CRACK JEE 2024

MOTION IN TWO DIMENSION - L2

GENERAL PROJECTILE MOTION: HORIZONTAL PROJECTION

GRADE 11 | PHYSICS

ANTHE

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Factors Influencing Projectile Motion

2 – dimensional motion under the effect of gravity.

Projectile Motion

Some Questions on these topics

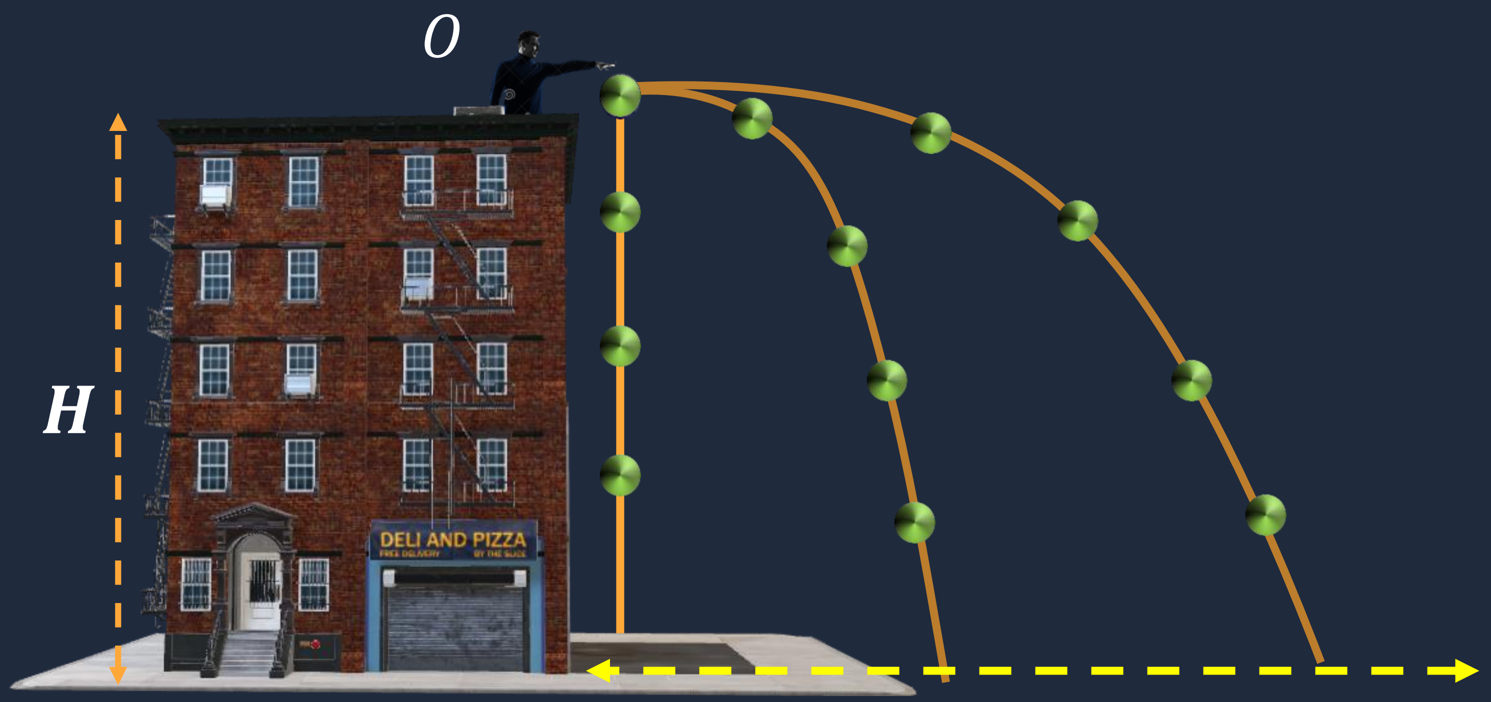
Projectile on an horizontal plane

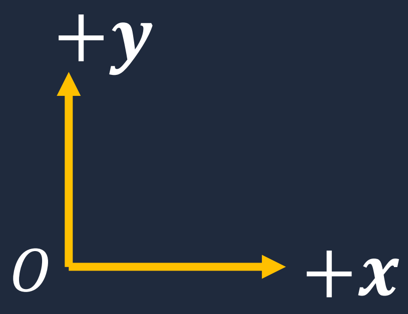
Projectile on an inclined plane

Some Questions on these topics

General Projectile Motion

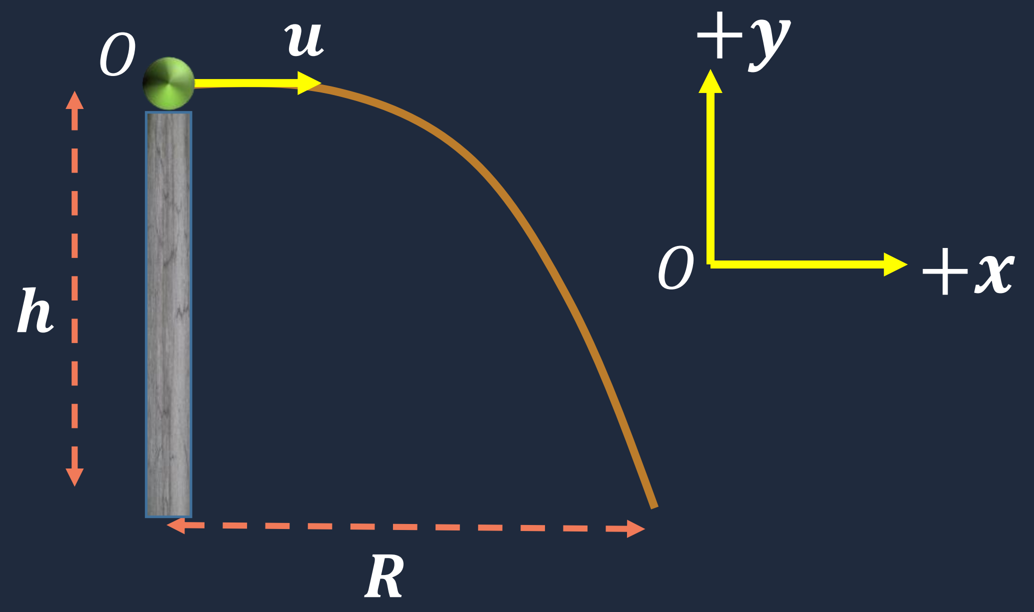
Case I – Horizontal projection





General Projectile Motion

x	y
$u_x = u$	$u_y = 0$
$a_x = 0$	$a_y = -g$



Time of flight:

Horizontal range:

General Projectile Motion

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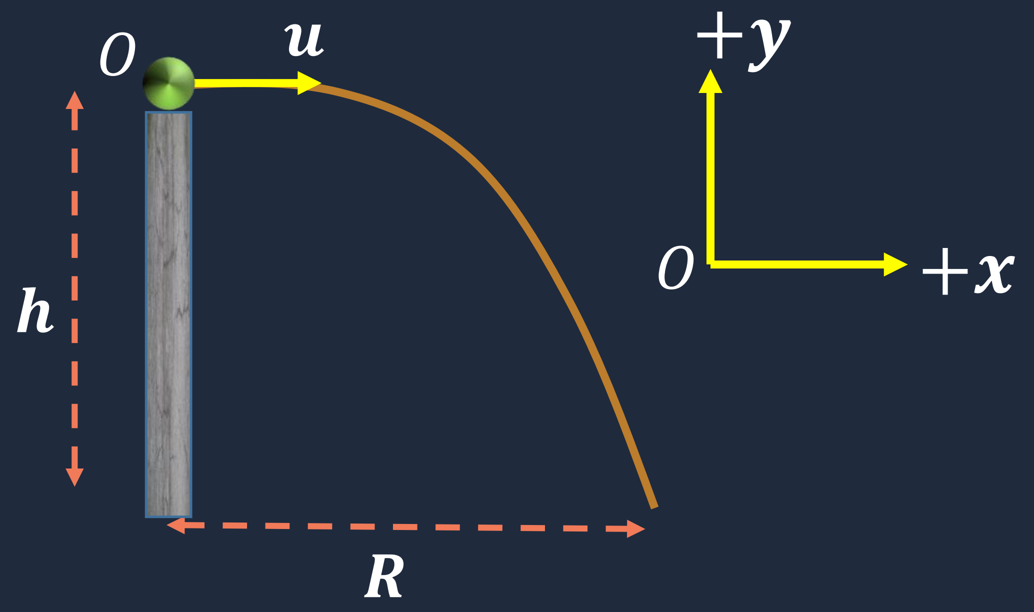


Time of flight:

