HW2

PHYS 4A

Chapter - 4

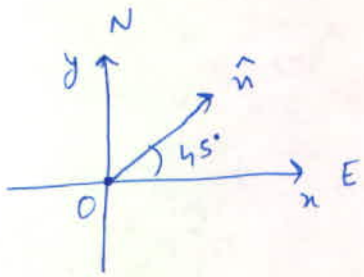
4.) a) $\vec{v}_f = \vec{a}\,t + \vec{v}_i$

$= 24 s\,(0.38\,\hat{i} + 0.72\,\hat{j})\ m/s^2 + 260\,\hat{i}\ m/s$

$= 269.12\,\hat{i} + 17.28\,\hat{j}\ m/s$

b) $\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)_{final} = 3.67°$

6.)



$\hat{n} \rightarrow$ unit vector along the north-east direction

$\hat{n} = \frac{1}{\sqrt{2}}(\hat{i} + \hat{j})$

Check: $|\hat{n}| = 1$ & $\phi = 45°$

$\therefore \vec{a} = |\vec{a}|\,\hat{n} = 2.1\left(\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right)\ m/s^2$

$\vec{v}_f = \vec{a}\,t + \cancel{\vec{v}_i} \rightarrow 0$

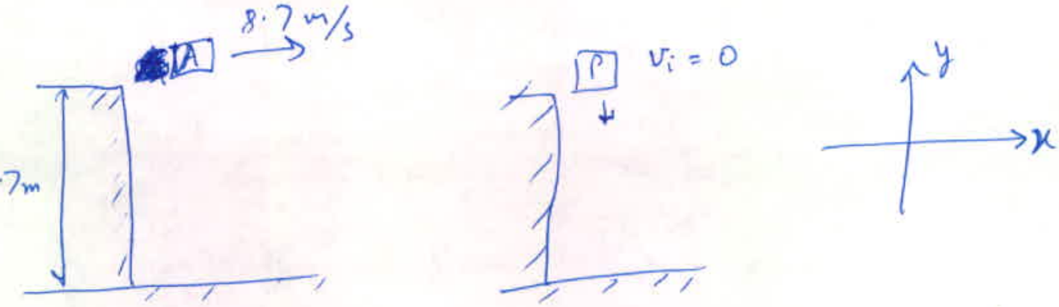
$\Rightarrow \vec{v} = 2.1\,t\,\hat{n}\ m/s$

$\vec{x} = \int \vec{v}\,dt = 2.1\,\frac{t^2}{2}\,\hat{n} + \cancel{\text{constant}} \rightarrow 0$

$\downarrow$ zero ($\because$ started from origin)

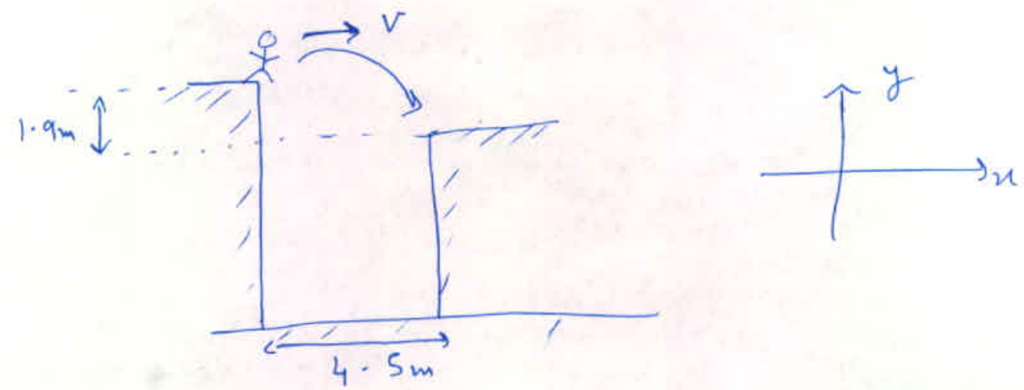
$\Rightarrow \vec{x} = 2.1\,\frac{t^2}{2}\,\hat{n}\ m$

14.)



Both take same time, since y-component of velocity is same (equal to 0) for both of them.

