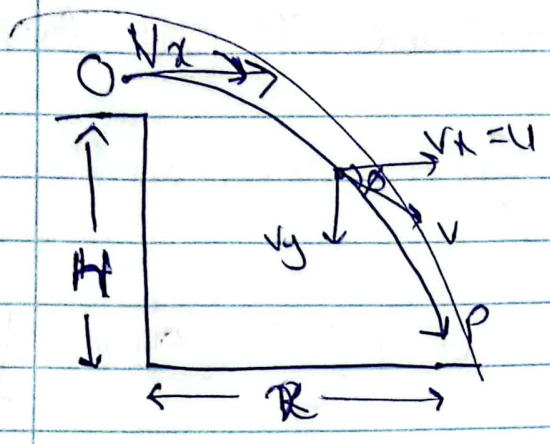
Date:

Projectile Formulas

(1) CASE 1:-



$H = \frac{1}{2} g t^2$

$R = V_x t$

$a_x = 0$

$V_x = V_0$

$V_x = V_0 \cos\theta$

$V_x = V_0 \cos 0^\circ$

$V_x = V_0$

$\Rightarrow R = V_0 t$

$a_y = -g$

$V_{fy} = V_{oy} + a_y t$

$d_x = V_x t$

$V = \sqrt{V_x^2 + V_y^2}$

$\theta_f = \tan^{-1}\left(\frac{V_y}{V_x}\right)$

$V_f =$

$V_x = V_0$

- Time of flight = $T = \sqrt{\frac{2H}{g}}$
- Horizontal Range = $x = V_x t = V_x \sqrt{\frac{2H}{g}}$
- Vertical velocity after t seconds, $V_y = gt$
- velocity of projectile after t seconds, $V = \sqrt{V_x^2 + V_y^2} = \sqrt{V_x^2 + (gt)^2}$
- Velocity makes angle ϕ, $\phi = \tan^{-1}\left(\frac{V_y}{V_x}\right)$
- equation of path of projectile, $y = \frac{g x^2}{2 V_x^2}$

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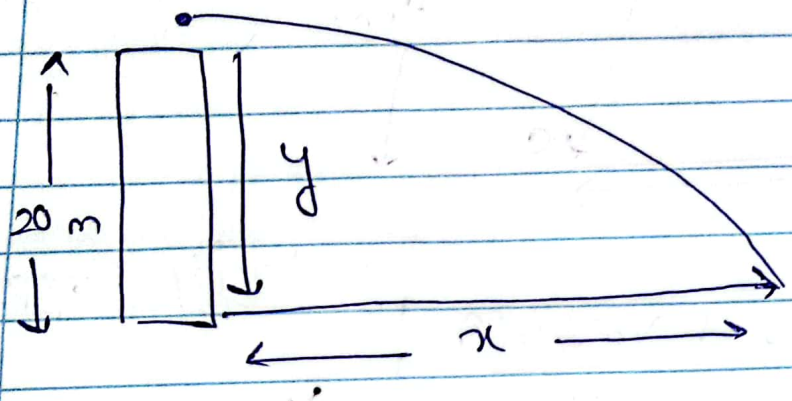
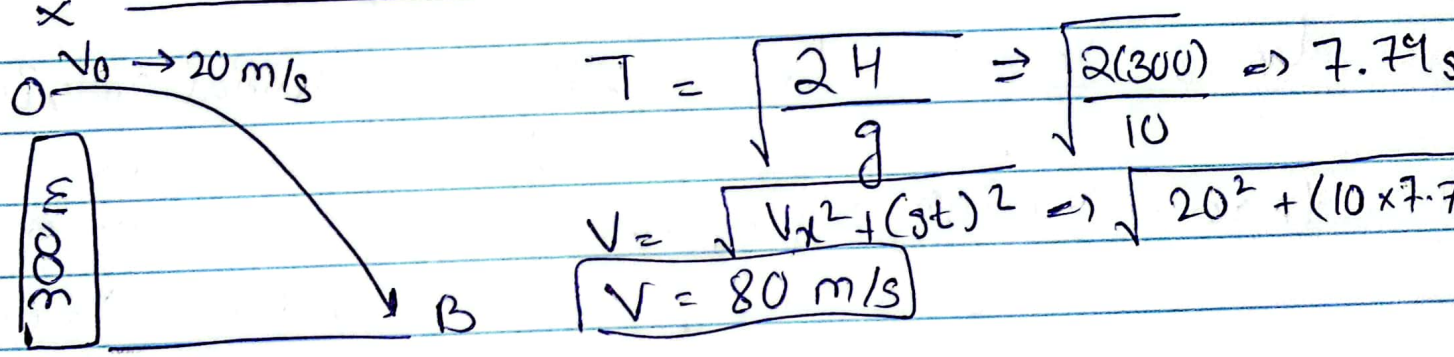
Q= Find the time taken by particle to reach ground?