Equation of motion $\Rightarrow s = ut + \frac{1}{2}at^2$

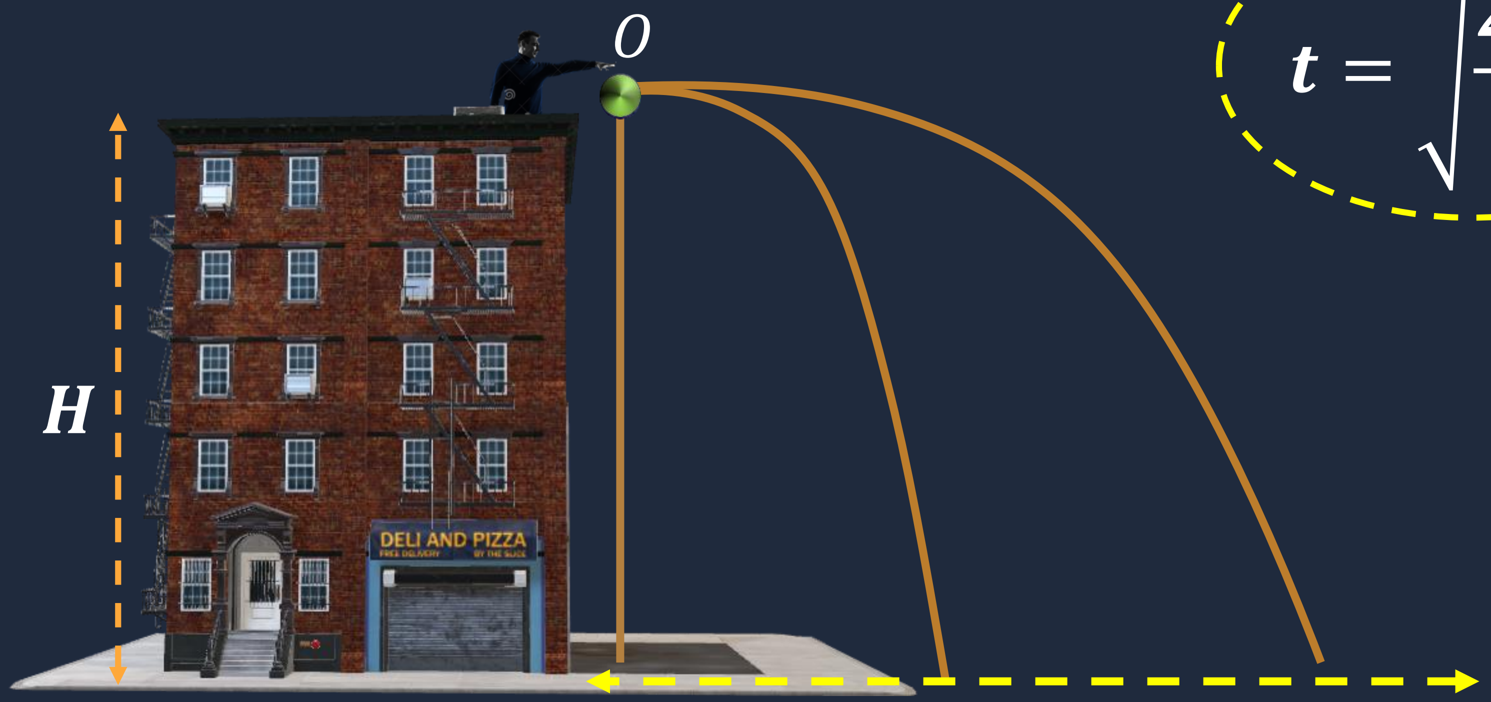
Along vertical direction

$$-h = u_y t + \frac{1}{2}(-g)t^2 \Rightarrow h = \frac{1}{2}gt^2 \Rightarrow \boldsymbol{t} = \sqrt{\frac{\boldsymbol{2h}}{\boldsymbol{g}}}$$

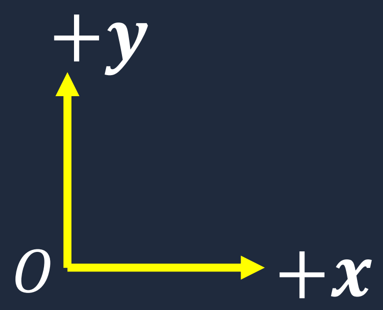
Horizontal range: $R = u_x . t \quad \Rightarrow \quad \boldsymbol{R} = \boldsymbol{u}\sqrt{\frac{\boldsymbol{2h}}{\boldsymbol{g}}}$

General Projectile Motion

Case I – Horizontal projection

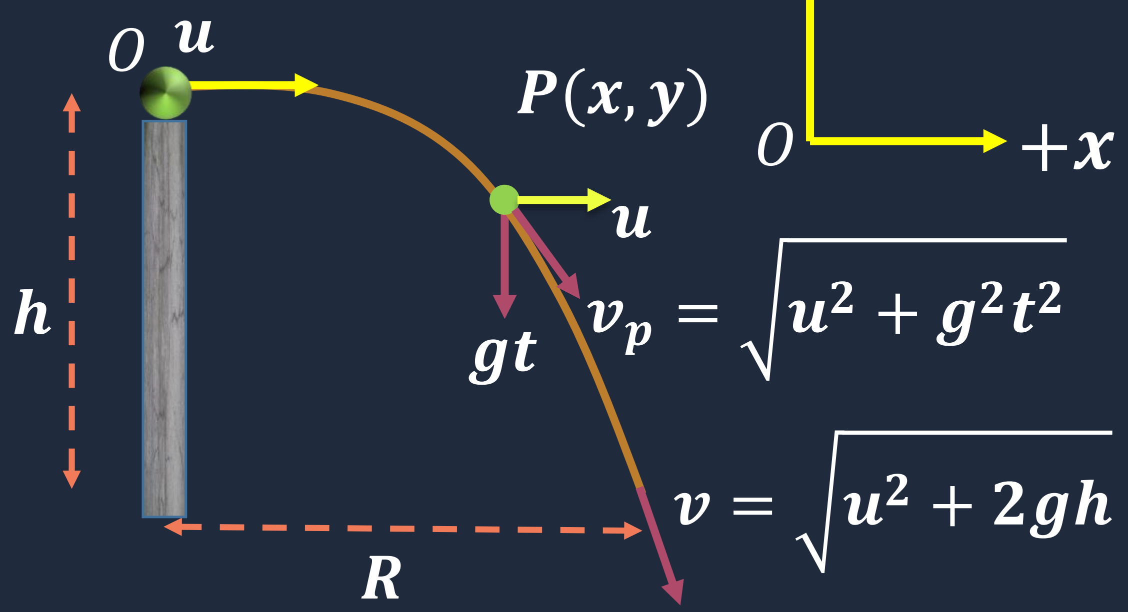


$$t = \sqrt{\frac{2h}{g}}$$



General Projectile Motion

x	y
$v_x = u$	$v_y = -gt$
$a_x = 0$	$a_y = -g$



Velocity at a general point $P(x, y)$:

$$v_p = \sqrt{u^2 + g^2t^2}$$

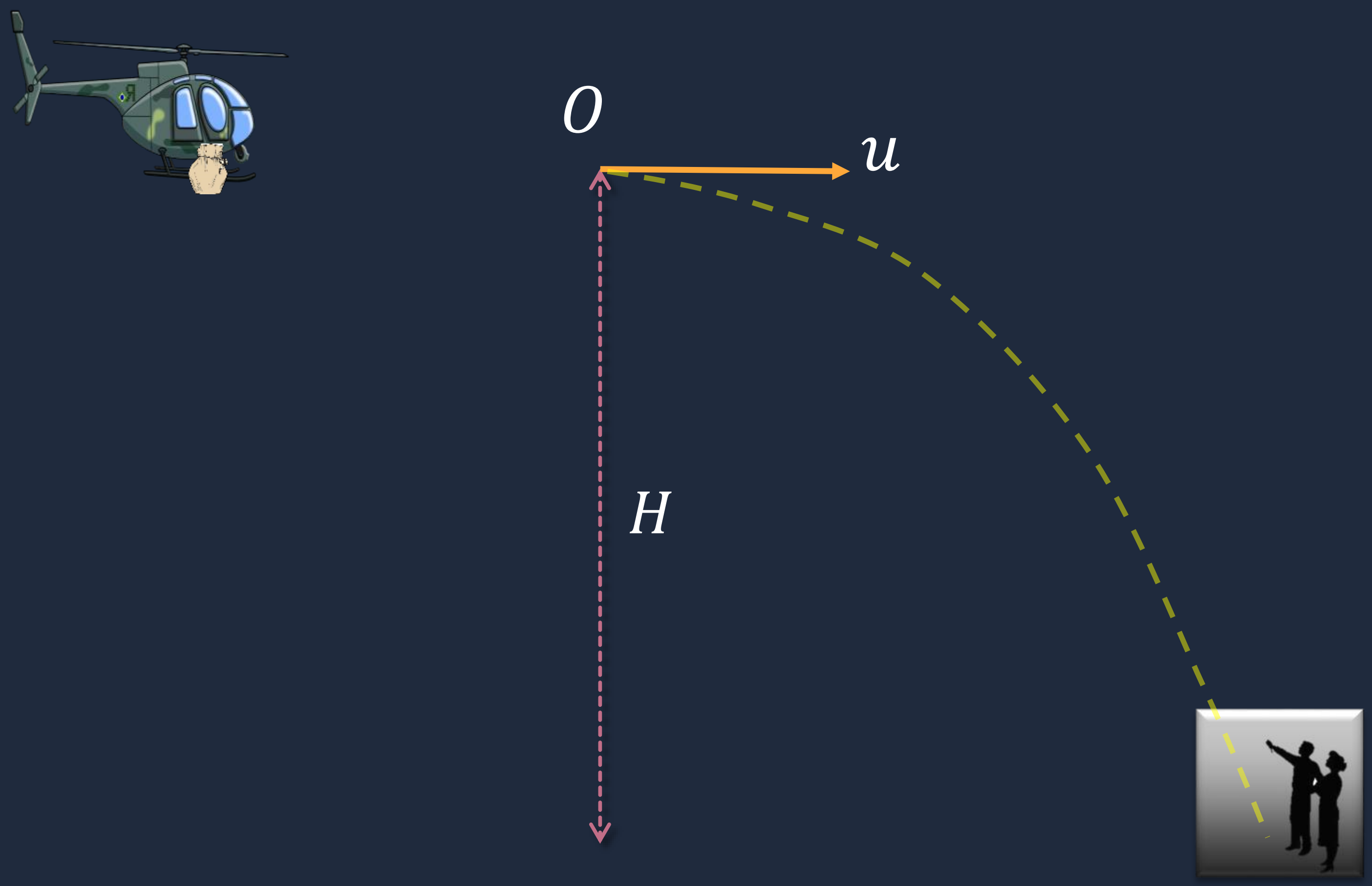
Velocity with which projectile hits the ground:

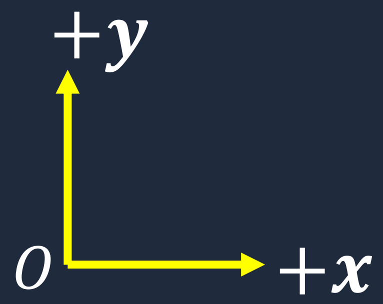
$$v_x = u \ ; \quad v_y^2 = 0^2 - 2g(-h) \ ; \ v_y = \sqrt{2gh}$$

$$v = \sqrt{v_x^2 + v_y^2} \quad \Rightarrow v = \sqrt{u^2 + 2gh}$$

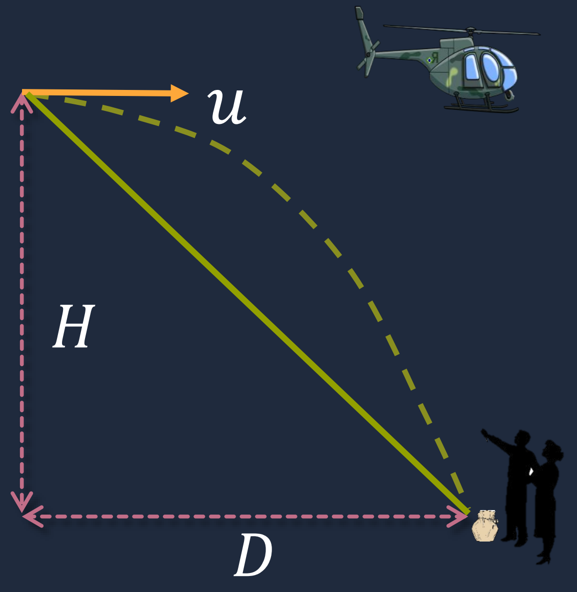
Let's solve this

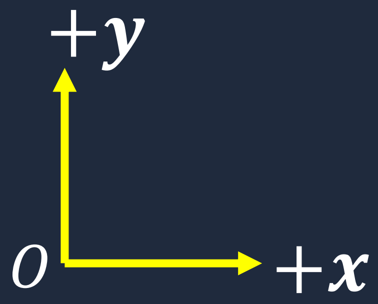
A helicopter on flood relief mission, flying horizontally with a speed $\boldsymbol{u}$ at an altitude $\boldsymbol{H}$ has to drop a food packet for a victim standing on the ground. At what distance from the victim should the packet be dropped? The victim stands in the vertical plane of the helicopter's motion.





Let's solve this

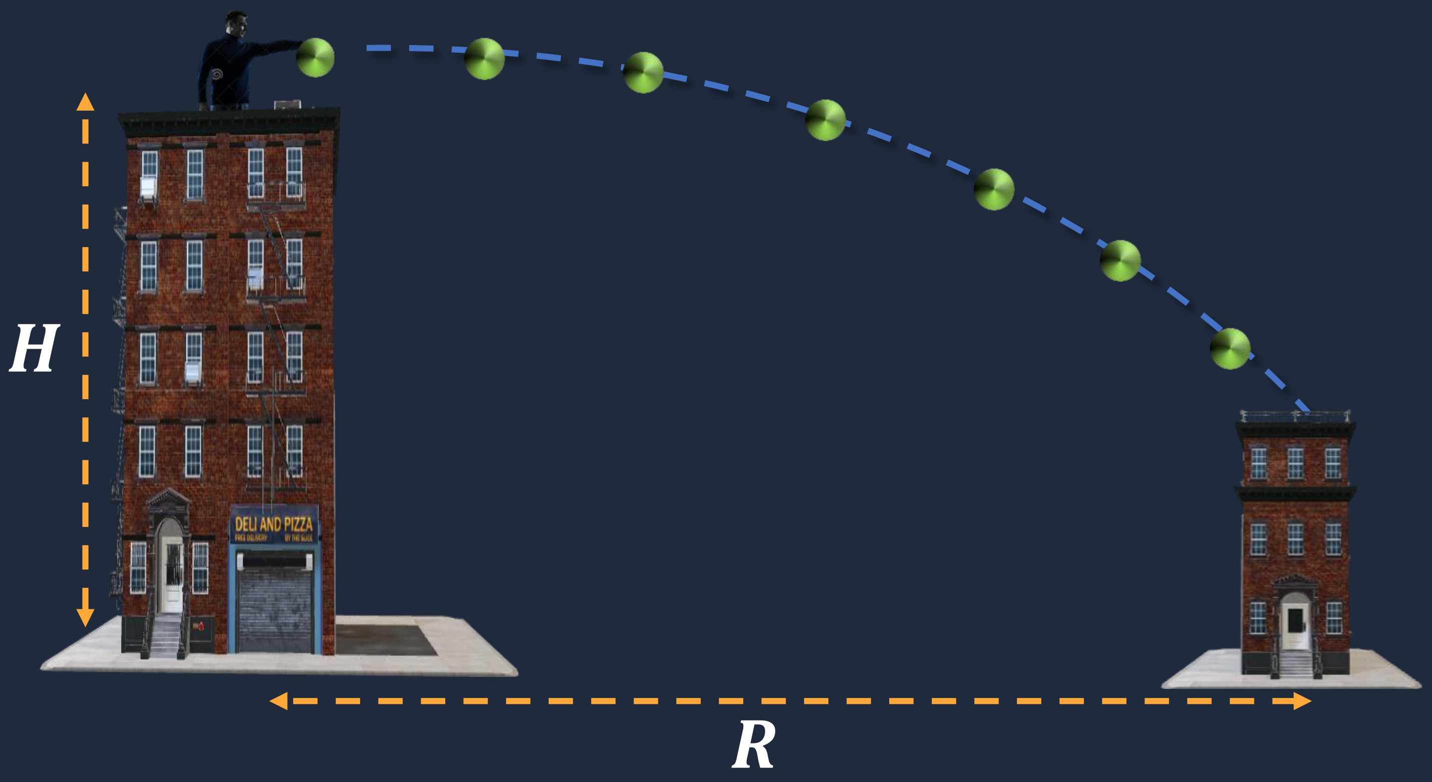




$$s = \sqrt{\frac{2u^2H}{g} + H^2}$$

Let's solve this

An object is thrown between two tall buildings $180\ m$ from each other. The object is thrown horizontally from the top of one building which is $45\ m$ high and lands on the top of the other building which is $10\ m$ high. Find out the speed of projection. (Use $g = 10\ m/s^2$)



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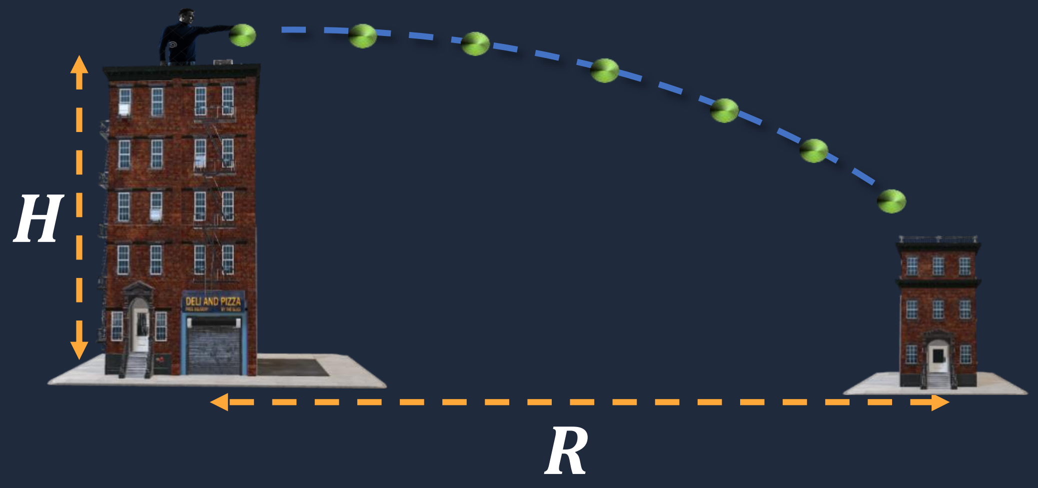


