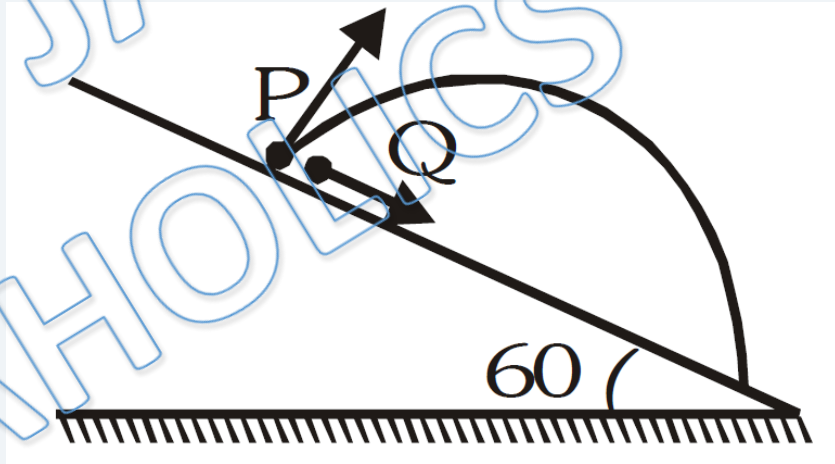
$v_y = u_y + a_y t = 0 + g/2 \times 2$

$= 10$ m/Sec Ans = 10 m/Sec

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

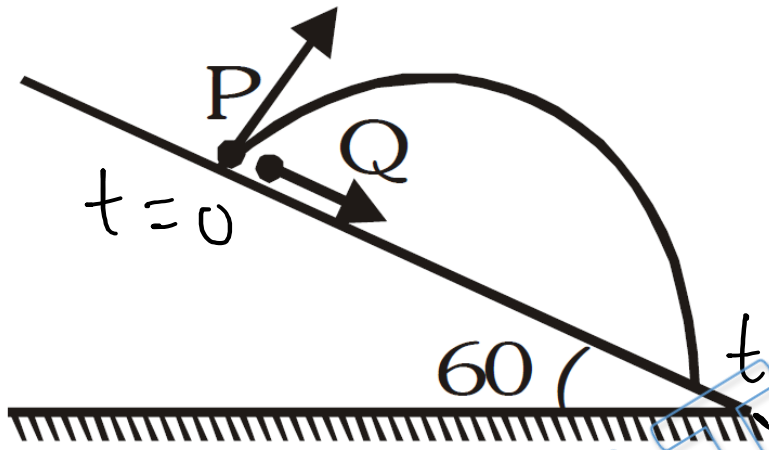
(a) 5 m/s (b) 10 m/s

(c) 15 m/s (d) 20 m/s



Ans. b

Solution:



for motion along x axis
P & Q both have same displacement, same time of motion & same acceleration ($g \sin 60°$)

Therefore their u_x must be same $\Rightarrow u_x = 0$

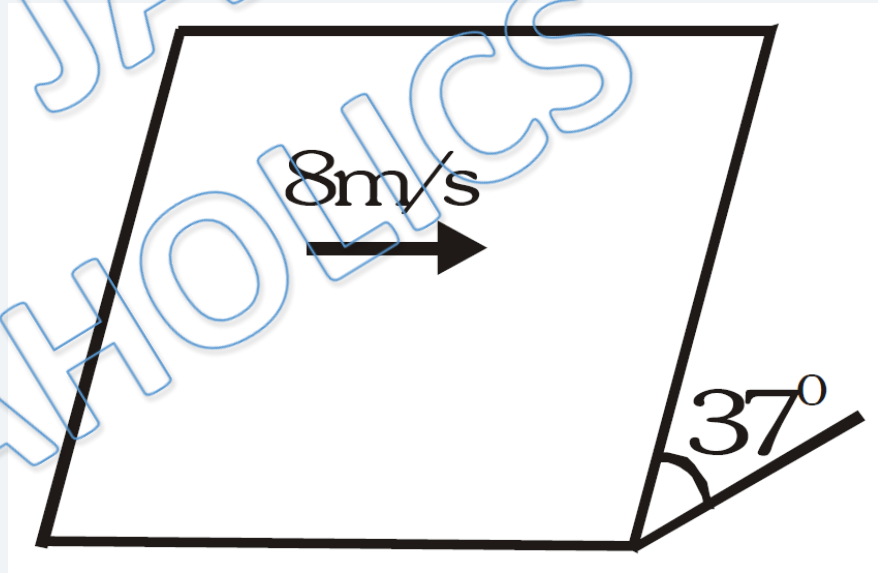
for P, $T = t = \frac{2u_y}{g_y} \Rightarrow \frac{2u_y}{g\cos 60°} = t$

