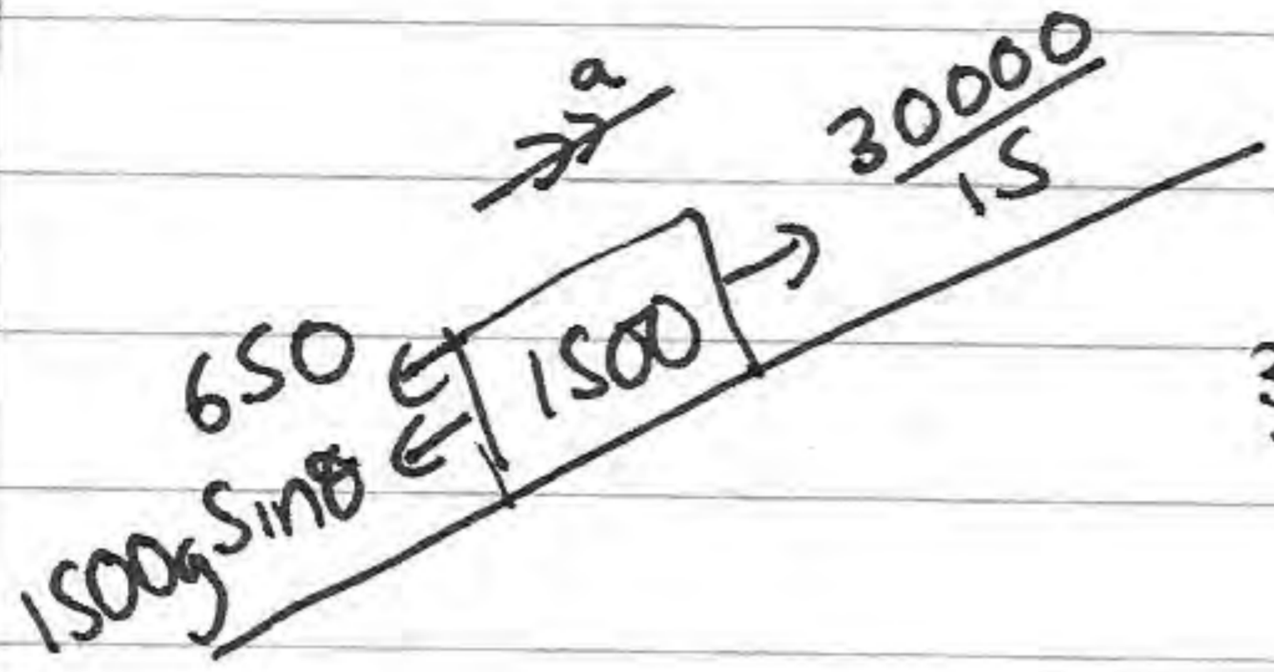
M2 JAN 09

1)

