

M2 JAN 09

1)

$R_f \nearrow = ma$ $\sin \theta = \frac{1}{14}$

$$\frac{30000}{15} - 650 - \frac{1500g}{14} = 1500a$$

$$a = \underline{0.2 \text{ ms}^{-2}}$$

2)

$R_f \uparrow = 0 \Rightarrow N_{RA} = 100g \text{ N}$

$$f_{\max} = \mu N_R = \frac{11}{25} \times 100g = \underline{44g \text{ N}}$$

$f_{\max} = \mu N_{RA}$ b) $R_f = 0 \Rightarrow f_{\max} = N_{RB} = 44g$

$M = \frac{11}{25}$ $\sum \tau = 0 \Rightarrow 25g \times 2 \cos \beta + 75g \times 3 \cos \beta = 44g \times 4 \sin \beta$

$$260 \cos \beta = 176 \sin \beta$$

$\Rightarrow \tan \beta = \frac{260}{176} \Rightarrow \beta = \tan^{-1} \left(\frac{260}{176} \right) = 55.905 \dots = \underline{56^\circ \text{ (nd)}}$

c) Reece's weight acts exactly at C.

3)

a) $R_f \uparrow = 0 \Rightarrow N_R = 100g \text{ N}$

$$f_{\max} = \mu N_R \Rightarrow f_{\max} = \frac{4}{7} \times 100g = \underline{\frac{400}{7}g \text{ N}}$$

$M = \frac{4}{7}$

$W_d \text{ against friction} = \frac{40}{7}g \times 50 = \underline{\underline{\frac{2000}{7}g \text{ J}}}$

b)

$KE \text{ at A} = KE \text{ at B} + W_d \text{ against friction} - W_d \text{ by force}$

$$\frac{1}{2}M(2)^2 = \frac{1}{2}Mv^2 + \frac{2000g}{7} - 70 \times 50$$

$$3520 - \frac{2000}{7}g = 5v^2 \Rightarrow v^2 = 144 \Rightarrow v = \underline{12 \text{ ms}^{-1}}$$