$$T = \sqrt{\frac{2H}{g}} \Rightarrow \sqrt{\frac{2(20)}{10}} \Rightarrow 2\ s$$



$$T = \sqrt{\frac{2H}{g}} \Rightarrow \sqrt{\frac{2(300)}{10}} \Rightarrow 7.74\ s$$

$$V = \sqrt{V_x^2 + (gt)^2} \Rightarrow \sqrt{20^2 + (10 \times 7.7}$$

$$V = 80\ m/s$$

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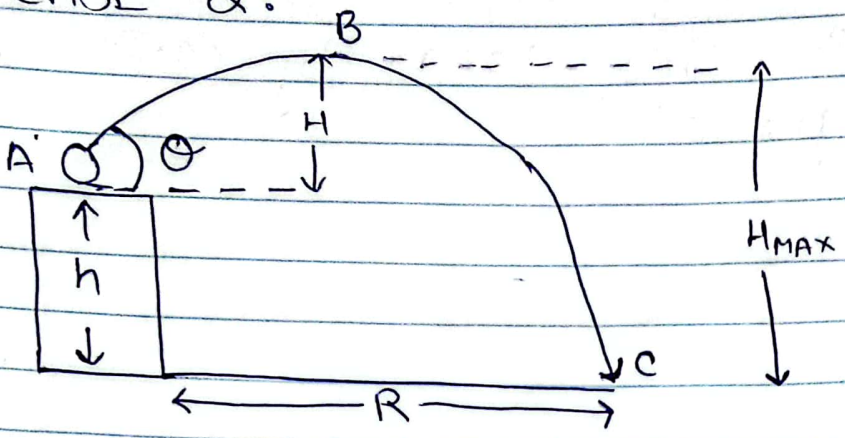
② CASE 2:



Height: $H_{MAX} = h + H = y_0 + \frac{v_0^2 \sin^2\theta}{2g}$

Time to flight:

$t_{A\to B} = \frac{v_0 \sin\theta}{g}$ $\quad t_{B\to C} = \sqrt{\frac{2H_{MAX}}{g}}$

$t_{A\to C} = \frac{v_0 \sin\theta}{g} + \sqrt{\frac{2H_{MAX}}{g}}$

Range: $R = v_0 \cos\theta\, t$

$R = v_x t$

Velocity Components:-

$v_x = v_0 \cos\theta$

$v_y = v_0 \sin\theta - gt$

Initial velocity:-

$v_0 = \frac{R}{t\cos\theta}$

Final velocity:-

$v_f = \sqrt{v_{xf}^2 + v_{yf}^2}$

$v_f = \sqrt{v_0^2 - (2gt\, v_0 \sin\theta) + (gt)^2}$

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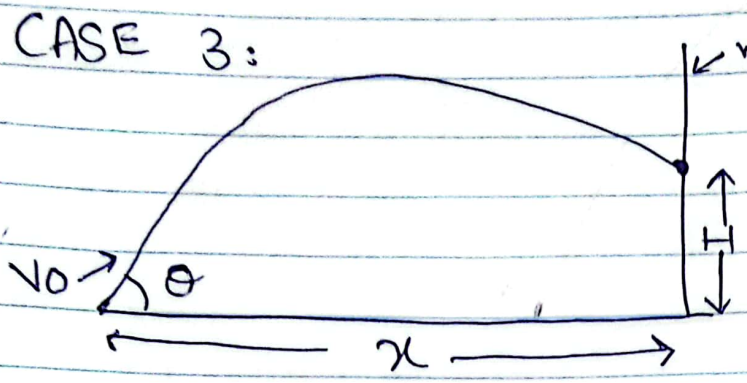
CASE 3:



- Time to Reach wall:-

$$x = V_0 \cos\theta \cdot t_{wall}$$

$$\boxed{t_{wall} = \frac{x}{V_0 \cos\theta}}$$

Horizontal Displacement

$$x = V_0 \cos\theta \cdot t$$

Vertical Displacement

$$y = V_0 \sin\theta \cdot t - \frac{gt^2}{2}$$

- Height of the wall:-

$$H = V_0 \sin\theta \cdot t_{wall} - \frac{1}{2} g t_{wall}^2$$

$$H = V_0 \sin\theta \cdot \frac{x}{V_0 \cos\theta} - \frac{1}{2} g \left(\frac{x}{V_0 \cos\theta}\right)^2$$