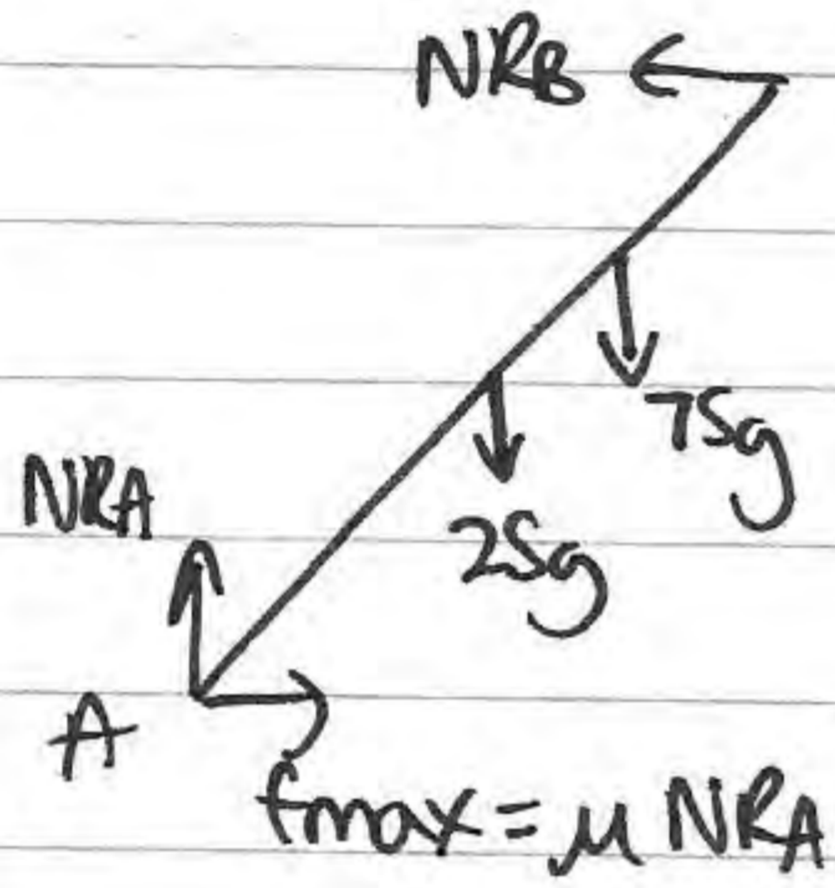


$Rf \nearrow = ma$ $\sin\theta = \frac{1}{14}$

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

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

2)



$Rf\uparrow = 0 \Rightarrow NRA = 100g\,N$

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

$\mu = \frac{11}{25}$

b) $\overrightarrow{Rf} = 0 \Rightarrow f_{max} = NRB = 44g$

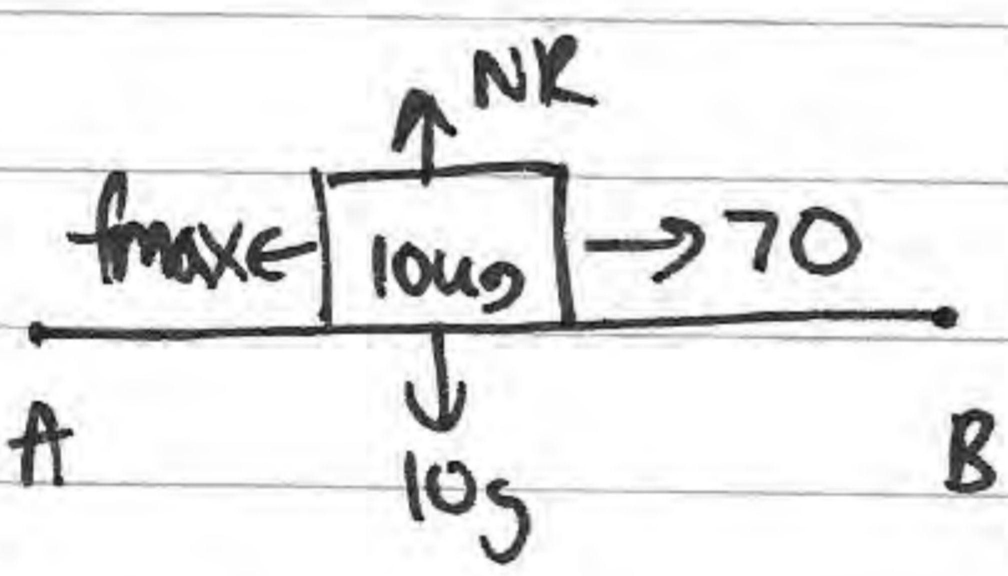
A ↻ $25g \times 2\cos\beta + 75g \times 3\cos\beta = 44g \times 4\sin\beta$

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

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

c) Reece's weight acts exactly at C.

3)



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

a) $Rf\uparrow = 0 \Rightarrow NR = 10g\,N$

$f_{max} = \mu NR \Rightarrow f_{max} = \frac{4}{7} \times 10g = \frac{40}{7}g\,N$

