Kinematics

Newton's laws of Motion

$v = u + at$ $\quad$ $S = ut + \frac{1}{2}at^2$ $\quad$ $v^2 = u^2 + 2as$

Gravity under free fall :-

(i) Thrown up and comes down →

$$T = \frac{2u}{g} \quad , \quad H_{max} = \frac{u^2}{2g}$$

(ii) Dropped from tower →

$$T = \sqrt{\frac{2H_{max}}{g}}$$

(*) Avg velocity = $\dfrac{\text{Final distance} - \text{initial distance}}{\text{Final time} - \text{initial time}}$

Graphs

(i) Area under v-t graph is → displacement

(ii) Area under a-t graph → velocity

$$a = \frac{dv}{dt} \Rightarrow \Delta V = \int a \cdot dt$$

$$\Rightarrow v - u = \int a \cdot dt = \text{Area under the curve}$$

(iii) Area under a-x graph →

$$\frac{v^2 - u^2}{2} = \text{Area under a-x graph}$$

Trajectory of equⁿ

Write both the equⁿ in terms of t and equate them. That equⁿ will be **Trajectory of equation**

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

Max Height :- $H_{max} = \frac{u_y^2}{2g} = \frac{u^2\sin^2\theta}{2g}$

Range :- $R = u_x \times \frac{2u_y}{g} = \frac{u\cos\theta \times 2u\sin\theta}{g}$

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

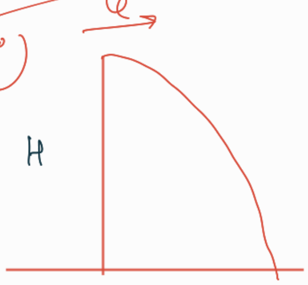
Equⁿ of Trajectory

$$y = x\tan\theta - \left(\frac{g}{2u^2\cos^2\theta}\right)x^2$$

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

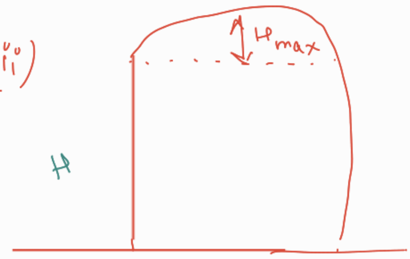
Cases

(i)



$T = \sqrt{\frac{2H}{g}}$ $\therefore$ Range $= u \times \sqrt{\frac{2H}{g}}$

(ii)



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

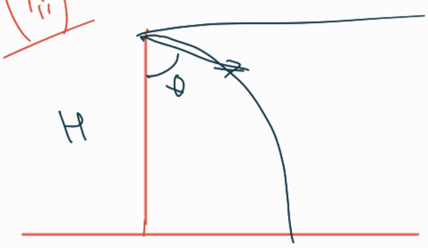
$-H = u\sin\theta T + \frac{1}{2}(-g) T^2$

$T = $ —

Range $\rightarrow u_x \times T = u\cos\theta \times T$

$u_y = u\sin\theta$
$u_x = u\cos\theta$

(iii)



$S = u_x T + \frac{1}{2}(-g)T^2$

and, $\text{Range} = T \times u\cos\theta$

Projection on Incline

Basic Sign convention

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

$$\boxed{T = \frac{2u_y}{a_y} = \frac{2u\sin\theta}{g\cos\alpha}}$$

Max^m Height

$$\boxed{H_{max} = \frac{u_y^2}{2a_y} = \frac{u^2\sin^2\theta}{2g\cos\theta}}$$

Range

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

$\Rightarrow S_x = u\cos\theta T - \frac{1}{2}g\sin\theta T^2$

R_{Max}

$$\boxed{\theta = \frac{90-\alpha}{2}} \rightarrow R \rightarrow R_{Max}$$

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