4) $V = 10t - 2t^2$

$S = \int v dt = 5t^2 - \frac{2}{3}t^3 + C$ $t=0, S=0 \Rightarrow C=0$

$S = 5t^2 - \frac{2}{3}t^3$ ($0 \leq t \leq 6$) $t=6, S=36m$

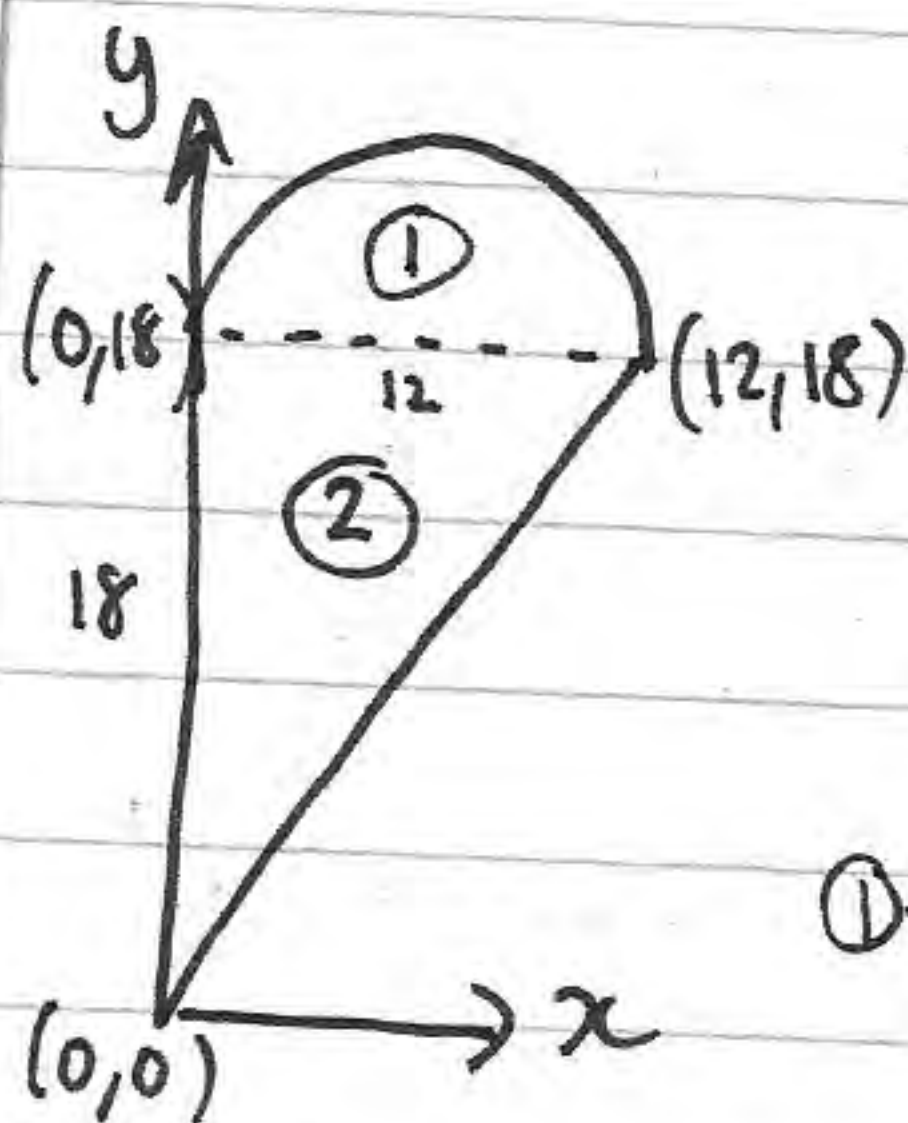
b) $V = -432t^{-2}$

$S = \int v dt = 432t^{-1} + C = \frac{432}{t} + C$ $t=6, S=36$ $36 = 72 + C$

$C = -36$

$S = \frac{432}{t} - 36$ $t=10, S = 43.2 - 36 = \underline{7.2m}$

5)



① $A = \frac{\pi(6)^2}{2} \Rightarrow M = 18\pi k$ $g_1(6, 18 + \frac{8}{\pi})$

② $A = \frac{1}{2}(12)(18) \Rightarrow M = 108k$ $g_2(4, 12)$

①+② $M = (108 + 18\pi)k$ $G(\bar{x}, \bar{y})$

$g_2(\frac{0+0+12}{3}, \frac{0+18+18}{3})$

\uparrow $18\pi kg \times 6 + 108kg \times 4 = (108 + 18\pi)kg \times \bar{x}$

mass per unit area = k

$\bar{x} = \frac{108\pi + 432}{108 + 18\pi} = 4.69cm$ (3sf)

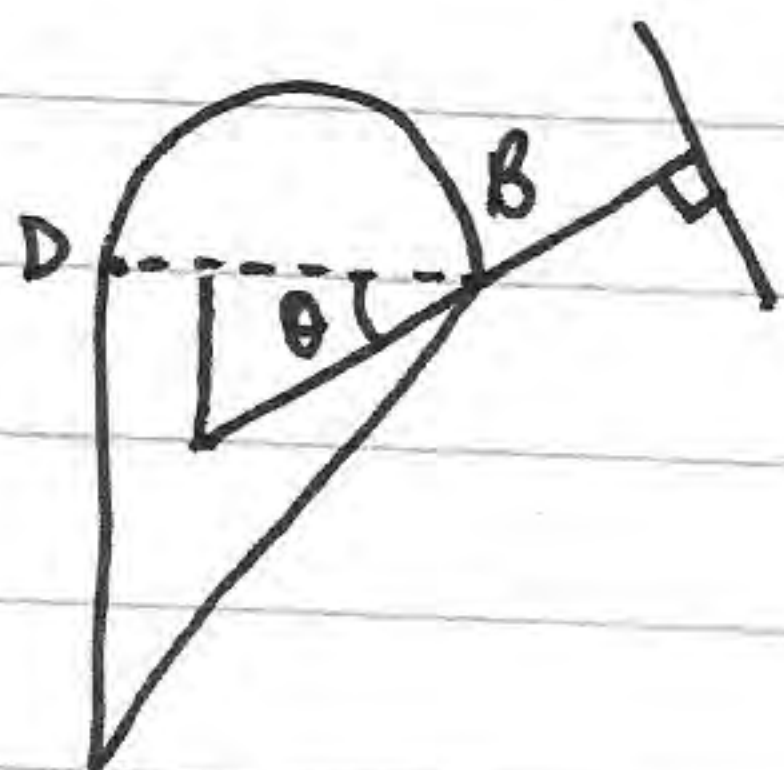
b) \uparrow $18\pi kg \times (18 + \frac{8}{\pi}) + 108kg \times 12 = (108 + 18\pi)kg \times \bar{y} = 18\pi(\frac{-8}{\pi}) + 108(6)$

