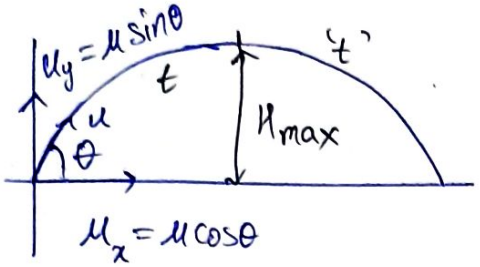
Projectile Motion.

I) Ground to Ground



① Time of flight:

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

② $T_{max} = \frac{2u}{g}$ if $\theta = 90°$

③ Maximum Height.

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

④ Horizontal Range (R) (2θ)

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

$$R_{max} = \frac{u^2}{g} \quad \text{if } \theta = 45°$$

Range is same for two different angle of projection if 'u' is same 'θ' & '90 − θ'

⑤ Equation of trajectory.

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

⑥ % Increase in Range $= \frac{\delta R}{R} \times 100 = \frac{2\delta V_0}{V_0} \times 100$

⑦ If T_1 & T_2 are the time of flights for same range R, then

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

8. If vectors $\vec{A}$ & $\vec{B}$ are $\perp^{rd}$ then,

$$|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$$

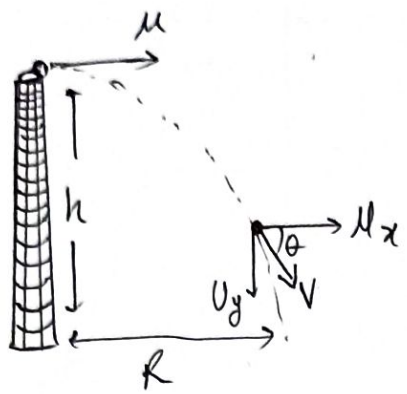
⑨ The maximum height, H & range R are related as: $R = 4H\cot\theta$

⑩ If horizontal Range, R = H, the Maximum height, then angle of projection $\theta = \tan^{-1} 4$

⑪ Other form of Equation of Trajectory:

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

II Height to Ground



① Time of flight: $u_y = 0$, $a_y = -g$, $s_y = -h$, 't'

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

$s = ut + \frac{1}{2}at^2$

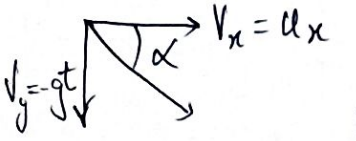
② Horizontal Range:

$$R = u\sqrt{\frac{2h}{g}}$$

③ Velocity at a general Point P after time 't'.

x-direction	y-direction
$u_x = u$	$u_y = 0$
$v_x = u$	$a_y = -g$
	$t = t$
	$v = u + at$
	$v_y = 0 - gt$
	$v_y = -gt$

$$\vec{v} = u\hat{i} - gt\hat{j}$$



$$\tan\alpha = -\frac{gt}{u_x}$$

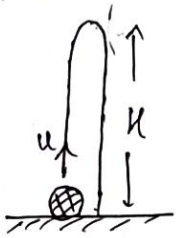
Free fall

① 

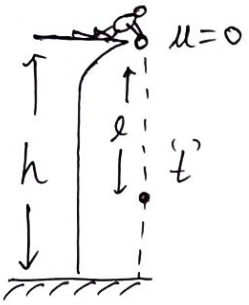
$t_1 = \frac{u}{g}$, $t_2 = \frac{u}{g}$

Total Time, $T = \frac{2u}{g}$

② Maximum Height

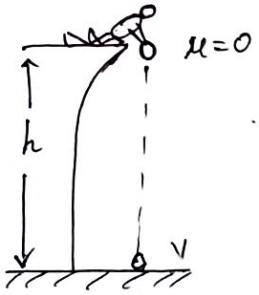


$$H = \frac{u^2}{2g}$$

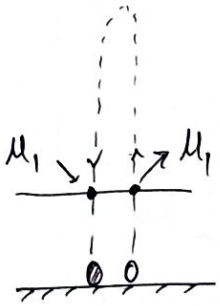
③ 

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

for 'l' height $t = \sqrt{\frac{2l}{g}}$

④ 

$$v = \sqrt{2gh}$$

⑤ 

④ Eq^n of Trajectory

$$y = \frac{1}{2}\frac{gx^2}{u^2}$$