$$u = \frac{180}{\sqrt{7}}\ m/s$$

General Projectile Motion

Case II- Projection at an angle θ above horizontal

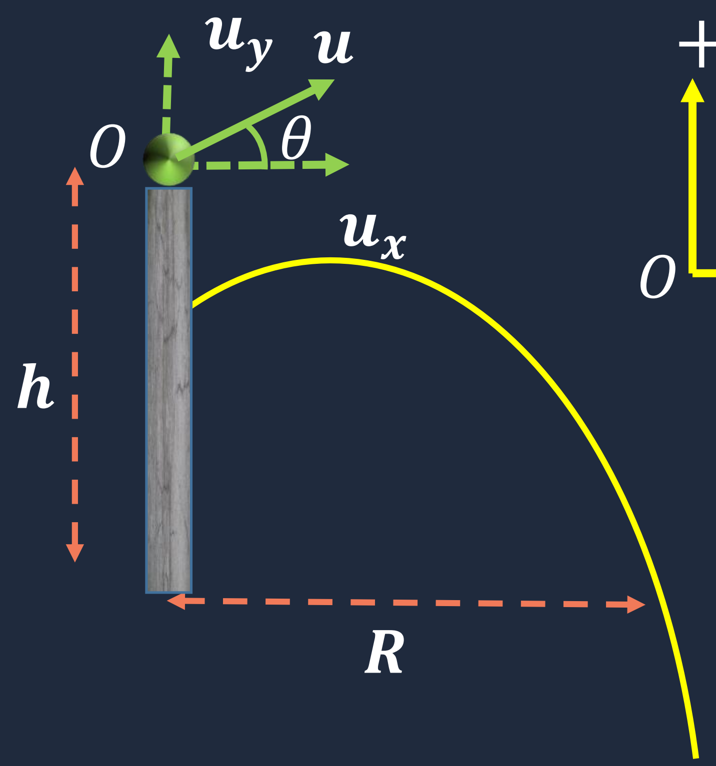
x	y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$a_x = 0$	$a_y = -g$

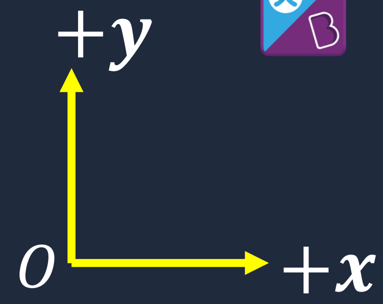
Equation of motion : $s = ut + \frac{1}{2}at^2$

In horizontal direction, $y = -h,$

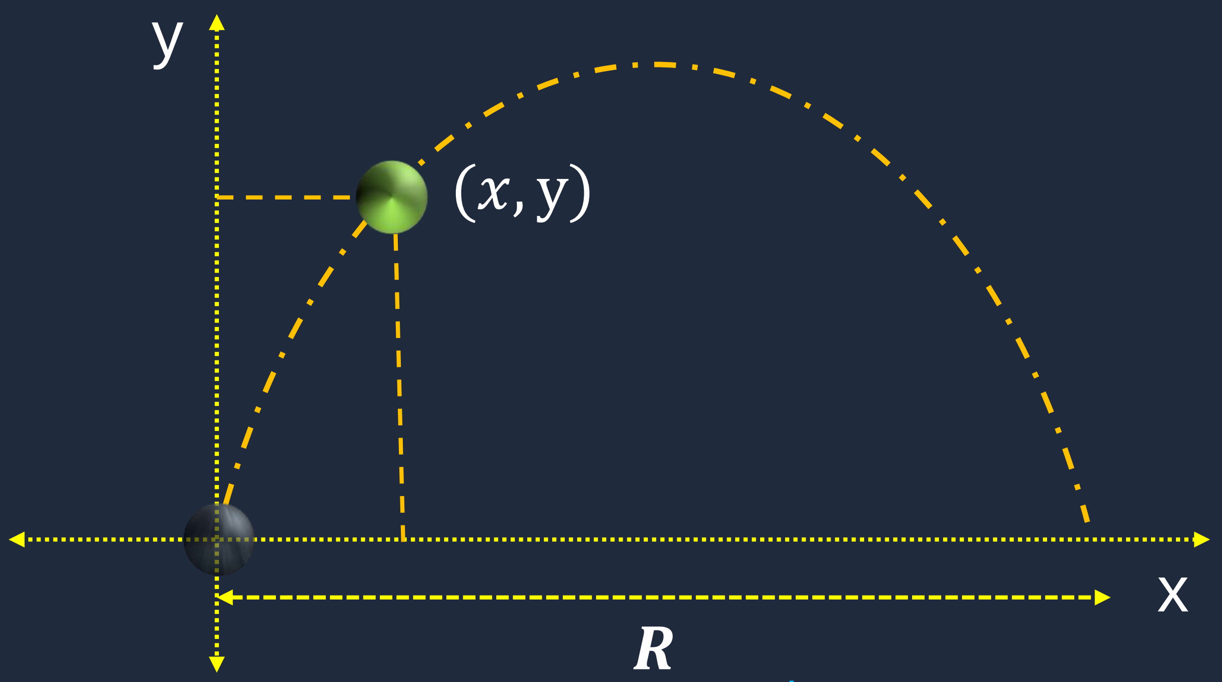
$-h = u\sin\theta\, t - \frac{1}{2}gt^2$, Putting $t = T$, we get time of flight

$\boldsymbol{R = u_xT = u\cos\theta\,.\,T}$





General Projectile Motion



$$y = x\tan\theta - \frac{x^2\tan\theta}{R}$$

$$\boldsymbol{y = x\tan\theta\left(1 - \frac{x}{R}\right)}$$

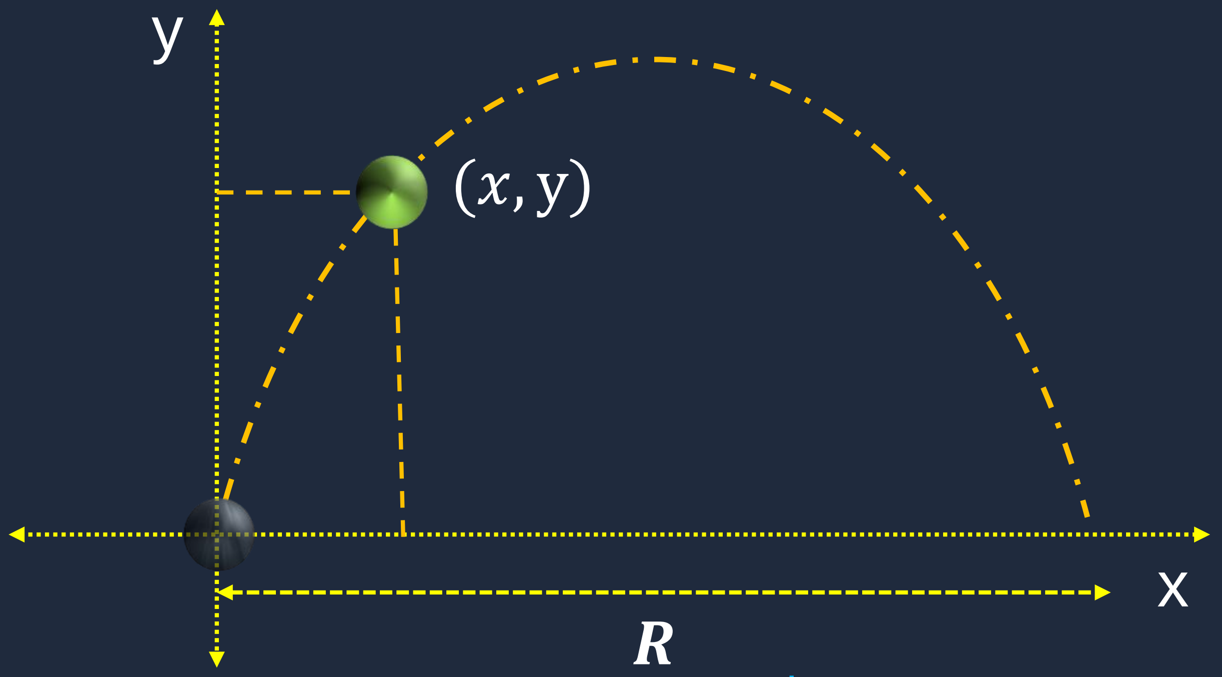
$$R = \frac{u^2\sin2\theta}{g} = \frac{2u^2\sin\theta\cos\theta}{g}$$