18.)



In y-direction

$s = -1.9\,m \; ; \; a = -9.8\,m/s^2$

& $u = 0$

$\therefore \; s = \cancel{ut}^{\,0} + \frac{1}{2} a t^2$

$\Rightarrow -1.9 = \frac{1}{2} \times (-9.8)\, t^2$

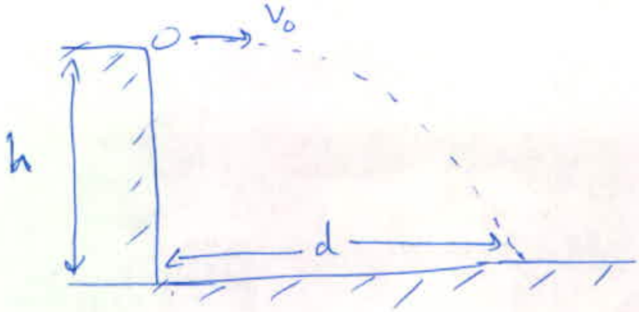
$\Rightarrow t = 0.623\ s$

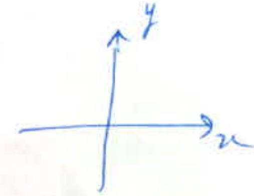
$\therefore$ Stuntman has a maximum of 0.623 s to ~~reach~~ cover the horizontal (x-direction) distance of 4.5 m.

$v = \frac{x}{t} = \frac{4.5\ m}{0.623\ s}$

$\Rightarrow v = 7.22\ m/s$ → Minimum velocity/speed needed.

22.)



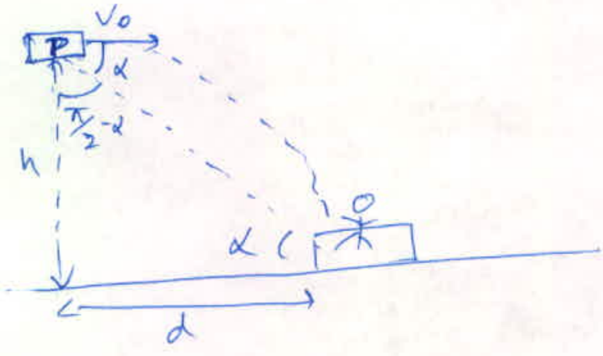


Time before it hits the ground $(t) = \sqrt{\frac{2h}{g}}$

(using $s = ut + \frac{1}{2}at^2$ in y-direction)

$$\therefore \quad d = v_0 t = \sqrt{\frac{2h}{g}}\, v_0$$

28.)



$$\tan\alpha = h/d$$

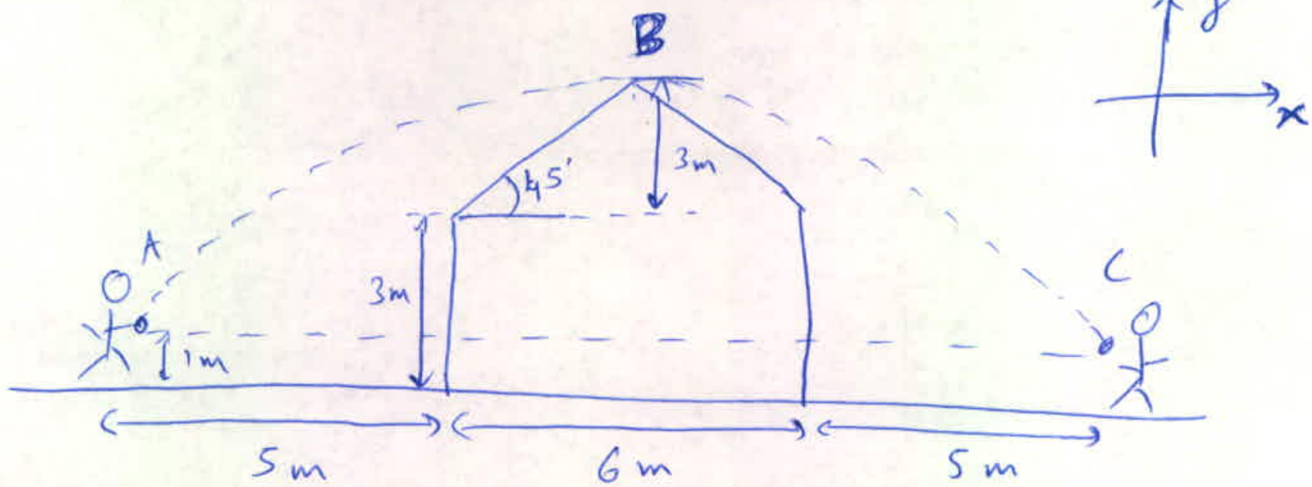
From Q22.), $d = \sqrt{\frac{2h}{g}}\, V_0$