$$H = x \tan\theta - \frac{g x^2}{2 V_0^2 \cos^2\theta}$$

$$\boxed{H = x \tan\theta - \frac{g x^2}{2 V_0^2 \cos^2\theta}}$$

$$V_x = V_0 \cos\theta$$

$$V_y = V_0 \sin\theta - g t_{wall}$$

$$V = \sqrt{V_x^2 + V_y^2}$$

$$\phi_v = \tan^{-1}\left(\frac{V_y}{V_x}\right)$$

$$d = \sqrt{x^2 + (x\tan\alpha)^2}$$

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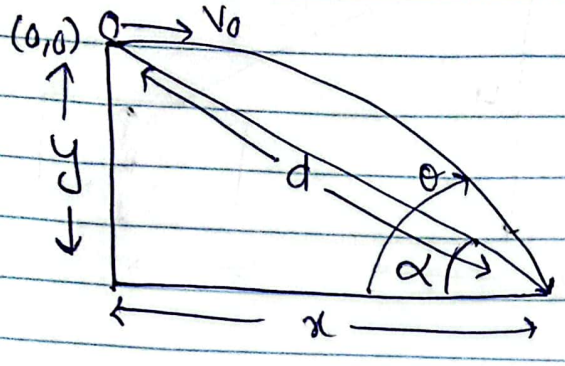
CASE - 4:



$x = V_0 t$

$y = \frac{1}{2} g t^2$

$y = \frac{1}{2} g \left(\frac{x}{V_0}\right)^2$

$\theta = g$

Horizontal Distance (x):-

$$x = \frac{2V_0^2 \tan\alpha}{g} \quad \text{(Horizontal Distance)}$$

$$y = x\tan\alpha \quad \text{(Vertical Distance)}$$

$$d = \frac{2V_0^2 \sec\alpha\tan\alpha}{g} \Rightarrow d = \sqrt{x^2 + (x\tan\alpha)^2}$$

$$\boxed{d = x\sec\alpha}$$

$$T = \frac{2V_0\tan\alpha}{g} \quad \text{(Time of flight)}$$

$$\boxed{d = \sqrt{x^2 + y^2}}$$

Velocity:-

$V_x = V_0$

$V_y = gt$

$V_y = g \cdot \frac{2V_0\tan\alpha}{g}$

$$V = \sqrt{V_x^2 + V_y^2}$$

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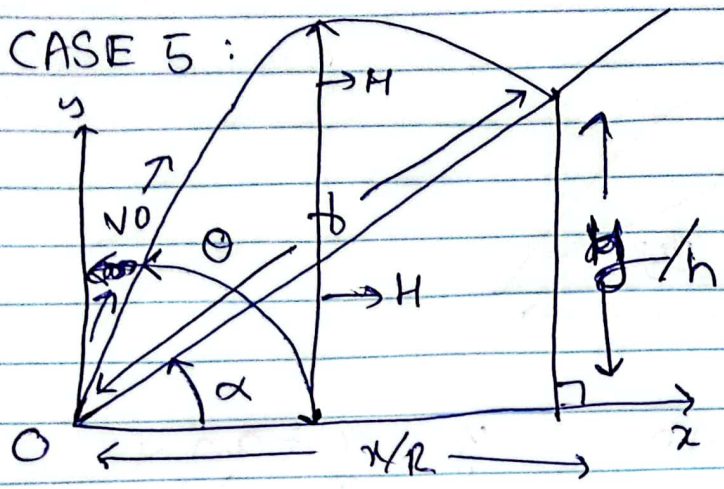
CASE 5 :



∥ to plane

$V_x = V_0 \cos(\theta - \alpha)$

$V_y = V_0 \sin(\theta - \alpha)$

⊥ to plane

$a_x = -g \sin\alpha$

$a_y = -g \cos\alpha$

$V_{0x} = V_0 \cos\theta$

$$T = \frac{2V_y}{g\cos\alpha} \Rightarrow \frac{2V_0 \sin(\theta - \alpha)}{g\cos\alpha}$$

$$\gamma = \frac{V_0^2 \sin(2(\theta - \alpha))}{g\cos\alpha}$$

$$H = \frac{(V_0^2 \sin^2(\theta - \alpha))}{2g\cos\alpha}$$

$$h/y = V_{0y}T - \frac{1}{2}gT^2$$

$$R/x = V_{0x} \cdot T \Rightarrow V_0 \cos\theta \cdot T$$

$$V = \sqrt{V_x^2 + V_y^2} \Rightarrow V = \sqrt{V_0^2 \cos^2(\theta-\alpha) + V_0^2 \sin^2(\theta-\alpha)}$$