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

b) KE at A = KE at B + wd against friction − Wd by force

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

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

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

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

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

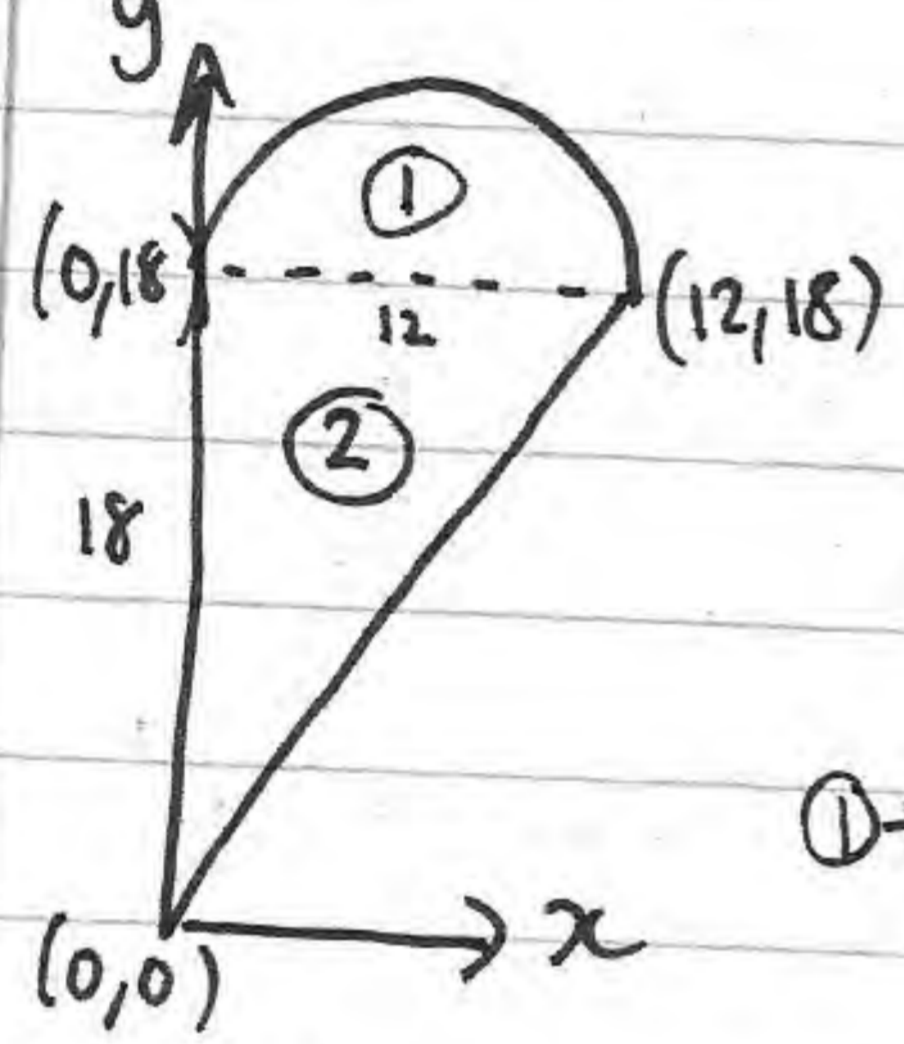
b) $V = -432t^{-2}$

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

$c = -36$

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

5)



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

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

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

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

mass per unit area $= k$

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

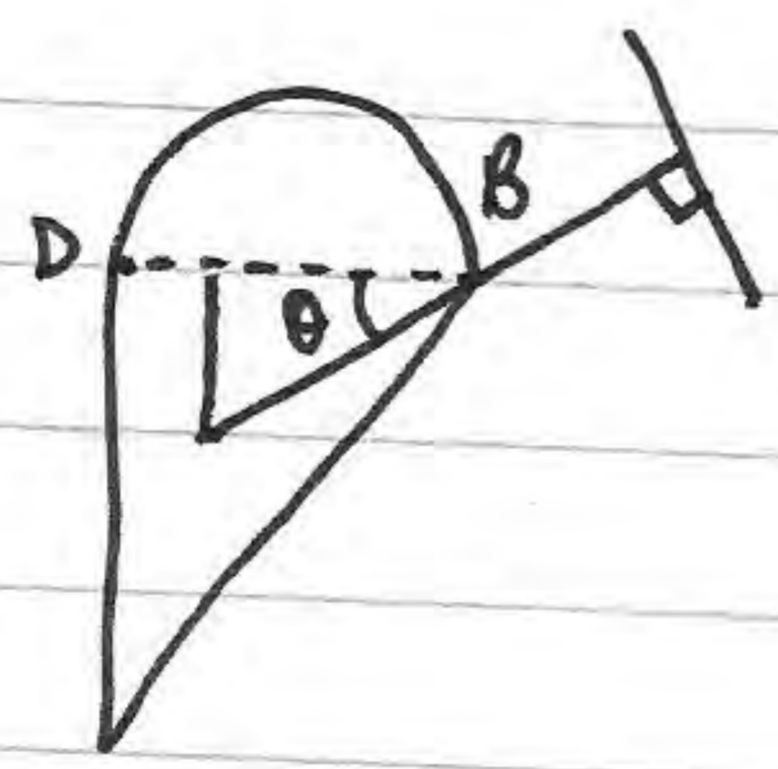
$\bar{x} = \frac{108\pi + 432}{108 + 18\pi} = 4.69cm$ (3sf)