$$\therefore \quad \tan\alpha = \frac{h\sqrt{g}}{V_0\sqrt{2h}}$$

$$\Rightarrow \tan\alpha = \frac{1}{V_0}\sqrt{\frac{gh}{2}}$$

$$\alpha = \tan^{-1}\left(\frac{1}{V_0}\sqrt{\frac{gh}{2}}\right)$$

34.)



a) For minimum speed, the ball must just cross over the roof of the house.

Applying Newton's equations of motion between points A & B for y-direction of the motion

$$V_{y_B}^2 = V_{y_A}^2 + 2as$$

$$V_{y_B}^2 = 0, \quad s = (3-1)+3$$
$$= 5\ m$$

$$\therefore \quad V_{y_A}^2 = 2 \times 9.8 \times 5 = 98\ m^2/s^2$$

$$\Rightarrow V_{y_A} = 7\sqrt{2}\ m/s$$

Also, $V_{y_B} = V_{y_A} + a\,t_{A\text{-}B}$

$$\Rightarrow \quad 0 = 7\sqrt{2} - 9.8\, t_{A-B}$$

$$\Rightarrow \quad t_{A-B} = \frac{7\sqrt{2}}{9.8} \text{ s}$$

$$\therefore \quad t_{A-C} = 2\, t_{AB} = \frac{14\sqrt{2}}{9.8} \text{ s}$$

Now, In x-direction, velocity is constant

$$\therefore \quad v_{x_A} t_{AC} = d = (5 + 6 + 5) \text{ m}$$

$$\Rightarrow \quad V_{x_A} = \frac{16}{t_{A-C}} = 7.92 \text{ m/s}$$

$$\therefore \quad |\vec{V}_A| = \sqrt{V_{x_A}^2 + V_{y_A}^2} = 12.68 \text{ m/s}$$

b)

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

$$= 51.34^\circ$$

48.)

$$a_r = 3.35 \times 10^{17}\ m/s^2 = \frac{v^2}{r} = \omega^2 r$$

angular velocity

$$\Rightarrow \omega = \sqrt{\frac{a_r}{r}}$$

$$\Rightarrow \omega = \sqrt{\frac{3.35 \times 10^{17}}{4.3 \times 10^{-2}}}\ \frac{rad}{s}$$

$$\Rightarrow \omega = 2.79 \times 10^{9}\ \frac{rad}{s}$$

$$\therefore \quad \theta = \omega t.$$

deflection

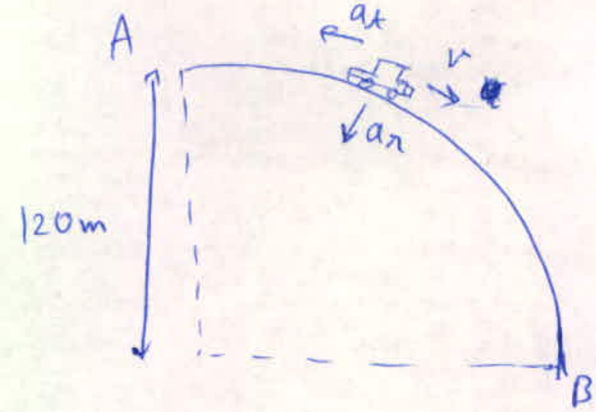
$$\Rightarrow t = \theta/\omega$$

$$\Rightarrow t = \frac{55^\circ}{2.79 \times 10^{9}} \times \frac{\pi}{180}\ s$$

