ME316 HW-1

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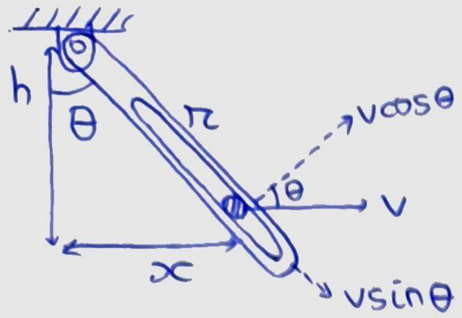
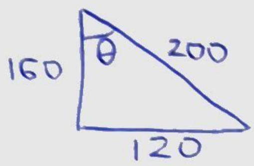
Q5)



$$\frac{dr}{dt} = v\sin\theta$$

$$r\frac{d\theta}{dt} = v\cos\theta$$

At that instant,

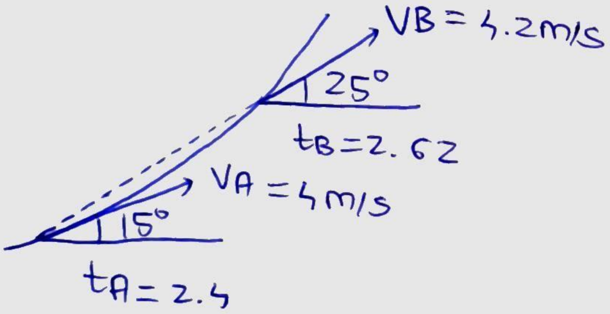


$$\tan\theta = \frac{120}{160} = \frac{3}{4} \Rightarrow r = 200$$

$$\frac{dr}{dt} = 25 \times \frac{3}{5} = 15\ mm/s$$

$$\frac{d\theta}{dt} = \frac{25 \times \frac{4}{5}}{200} = 0.1\ rad/s$$

Q4)



Avg. tangential acceleration

$$= \frac{|\vec{V_B} - \vec{V_A}|}{\Delta t}$$

$$\vec{V_A} = V_A\cos 15^\circ\,\hat{i} + V_A\sin 15^\circ\,\hat{j}$$
$$\vec{V_B} = V_B\cos 25^\circ\,\hat{i} + V_B\sin 25^\circ\,\hat{j}$$
} Tangential velocities

Normal velocities = 0

$$\text{Avg. normal acceleration} = \frac{|\vec{V_{B,n}} - \vec{V_{A,n}}|}{\Delta t} = 0$$

$$\text{Avg. tangential acceleration} = \frac{\sqrt{(4.2\cos 25 - 4\cos 15)^2 + (4.2\sin 25 - 4\sin 15)^2}}{(2.62 - 2.4)}$$

$$= \boxed{3.138\ m/s^2}$$

Q2) $a = \sigma - \eta v^2$

$$a = \frac{dv}{dt} = \frac{dx}{dt}\frac{dv}{dx} = v\frac{dv}{dx}$$

$$\Rightarrow \quad v\frac{dv}{dx} = \sigma - \eta v^2$$

$$\Rightarrow \quad \frac{v\,dv}{\sigma - \eta v^2} = dx$$

$$\sigma - \eta v^2 = a' \Rightarrow \quad -2\eta v\,dv = da'$$

$$\Rightarrow \quad \frac{da'}{-2\eta\, a'} = dx$$

$$\Rightarrow \quad -\frac{1}{2\eta}\ln\left(\frac{a'}{a'_0}\right) = x$$

$$\Rightarrow \quad -\frac{1}{2\eta}\left[\ln\left(\frac{\sigma - \eta v^2}{\sigma - \eta v_0^2}\right)\right] = x$$

For $x =$ displacement covered, $v = \frac{v_0}{2}$

$$\Rightarrow \quad \boxed{\Delta s = \frac{1}{2\eta}\ln\left(\frac{4\sigma - \eta v_0^2}{4\sigma - 4\eta v_0^2}\right)}$$

For terminal velocity, $a = 0 \quad \Rightarrow \boxed{v_t = \sqrt{\frac{\sigma}{\eta}}}$

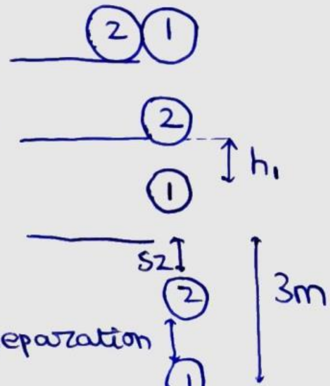
Q1)