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

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

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

General Projectile Motion



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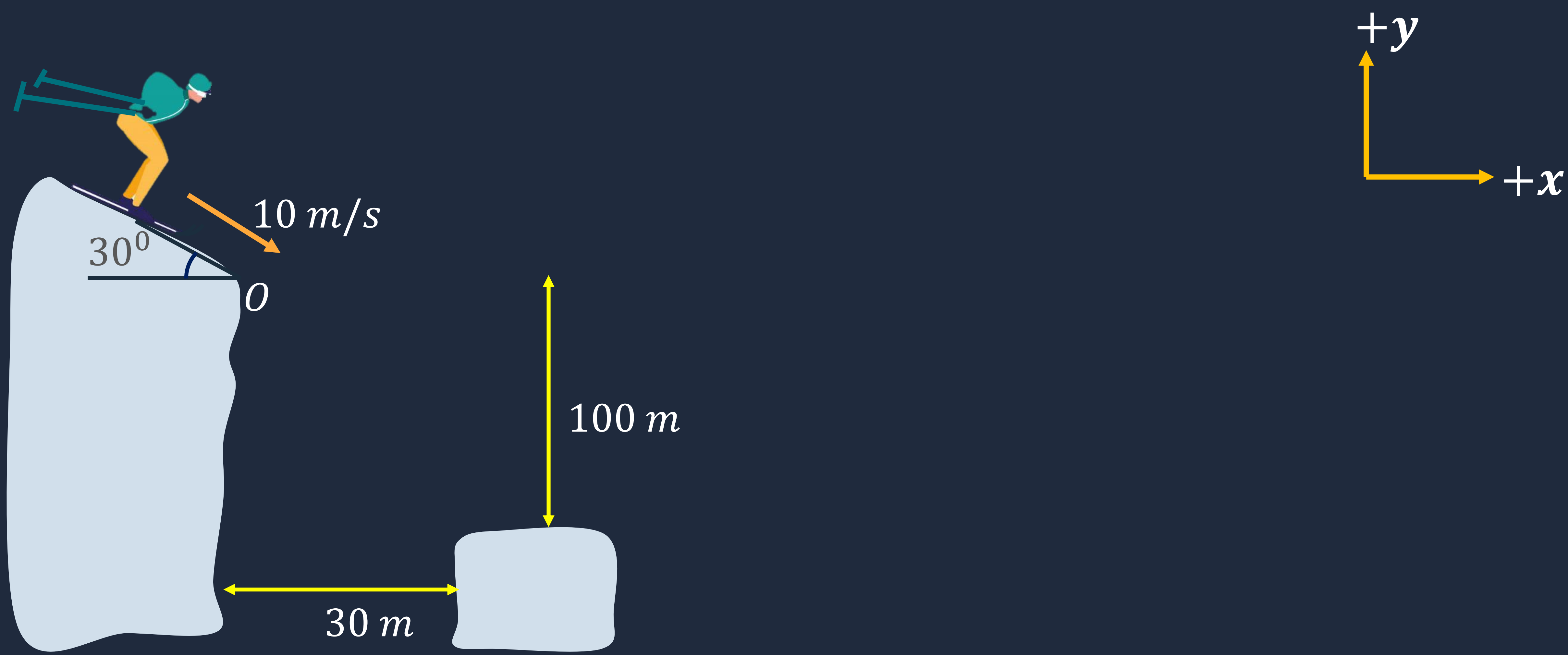
$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \times \frac{\sin\theta}{\sin\theta}$$

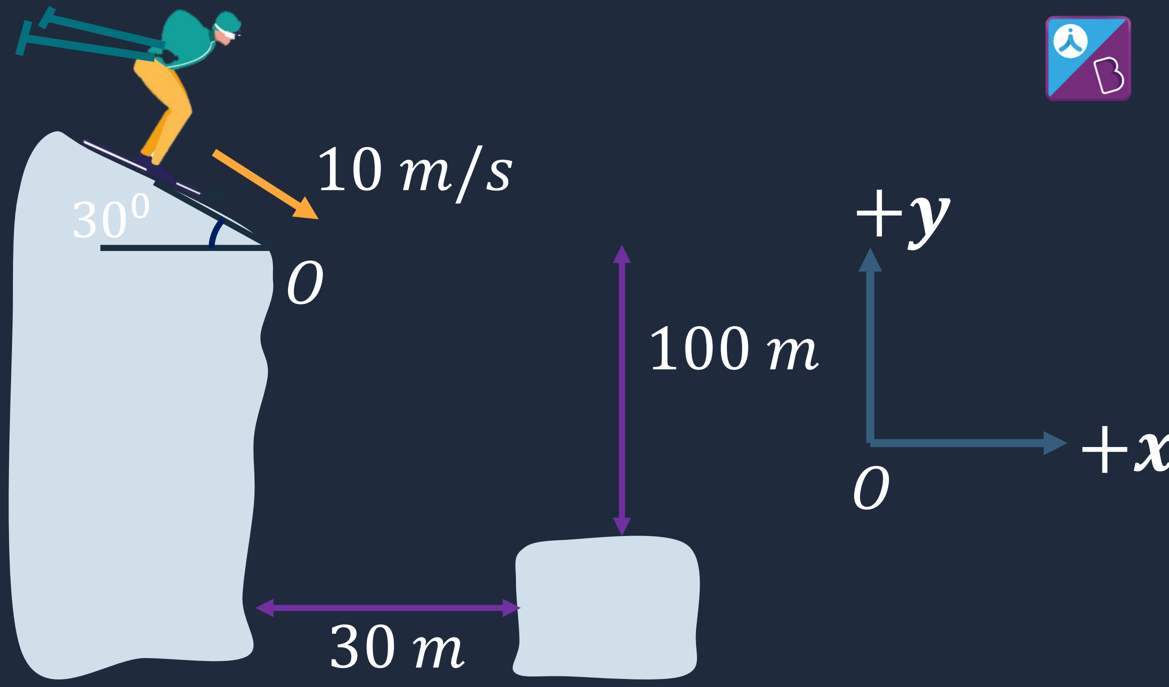
$$y = x\tan\theta - \frac{x^2\sin\theta}{\frac{2u^2\sin\theta\cos\theta}{g}} \times \frac{1}{\cos\theta}$$

Let's solve this

In a high speed ski-chase, a secret agent skis off a slope inclined at 30^0 below the horizontal at $10\ m/s$. In order to land safely on the snow $100\ m$ below, the agent must clear a $valley$ $30\ m$ wide. Does he make it? Ignore the air resistance.