b) $\curvearrowright x \quad 18\pi kg \times \left(18 + \frac{8}{\pi}\right) + 108kg \times 12 = (108+18\pi)kg \times \bar{y}$

$\bar{y} = \frac{324\pi + 144 + 1296}{108 + 18\pi}$

$= 14.937\ldots = 14.9$ (3sf)

c)



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

$\theta = 23°$ (nd)

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

$x = 57.6$

$t = 3$

b) $V\uparrow$ $\quad u = q\uparrow$ $\quad s = ut + \frac{1}{2}at^2 \Rightarrow -0.9 = 3q - 4.9 \times 3^2$

$a = -9.8\uparrow$ $\quad \Rightarrow 3q = 43.2$

$s = -0.9$ $\quad q = \underline{14.4}$ #

$t = 3$

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

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

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

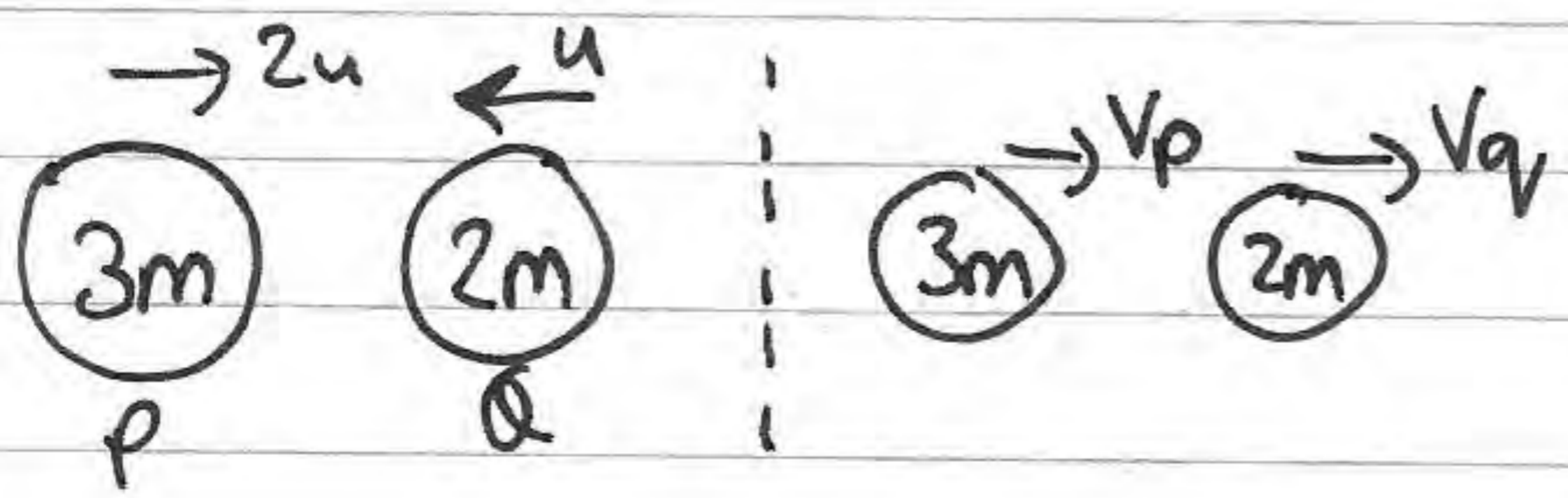
$3.1 = 14.4t - 4.9t^2 \Rightarrow 4.9t^2 - 14.4t + 3.1 = 0$