$\bar{y} = \frac{504}{108 + 18\pi} = 3.06$ (3sf)

(vertical distance from $BD = 6$)

~~$\bar{x} = 14.937 \dots = 14.9$ (3sf)~~

c)



$\theta = \tan^{-1}\left(\frac{18 - 14.9}{12 - 4.69 \dots}\right)$

$\theta = 23^\circ$ (nd)

6) \vec{F} $Vel = p$ $x = vt \Rightarrow 57.6 = 3p \Rightarrow p = \underline{19.2}$
 $x = 57.6$
 $t = 3$

b) $v \uparrow$ $u = q \uparrow$ $s = ut + \frac{1}{2}at^2 \Rightarrow -0.9 = 3q - 4.9 \times 3^2$
 $a = -9.8 \uparrow$ $\Rightarrow 3q = 43.2$
 $s = -0.9$ $q = \underline{14.4} \#$
 $t = 3$

c) Initial speed = $\sqrt{14.4^2 + 19.2^2} = \underline{24 \text{ ms}^{-1}}$

d) $\tan \alpha = \frac{14.4}{19.2} \Rightarrow \tan \alpha = \frac{3}{4}$

e) 4 m above ground $\Rightarrow s = 3.1$

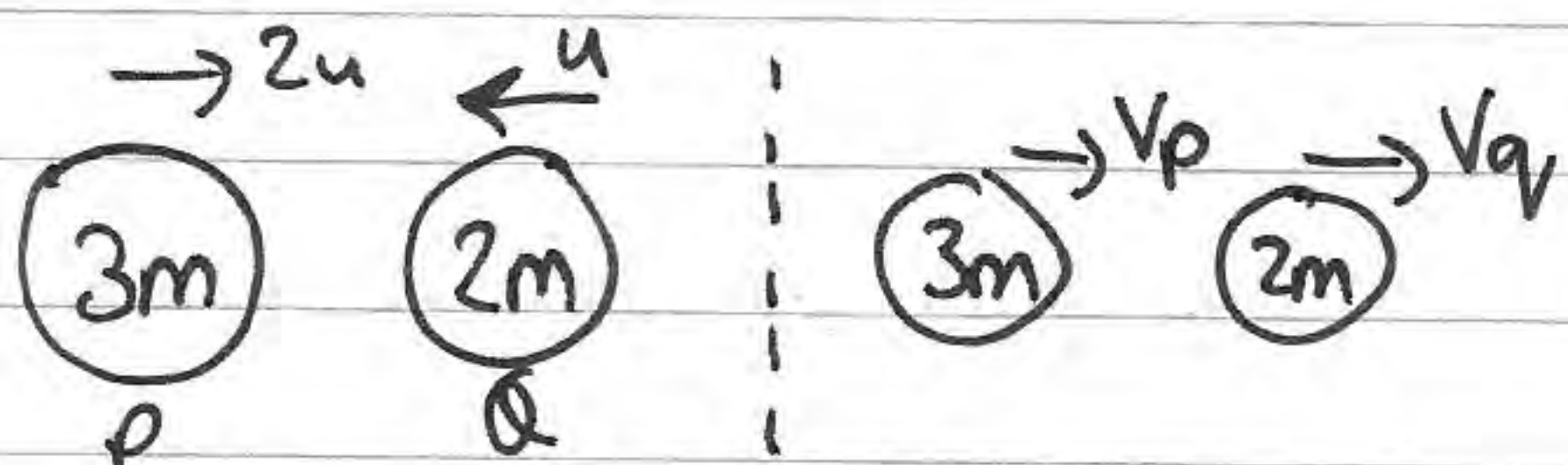
$$3.1 = 14.4t - 4.9t^2 \Rightarrow 4.9t^2 - 14.4t + 3.1 = 0$$