2 balls per second $\Rightarrow$ 1 in 0.5 s

At $t=0$

At $t=0.5$

At $t=t'$



In 0.5 s, $h_1 = 0(t) + \frac{1}{2}g(0.5)^2$

$v_1 = u_1 + gt_1 = 10 \times 0.5 = 5\text{ m/s}$, $u_1 = 0$

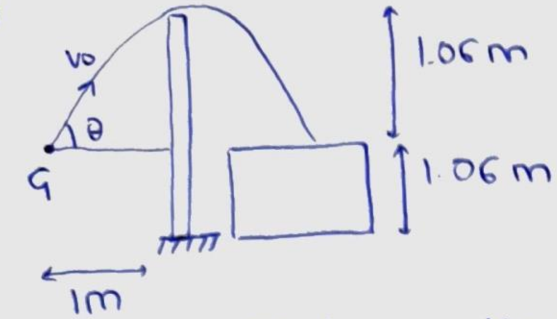
$s_1 = 3$ when $t = t'$ $\Rightarrow$ $3 = u_1 t' + \frac{1}{2}g(t')^2$, $u_1 = 0$ $\Rightarrow$ $t' = \sqrt{0.6}$ s

In t's ② travels $s_2 = \frac{1}{2}g(t'-t)^2 = \frac{1}{2}\times 10(\sqrt{0.6} - 0.5)^2$

$\Rightarrow s_2 = 0.377\,m$

Separation between 1 and 2 $= 3 - 0.377 = \boxed{2.623\,m}$

Q3)



$h_{max} = 2.12\,m$

$v\sin\theta$, $v\cos\theta$

$t_{max} = \frac{x}{v\cos\theta} = \frac{1}{v\cos\theta}$

At h_{max}, $v_y = 0 = v\sin\theta - g t_{max}$

$\Rightarrow v\sin\theta = \frac{g}{v\cos\theta} \Rightarrow v = \sqrt{\frac{g}{\sin\theta\cos\theta}}$

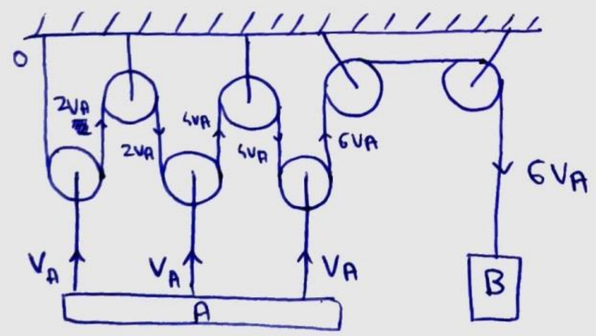
$s = v\sin\theta\, t_{max} - \frac{1}{2} g t_{max}^2 = 1.06$

$1.06 = \tan\theta - \frac{g}{2} \times \frac{1}{v^2\cos^2\theta} = \tan\theta - \frac{g}{2g\frac{\cos^2\theta}{\sin\theta\cos\theta}} = \frac{\tan\theta}{2}$

$\Rightarrow \tan\theta = 2.12 \Rightarrow \boxed{\theta = 64.757°}$

$v = \sqrt{\frac{g}{\sin\theta\cos\theta}} = \boxed{5.09\,m/s}$

Q7)



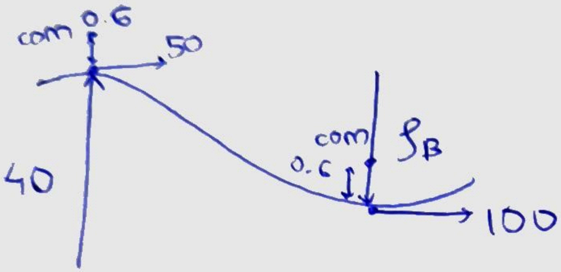
VA : velocity of A at all points on A is equal as bar is horizontal

$V_B = -6V_A$

$\Rightarrow V_{B/A} = V_B - V_A = -6V_A - V_A = -7V_A = 3.5\hat{j}$ (given)

$\Rightarrow \boxed{\begin{matrix} V_A = -0.5\hat{j} \\ V_B = 3\hat{j} \end{matrix}}$

Q5)



$a_A = a_B$

$$V_A = 50 \times \frac{5}{18} = \frac{125}{9}$$

$$V_B = 100 \times \frac{5}{18} = \frac{250}{9}$$

$$V_B = V_A + a_t t$$

$$\frac{250}{9} = \frac{125}{9} + a_t(10) \Rightarrow a_t = \frac{125}{90} = \frac{25}{18}\ m/s^2$$

$$a_A = \sqrt{\left(\frac{V_A^2}{40+0.6}\right)^2 + (a_t)^2}$$

$$a_B = \sqrt{\left(\frac{V_B^2}{\rho-0.6}\right)^2 + (a_t)^2}$$

$$a_A = a_B \Rightarrow \frac{\left(\frac{125}{9}\right)^{2\times2}}{(40.6)^2} = \frac{\left(\frac{250}{9}\right)^{2\times2}}{(\rho-0.6)^2}$$

$$\Rightarrow \rho - 0.6 = 40.6 \times 4$$

$$\Rightarrow \rho = 162.4 + 0.6 = \boxed{163\,m}$$