Need to convert Degree to radians

$$\Rightarrow t = 3.44 \times 10^{-10}\ s$$

54.)



a)

$$a_t = -0.65\ m/s^2$$

Total distance (tangential) travelled between A & B is

$$S = \frac{2\pi r}{4} = \frac{\pi r}{2}$$

$$\therefore \quad V_B^2 = V_A^2 + 2 a_t S$$

$$= \left(65 \times \frac{5}{18}\right)^2 + 2(-0.65) \times 120$$

Conversion from km/h to m/s

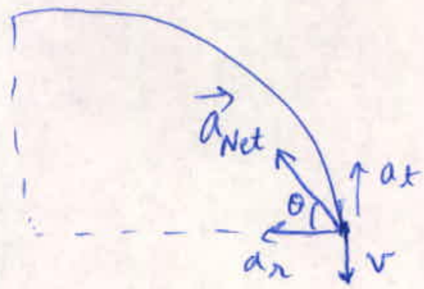
$$\Rightarrow \quad V_B = 13.04\ m/s$$

$$\therefore \quad a_r \text{ at Point } B = \frac{V_B^2}{r} = 1.42\ m/s^2$$

$$\therefore \quad |\vec{a}_B| = \sqrt{a_{r_B}^2 + a_{t_B}^2} = \sqrt{1.42^2 + 0.65^2}$$

$$= 1.56\ m/s^2$$

b)



$$\tan\theta = \frac{|a_t|}{|a_r|} = \frac{0.65}{1.42}$$

$\Rightarrow \theta = 24.6°$

∴ Angle between acceleration vector and direction of motion is $24.6° + 90° = 114.6°$

Chapter - 5

4.) $a_{avg} = \dfrac{110 \text{ km/h}}{0.14 s}$

$\Rightarrow a_{avg} = \dfrac{110}{0.14} \times \dfrac{5}{18} \text{ m/s}^2$

$\Rightarrow a_{avg} = 218.25 \text{ m/s}^2$

$\therefore F_{avg} = m a_{avg}$

$= 60 \times 218.25$

$= 13095 N$

18.) The person is capable of applying same force.

$\therefore F_{earth} = F_{moon}$

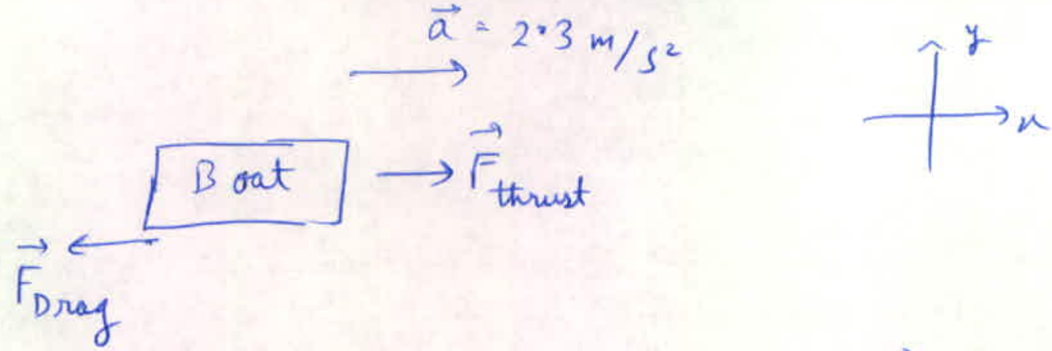
$m_{earth} g_{earth} = m_{moon} g_{moon}$

$\Rightarrow m_{moon} = 35 \text{ kg} \times \dfrac{g_{earth}}{g_{moon}}$

$\Rightarrow m_{moon} = 35 \text{ kg} \times \dfrac{9.81}{1.62} \rightarrow$ from Appendix E

$\Rightarrow m_{moon} = 211.94 \text{ kg}$

26.)