$$t = \frac{14.4 \pm \sqrt{14.4^2 - 4(4.9)(3.1)}}{9.8} \Rightarrow t_1 = 2.70, t_2 = 0.23$$

total time above = $\underline{2.47}$ (3sf)

f) Wind/air resistance; ball not considered a particle; spin.

7)



$e = \frac{v_q - v_p}{3u} \Rightarrow 3eu = v_q - v_p$

$$6mu - 2mu = 3mv_p + 2mv_q$$

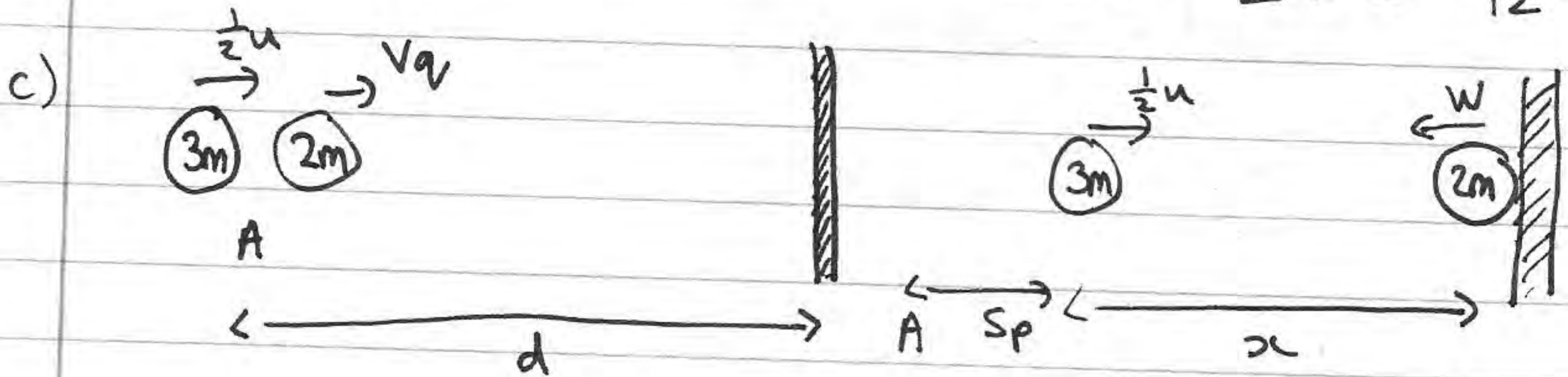
$$V_p = V_q - 3eu \Rightarrow 4mu = 3m(V_q - 3eu) + 2mV_q$$

$$4u = 5V_q - 9eu$$

$$4u + 9eu = 5V_q \Rightarrow V_q = \frac{1}{5}u(4 + 9e) \quad \#$$

b) $V_p = \frac{1}{2}u \Rightarrow \frac{1}{2}u = \frac{1}{5}u(4 + 9e) - 3eu \Rightarrow \frac{5}{2} = 4 + 9e - 15e$

$$\Rightarrow 6e = \frac{3}{2} \Rightarrow e = \frac{3}{12} = \frac{1}{4} \quad \#$$



$$\frac{1}{2}u = V_q - 3eu \Rightarrow \frac{1}{2}u = V_q - \frac{3}{4}u \Rightarrow V_q = \frac{5}{4}u$$

Q) $d = \frac{5}{4}ut \Rightarrow t = \frac{4d}{5u}$ P) $S = \frac{1}{2}u \times \left(\frac{4d}{5u}\right) = \frac{4}{10}d = \frac{2}{5}d$