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

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

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

7)



$e = \frac{V_q - V_p}{3u} \Rightarrow 3eu = V_q - V_p$

$6mu - 2mu = 3mV_p + 2mV_q$

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

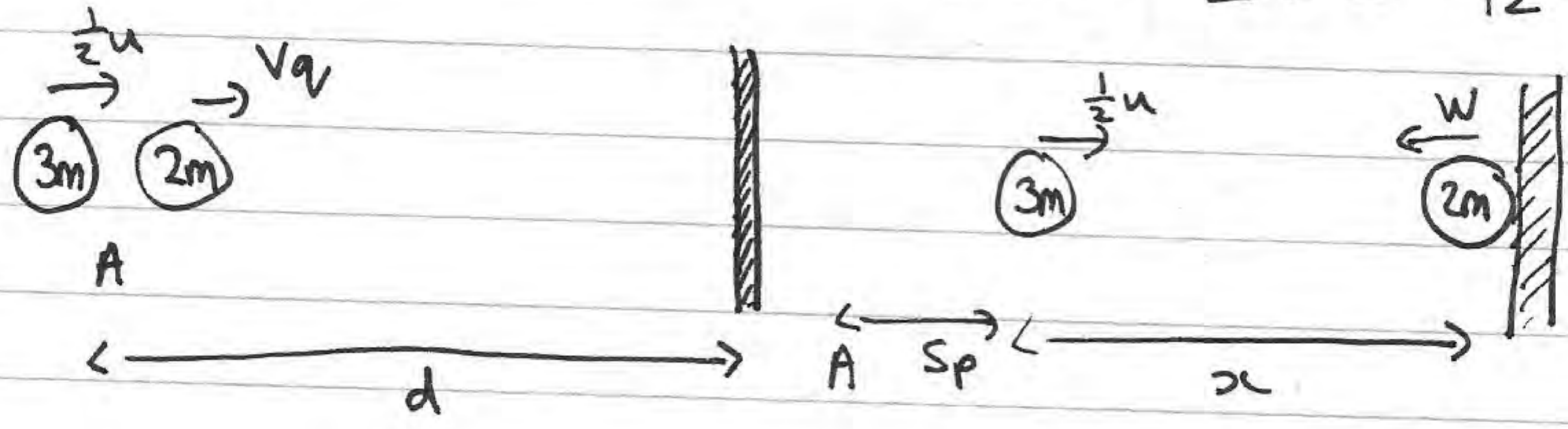
$4u = 5V_q - 9eu$

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

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

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

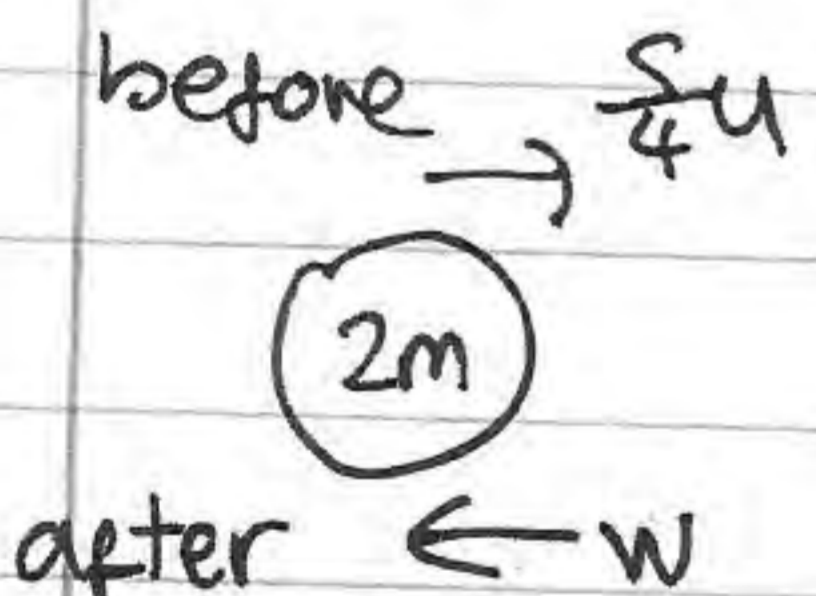
c)