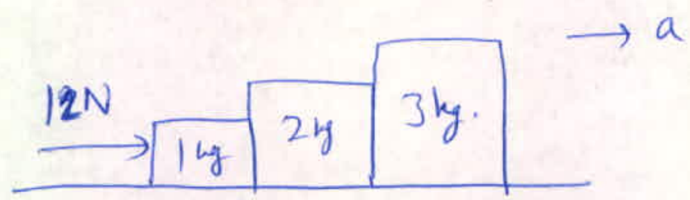
$$\therefore \vec{F}_{thrust} + \vec{F}_{Drag} = m\vec{a} \qquad \{\vec{F}_{Total} = m\vec{a}\}$$

$$\Rightarrow 3.9\times10^3\ N + (-F_{Drag}) = 930 \times 2.3\ N$$

in negative x-direction

$$\Rightarrow F_{drag} = 1761\ N$$

36.)

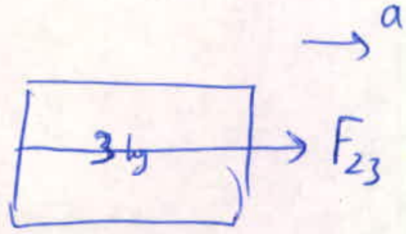


Using, $\vec{F} = m\vec{a}$ on whole system,

$$12 = \underbrace{(1+2+3)}_{\text{Total Mass}}\ a$$

$$\Rightarrow a = 2\ m/s^2$$

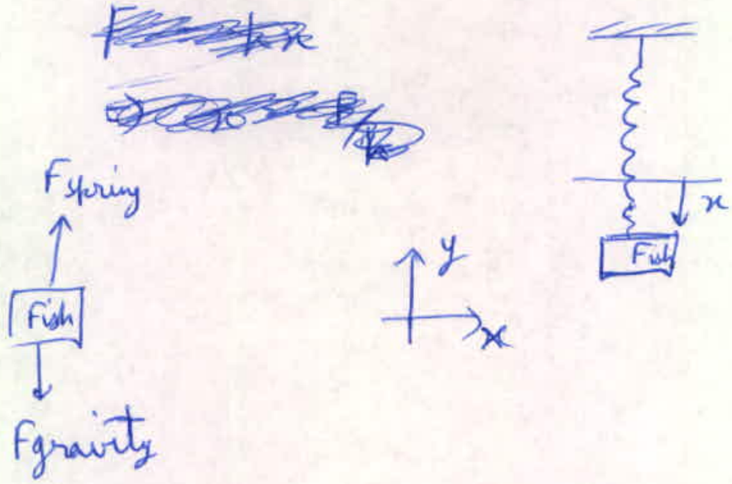
For 3 kg Box,



F_{23} ← Force on 3kg box due to 2kg Box.

$$\therefore F_{23} = 3\,kg \times 2\ m/s^2 = 6\ N$$

46.)



$$\vec{F}_{spring} + \vec{F}_{gravity} = 0$$

$$\Rightarrow |F_{spring}| - |F_{gravity}| = 0$$

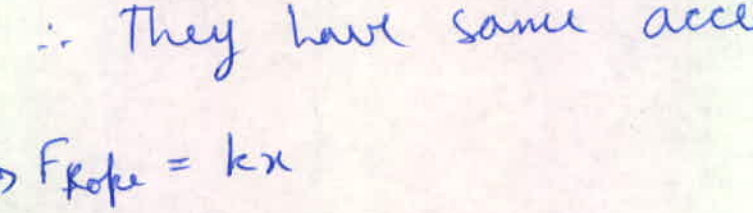
$$\Rightarrow kx = mg$$

$$\Rightarrow x = \frac{6.7 \times 9.8}{340}$$

$$\Rightarrow x = 0.193 \text{ m}$$

Stretch.

50.)



Since, car and truck move together
∴ They have same acceleration.

$\boxed{\text{Car}} \rightarrow F_{Rope} = kx$

$$m_{car} a = 1300 \times \frac{55}{100}$$

$$\Rightarrow \quad a = 0.376 \ m/s^2$$

$$\therefore \quad s = \cancel{v_i t}^{\,0} + \frac{1}{2} a t^2$$

$$\Rightarrow s = \frac{1}{2} \times 0.376 \ m/s^2 \times (60 s)^2$$

$$\Rightarrow s = 676.8 \ m$$