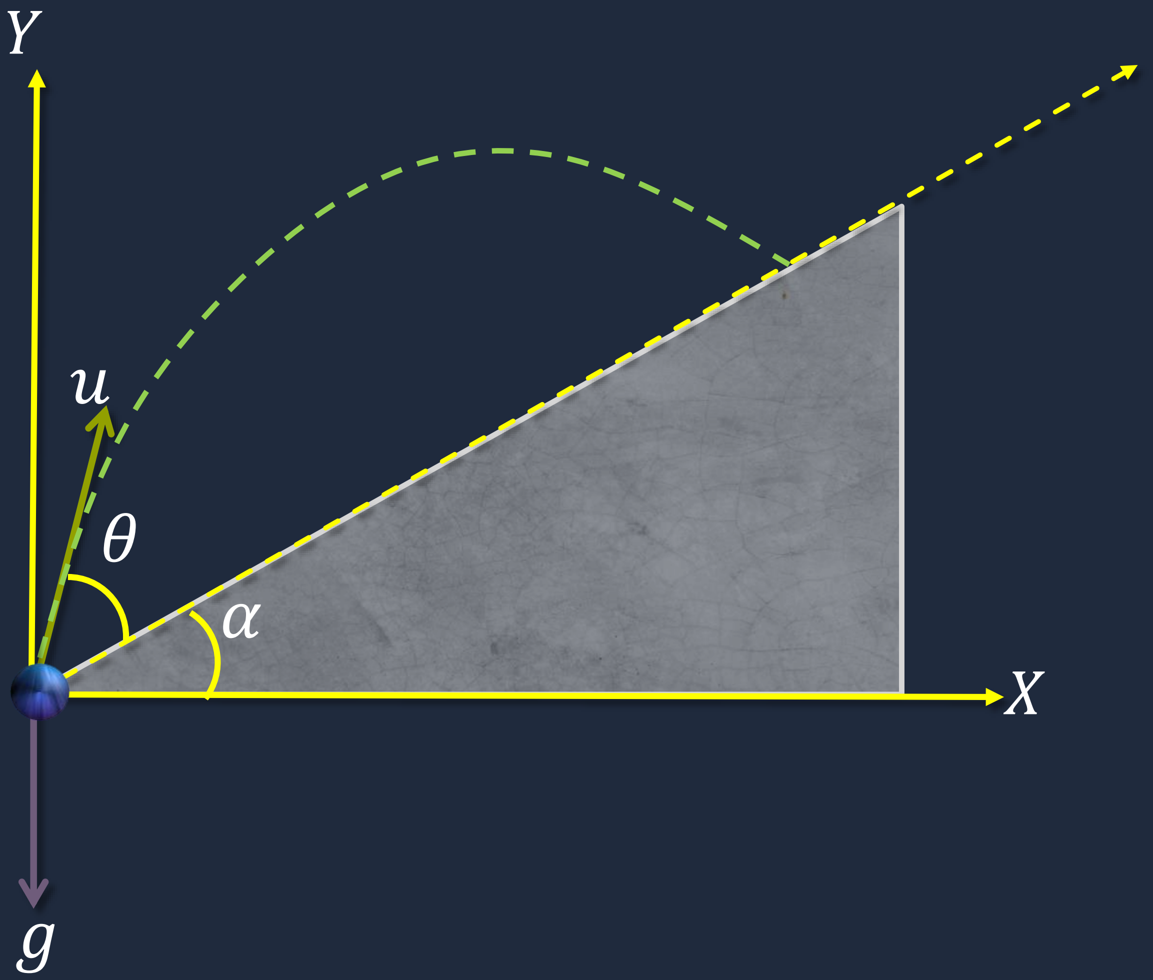
Let's solve this

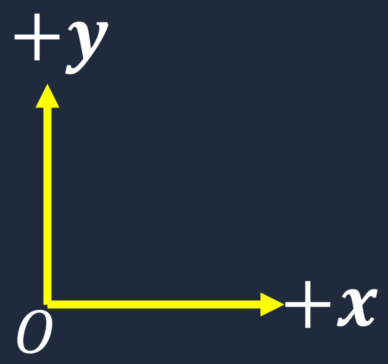


$Safe\ Landing!\ x = 34.6\ m\ >\ 30\ m$

Projectile on an inclined plane

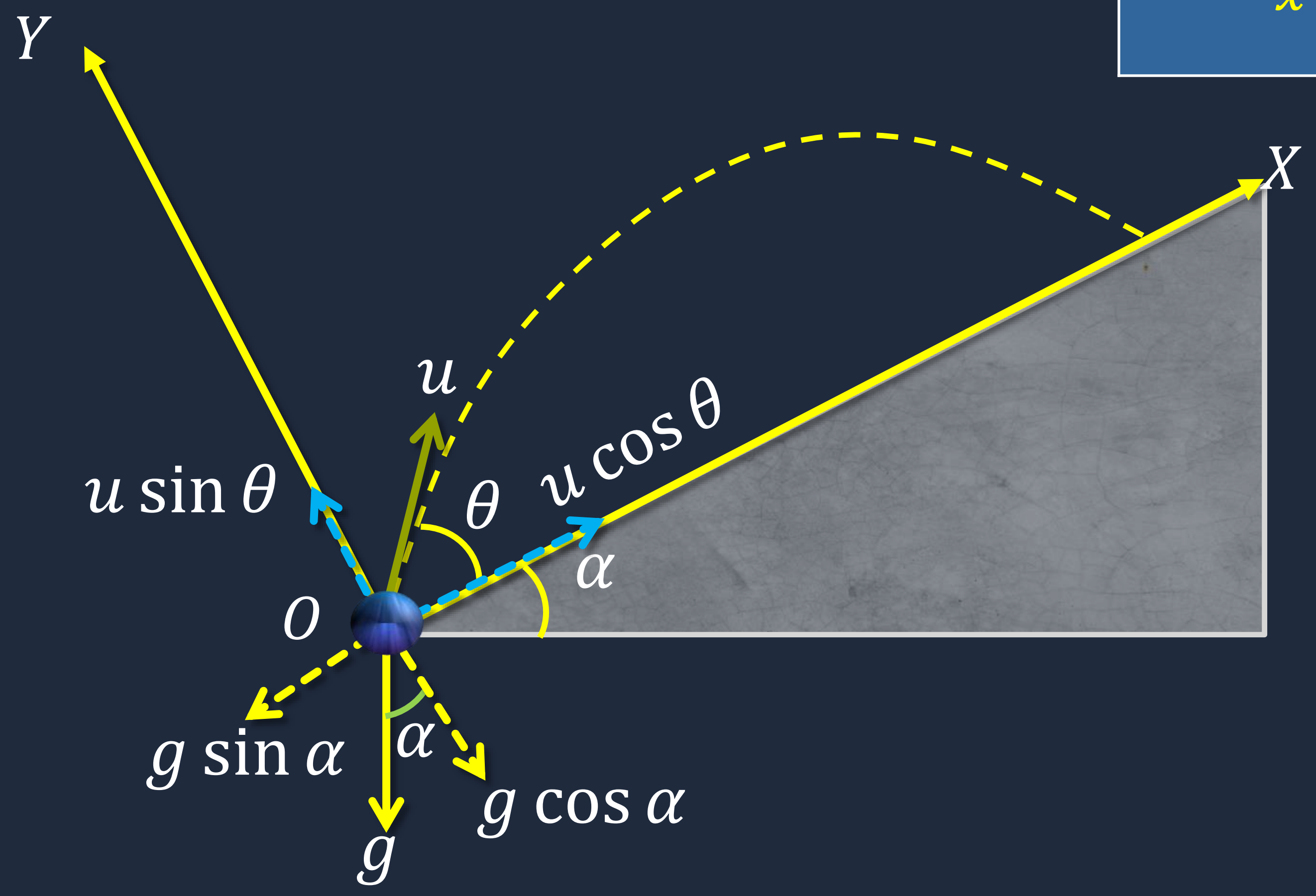
Case I – Bottom to Top



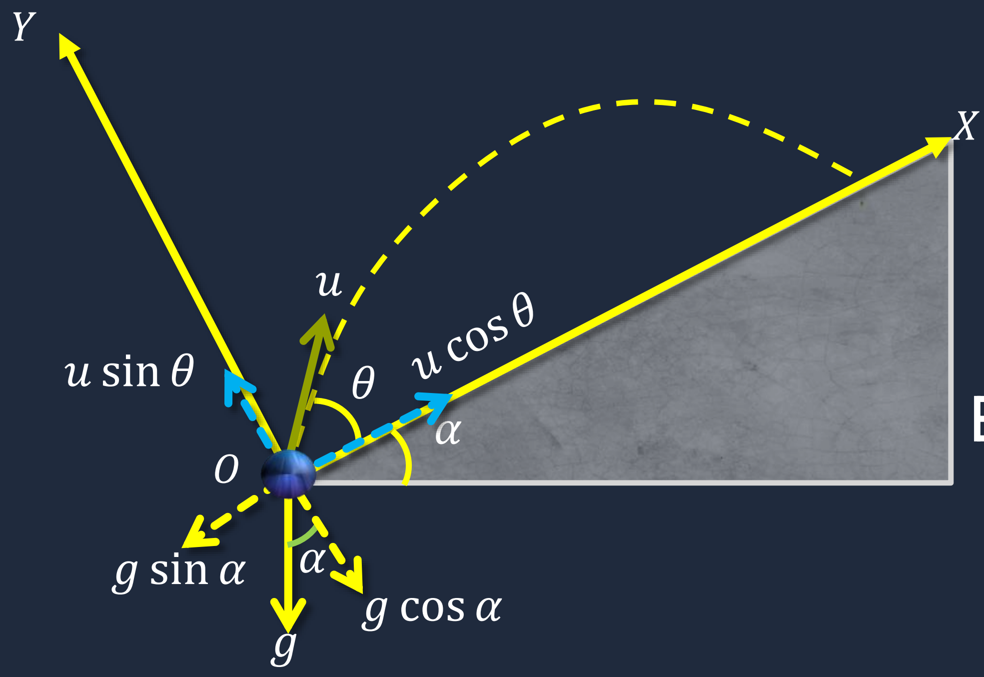


Projectile on an inclined plane

X	Y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$a_x = -g\sin\alpha$	$a_y = -g\cos\alpha$



Projectile on an inclined plane



X	Y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$a_x = -g\sin\alpha$	$a_y = -g\cos\alpha$

Time of flight

Equation of motion :

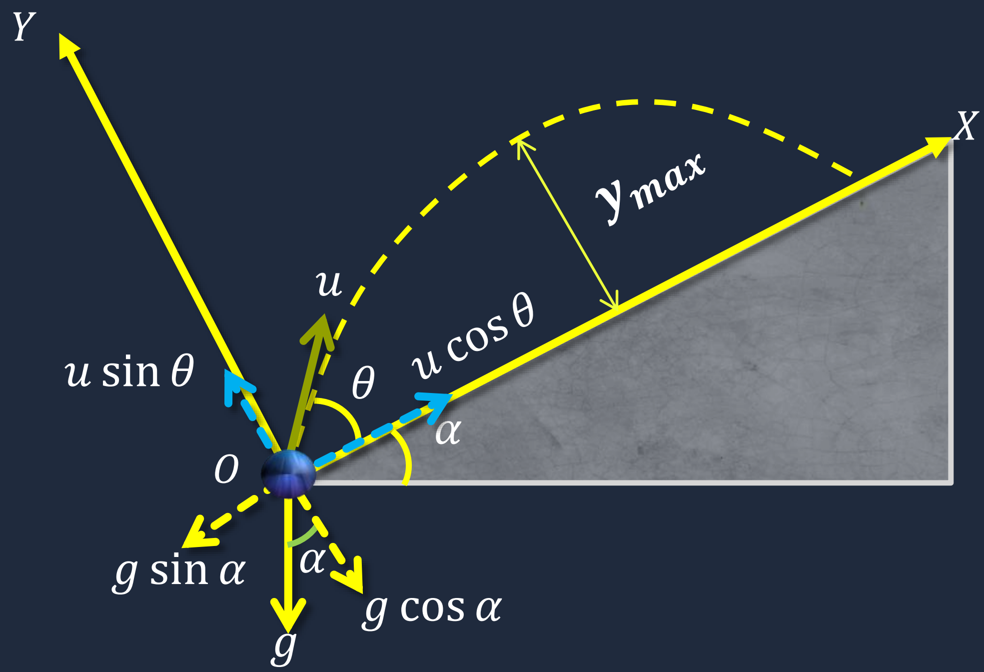
$$s_y = u_y t + \frac{1}{2}a_y t^2,$$

$$t = T$$

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

General form : $\boldsymbol{T = \frac{2u_y}{a_y}}$

Projectile on an inclined plane



X	Y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$a_x = -g\sin\alpha$	$a_y = -g\cos\alpha$