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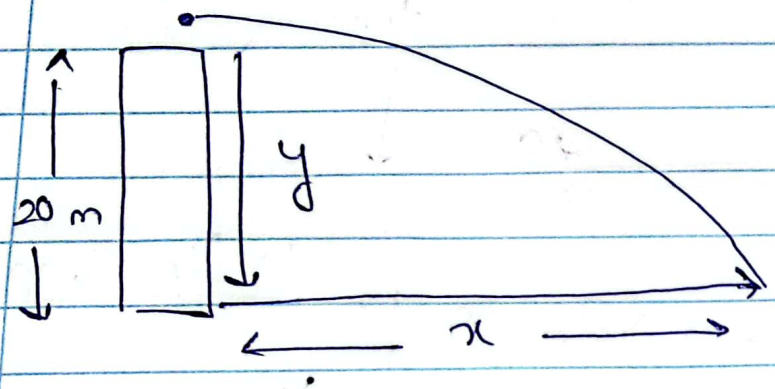
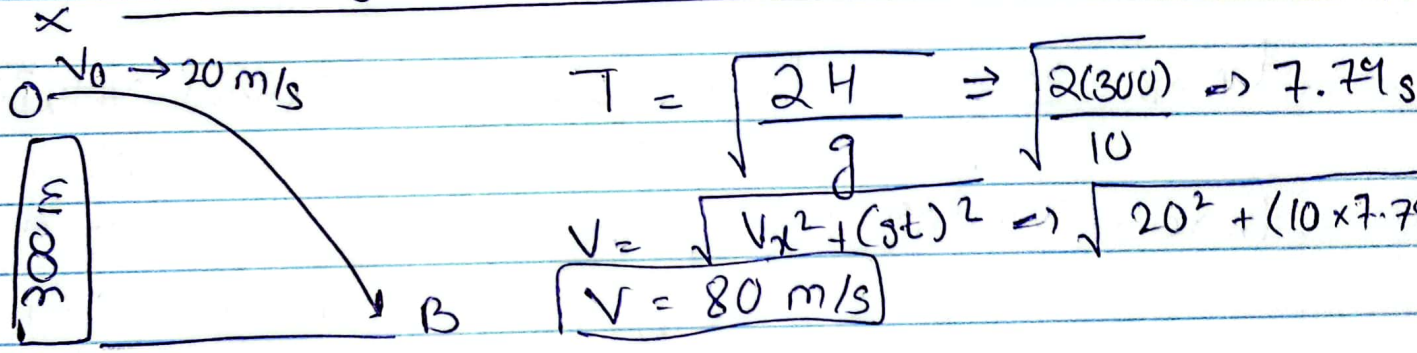
Q= Find the time taken by particle to reach ground?



$$T = \sqrt{\frac{2H}{g}} \Rightarrow \sqrt{\frac{2(20)}{10}} \Rightarrow 2\ s$$



$$T = \sqrt{\frac{2H}{g}} \Rightarrow \sqrt{\frac{2(300)}{10}} \Rightarrow 7.74\ s$$

$$V = \sqrt{V_x^2 + (gt)^2} \Rightarrow \sqrt{20^2 + (10 \times 7.74)^2}$$

$$\boxed{V = 80\ m/s}$$

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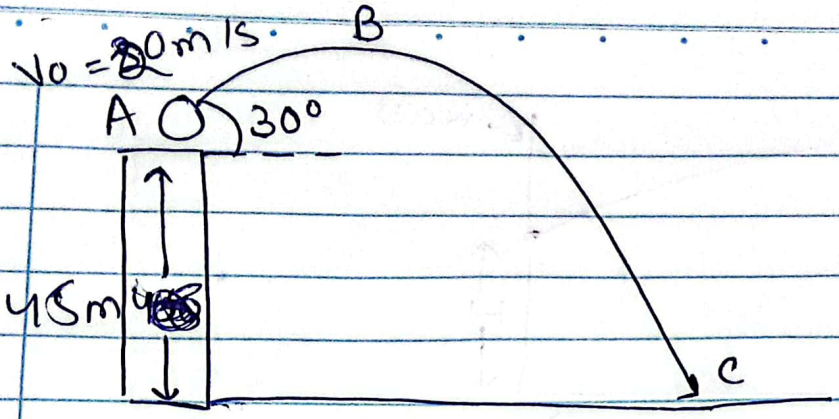