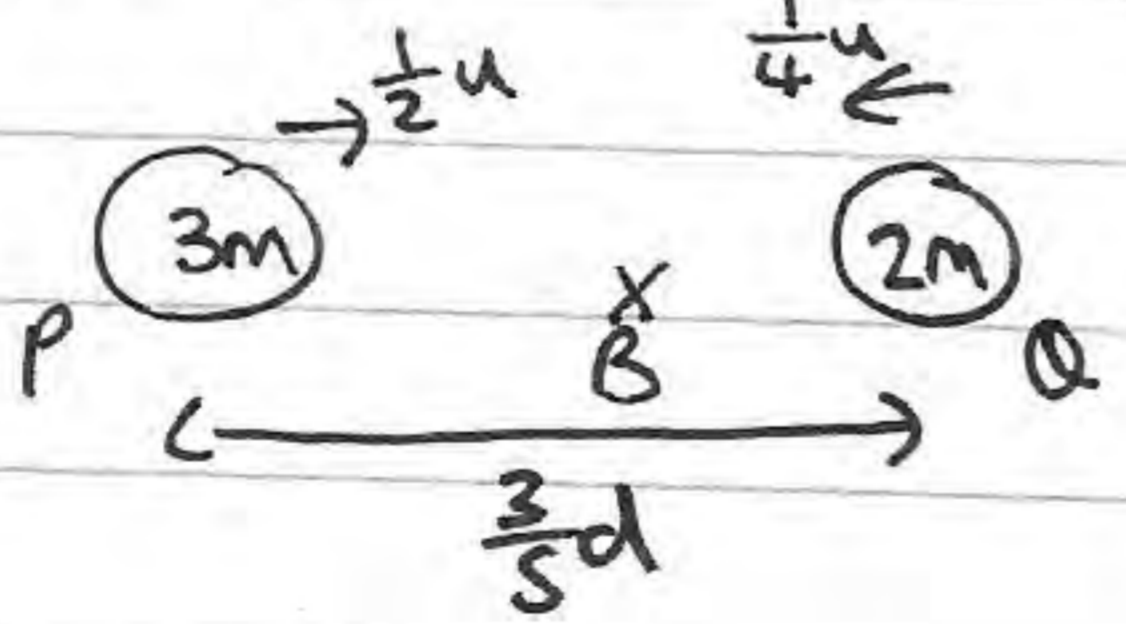
$\frac{1}{2}u = V_q - 3eu \Rightarrow \frac{1}{2}u = V_q - \frac{3}{4}u \Rightarrow V_q = \frac{5}{4}u$

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

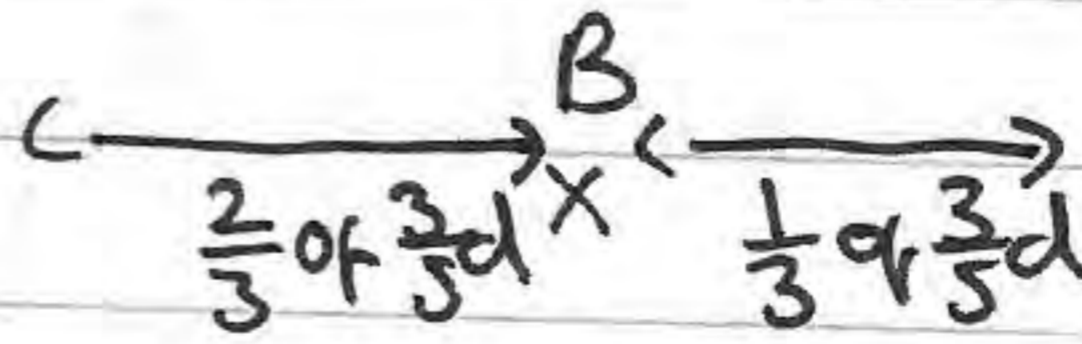
$x = d - \frac{2}{5}d = \frac{3}{5}d \Rightarrow P$ is $\frac{3}{5}d$ $(=x)$ when Q hits wall #



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



P is moving twice as fast as Q



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