Maximum distance from incline

Equation of motion :

$$v_y^2 = u_y^2 + 2a_y s_y$$

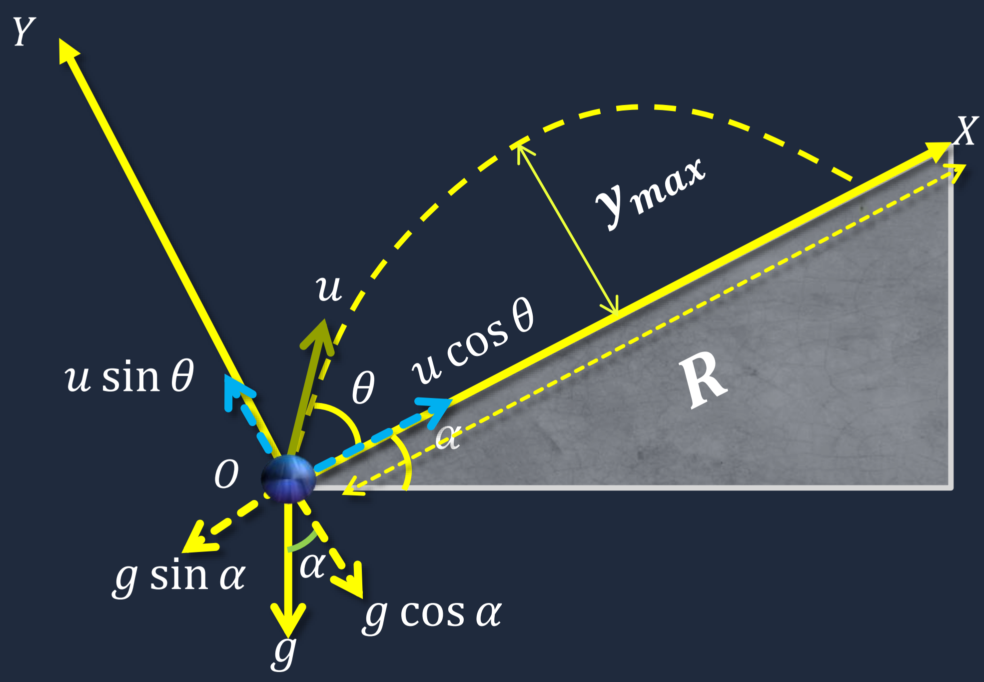
$$y_{max} = \frac{u^2 \sin^2\theta}{2g\cos\alpha}$$

For ground to ground

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

General form : $H = \frac{u_y^2}{2a_y}$

Projectile on an inclined plane



X	Y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$a_x = -g\sin\alpha$	$a_y = -g\cos\alpha$

Range

Equation of motion : $s_x = u_x t + \frac{1}{2}a_x t^2$,

$$s_x = R$$

$$s_x = u_x t + \frac{1}{2}a_x t^2$$

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

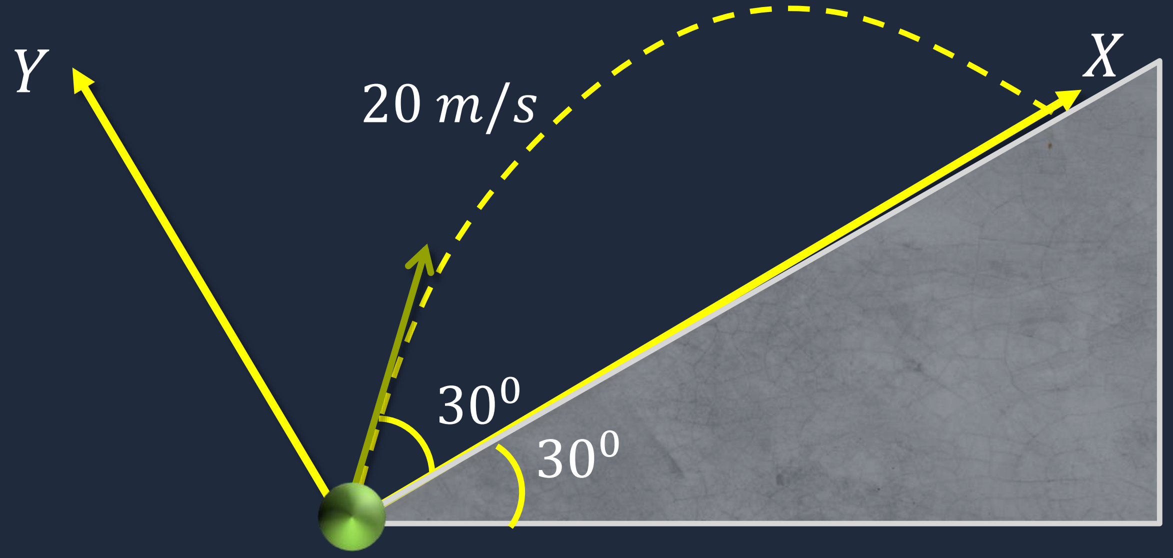
$$R = \frac{2u^2 \sin\theta \cos(\theta+\alpha)}{g\cos^2\alpha}$$

Let's solve this

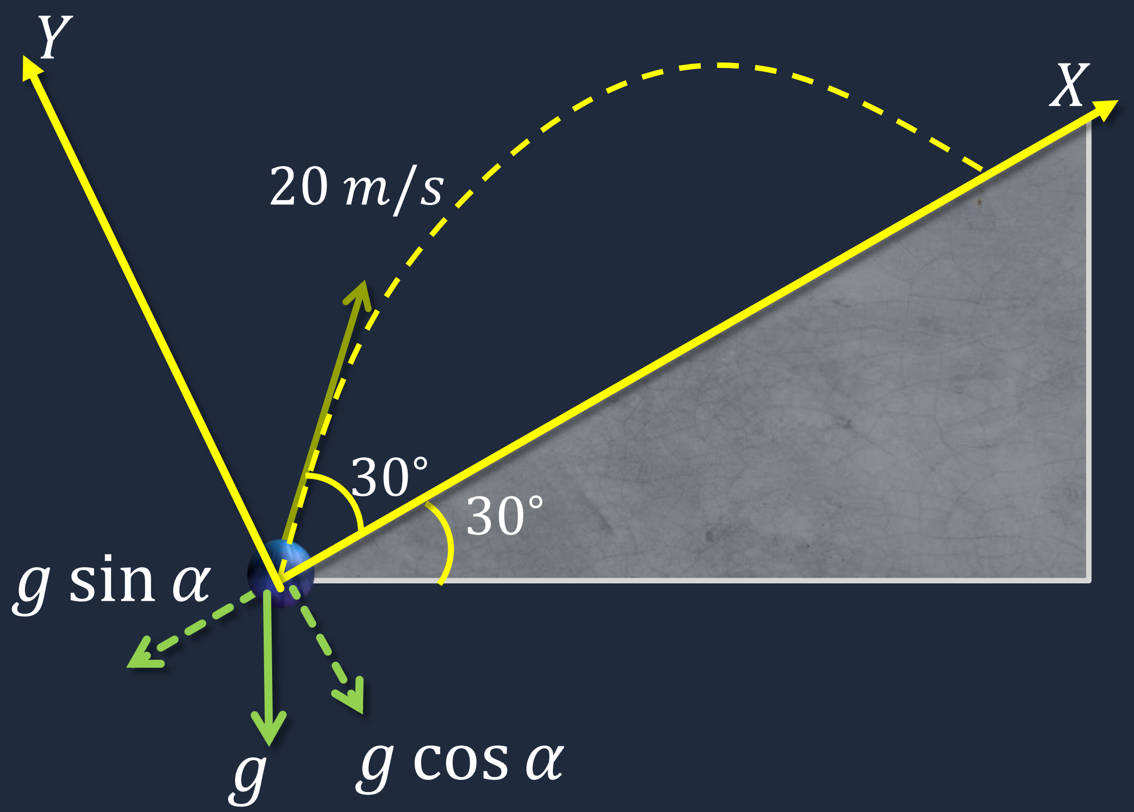
A projectile is thrown from the base of an inclined plane of angle 30^0 as shown in the figure. It is thrown at an angle of 30^0 from the incline at a speed of $20\ m/s$. (take $g = 10\ m/s^2$)