$u_y = 10 \text{ m/sec} \Rightarrow$ initial velocity of $P = 10 \text{ m/sec}$

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

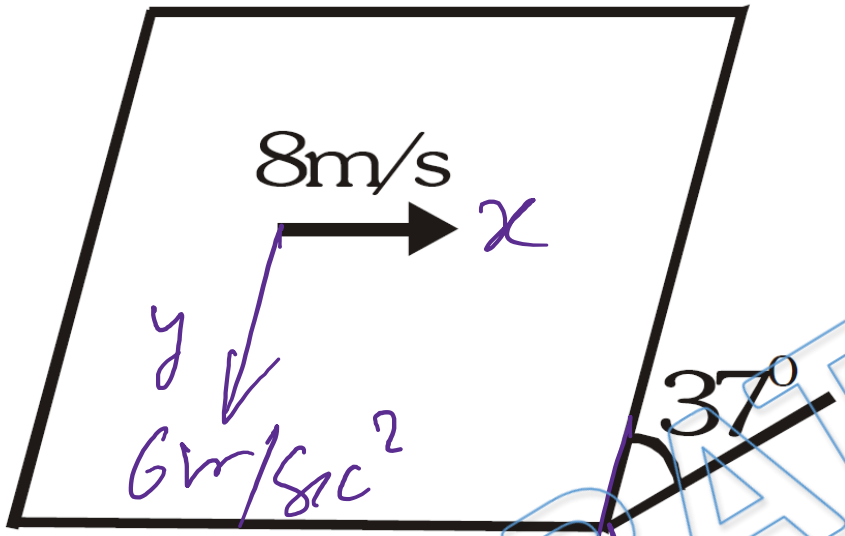
(a) 10 m/s (b) 12 m/s

(c) 15 m/s (d) 20 m/s



Ans. a

Solution:



motion along x axis is uniform

$\Rightarrow V_x = 8 m/sec$

motion along y axis has acceleration $6 m/sec^2$.

$V_y = u_y + a_y t = 0 + 6 \times 1$

$= 6 m/sec^2$

$g \sin 37° = 10 \times 3/5 = 6 m/sec^2$

at $t = 1$

$\vec{V} = 8\hat{i} + 6\hat{j}$

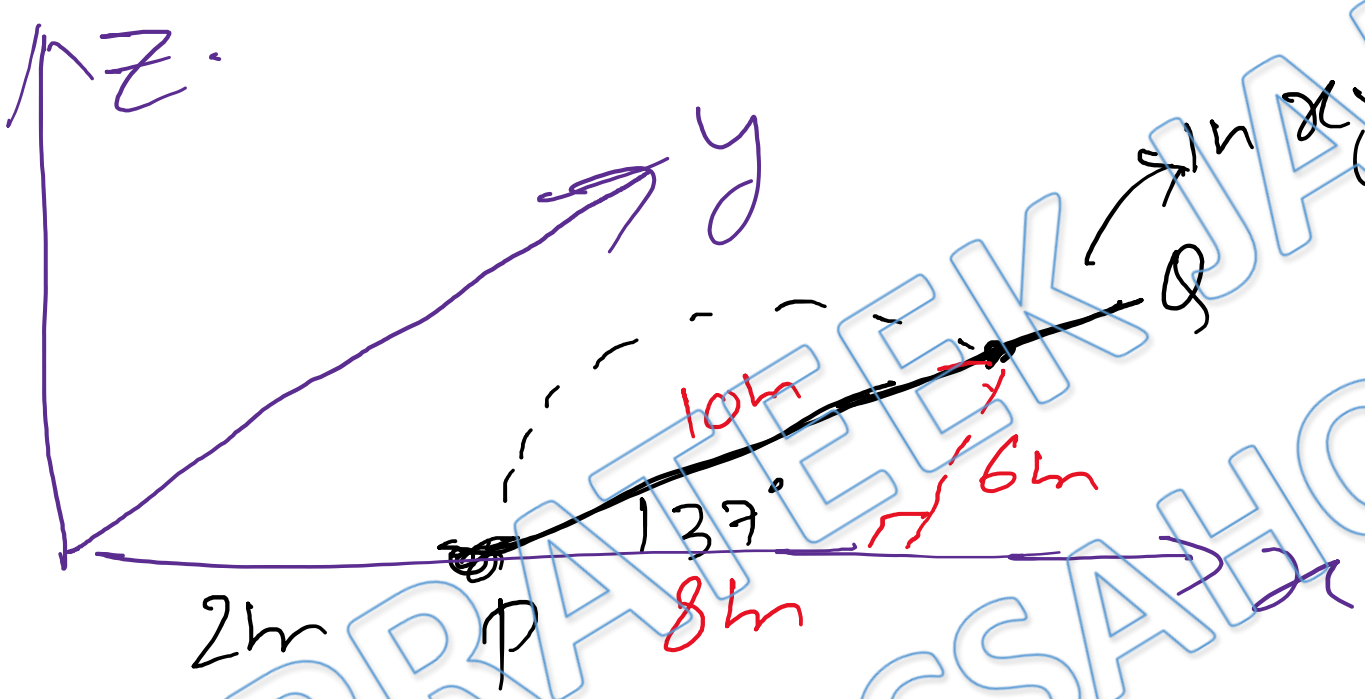
$V = 10 m/sec$

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

(a) (10,6,0)m (b) (8,6,0)m (c) (10,8,0)m (d) (6,10,0)m

Ans. a

Solution:



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

$$= \frac{10 \times 10}{10} = 10\text{m}$$

Co-ordinate of point of fall

$= (10, 6, 0)$

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Chalo Niklo