$$T_{A\to B} = \frac{V_0 \sin\theta}{g} \Rightarrow \frac{20 \sin 30}{9.8}$$

$$T_{B\to C} = \sqrt{\frac{2H_{MAX}}{g}} \Rightarrow \sqrt{\frac{2(45)}{9.8}}$$

$$T_{A\to C} = 4\,s$$

$$V_x = V_0 \cos\theta$$
$$V_x = 25.98\ m/s$$

$$V_y = V_0 \sin\theta - gt$$
$$V_y = 20\sin(30) - 9.8(4)$$
$$V_y = -29.2\ m/s$$

$$V_f = \sqrt{V_0^2 - (2gtV\sin\theta) + (gt)^2}$$

$$\boxed{V_f = 35.9\ m/s}$$

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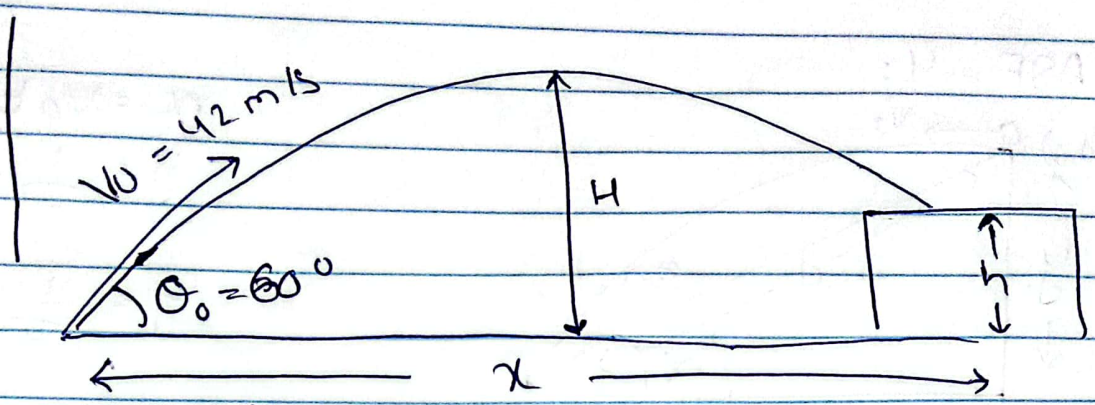

$t = 5.50\,s$

$h = ?$

$H = ?$

$V_0 = 42\ m/s$

$$H = \frac{V_0^2 \sin^2\theta}{2g} \Rightarrow \frac{(42)^2 \sin^2 60}{2(9.8)} \Rightarrow 67.5\ m$$

$$x = t_{wall}\,(V_0 \cos\theta)$$

$$x = (5.50)(42 \cos 60) \Rightarrow 115.5\ m$$

$$h = x\tan\theta - \frac{gx^2}{2V_0^2\cos^2\theta}$$

$$\boxed{h = 51.826\ m}$$

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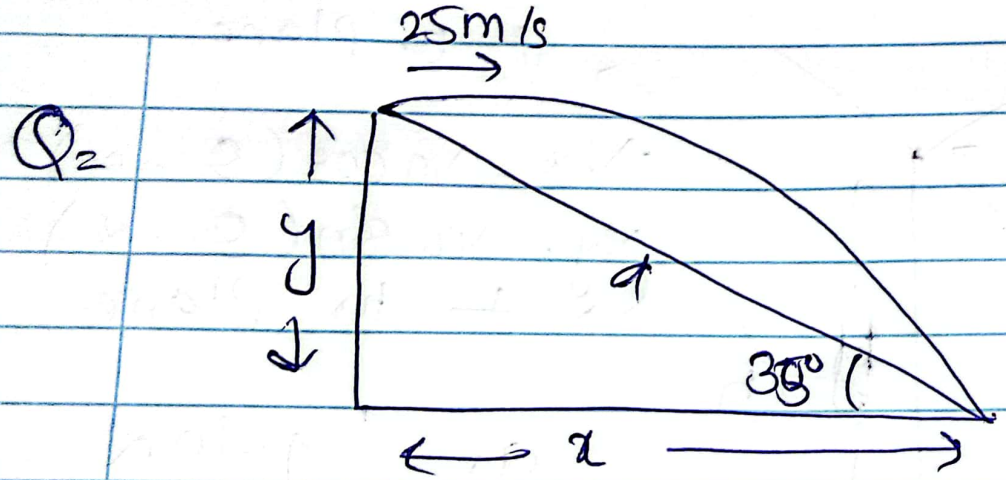
Q2



$$x = \frac{2 v_0^2 \tan\alpha}{g}$$

$$x = 89.3\ m$$

$$y = x \tan\alpha$$

$$y = (89.3)\tan(35°)$$

$$y = 62.53\ m$$

$$d = \sqrt{x^2 + y^2} \Rightarrow 109\ m$$