The total time of flight of projectile , and

Maximum distance from the incline

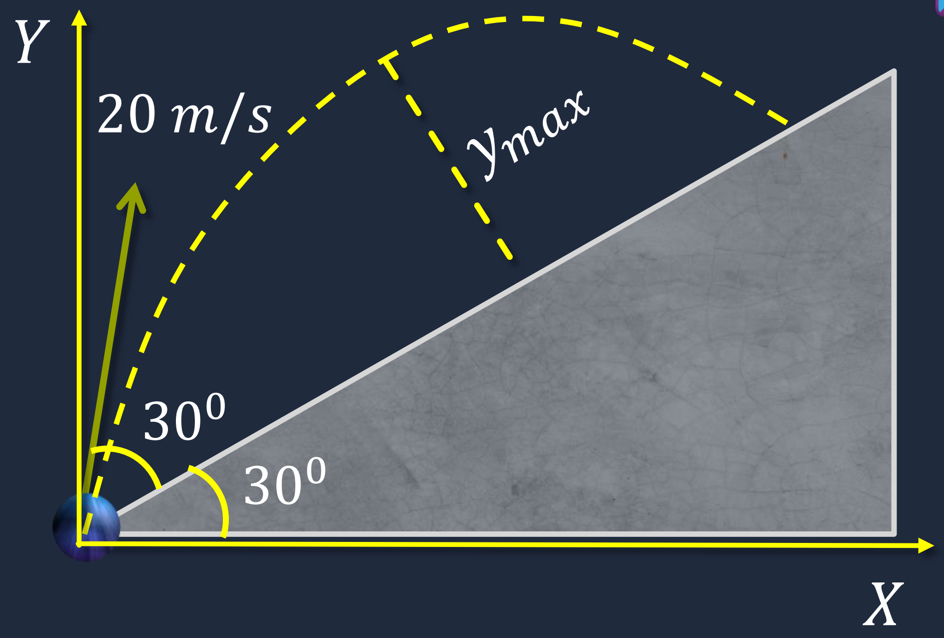


Let's solve this



$$T = \frac{4}{\sqrt{3}}\ s$$

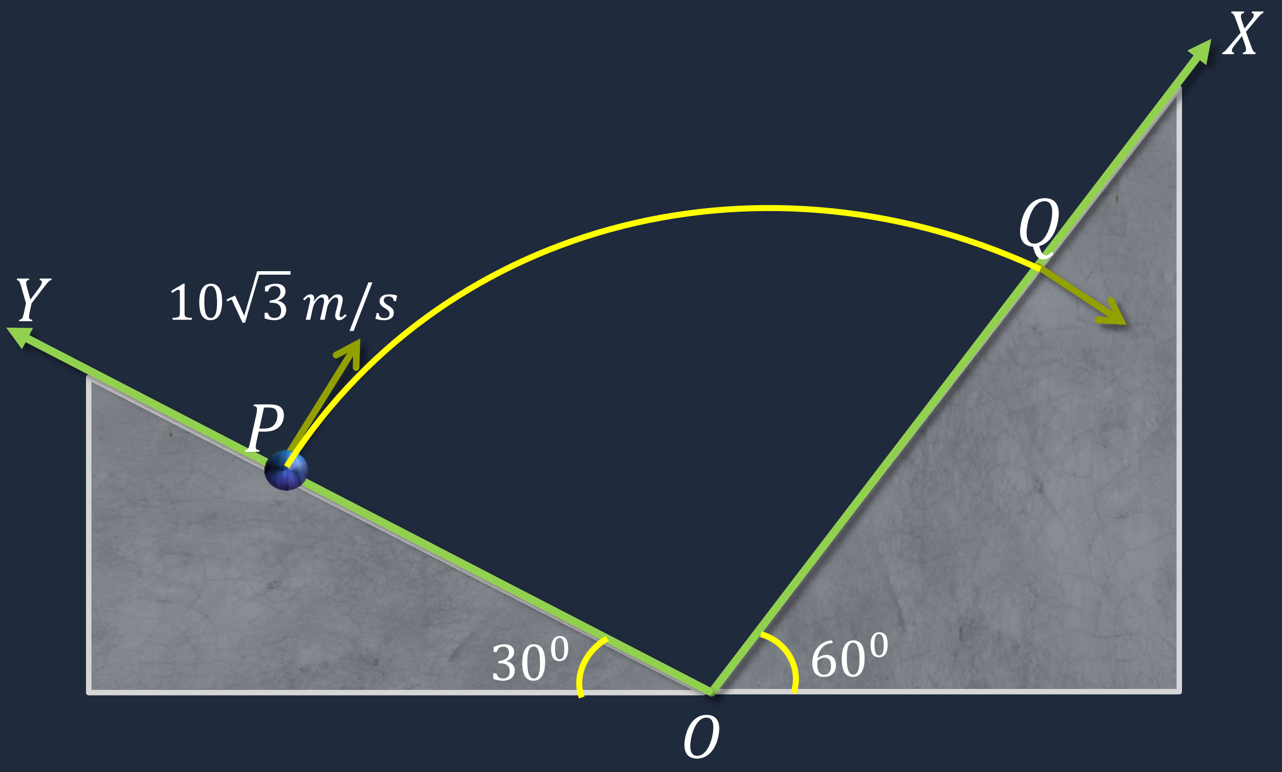
Let's solve this



Maximum distance from the incline reached by particle is $\frac{20}{\sqrt{3}}\ m$

Let's solve this

Two inclined planes of angles 30^0 and 60^0 are placed touching each other at the base as shown in the figure. A projectile is projected at right angle with a speed of $10\sqrt{3}\ m/s$ from point P and hits the other incline at point Q normally, find Speed with which the projectile hits the point Q



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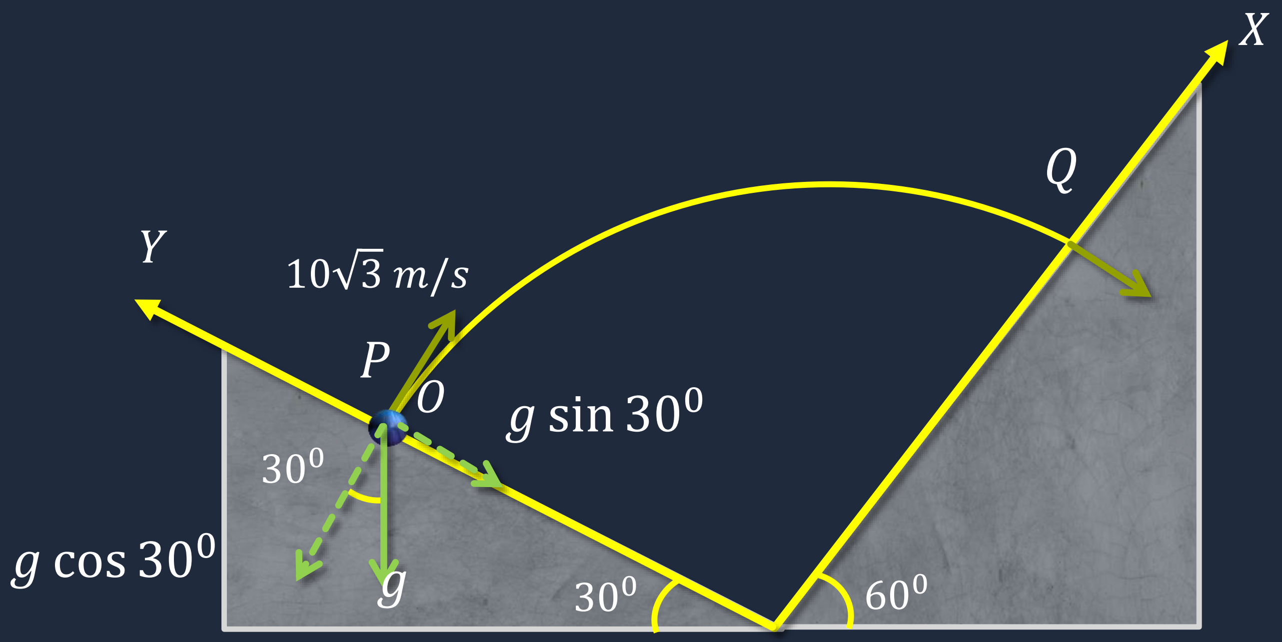
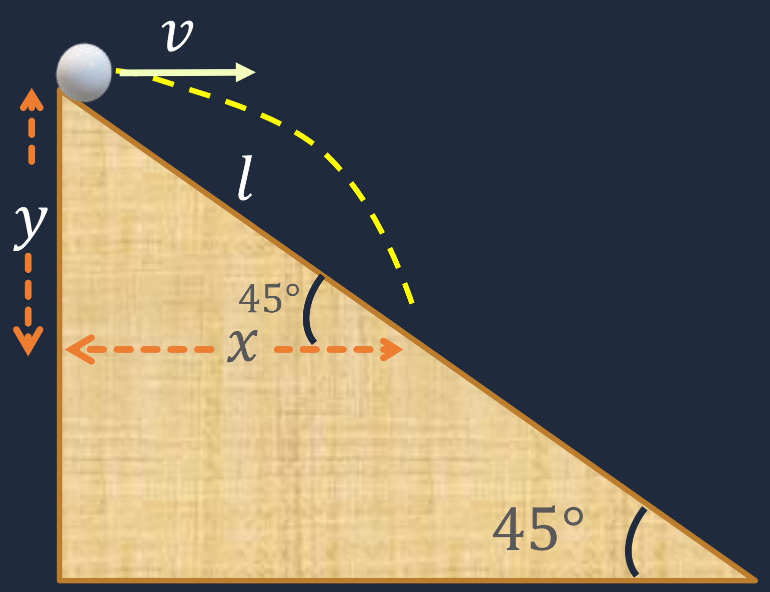


$$|v_y| = 10\ m/s$$

Let's solve this

A ball is projected horizontally with speed $\boldsymbol{v}$ from the top of a plane inclined at an angle $\mathbf{45^\circ}$ with the horizontal. How far from the point of projection will the ball strike the plane?



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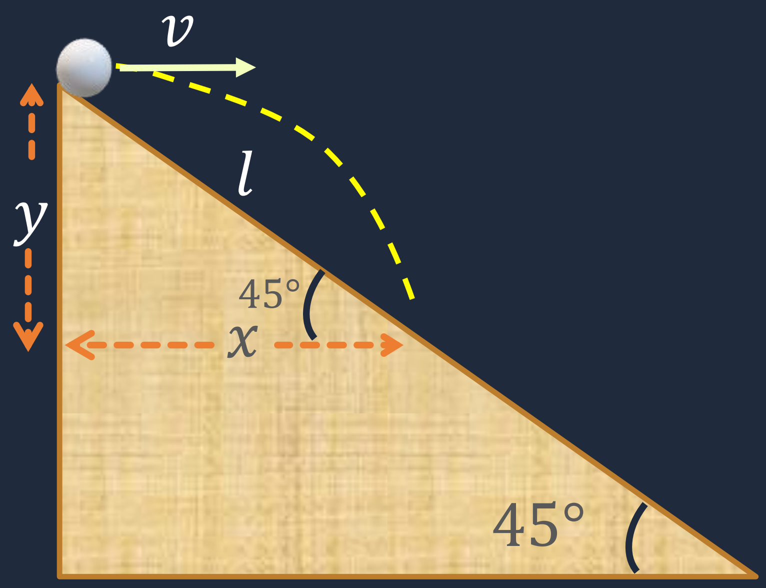

Thank You