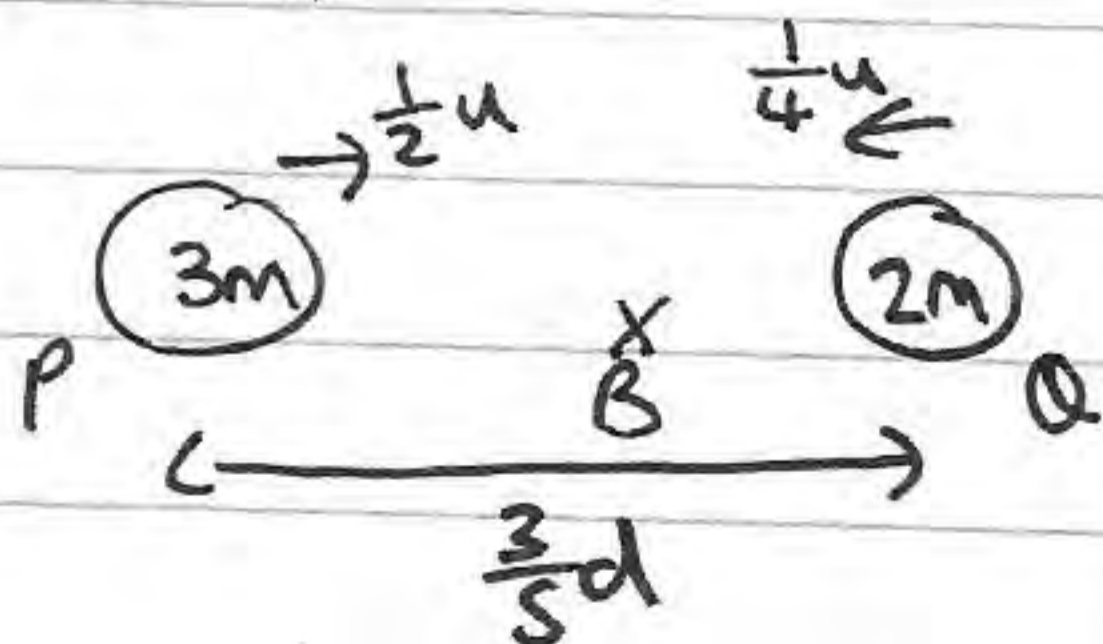
$$x = d - \frac{2}{5}d = \frac{3}{5}d \Rightarrow P \text{ is } \frac{3}{5}d (=x) \text{ when Q hits wall} \quad \#$$

before $\rightarrow \frac{5}{4}u$

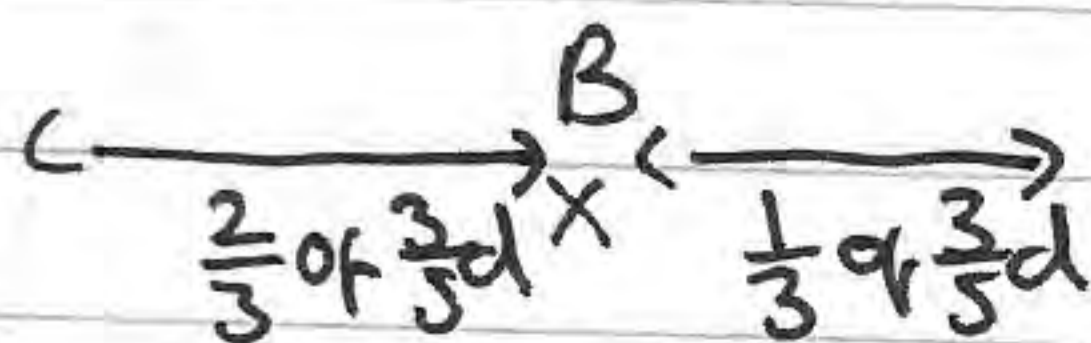
2m

$$e = \frac{w}{\frac{5}{4}u} = \frac{1}{5} \Rightarrow w = \frac{1}{4}u$$

after $\leftarrow w$



P is moving twice as fast as Q



\therefore the point B is $\frac{1}{5}d$ from the wall.