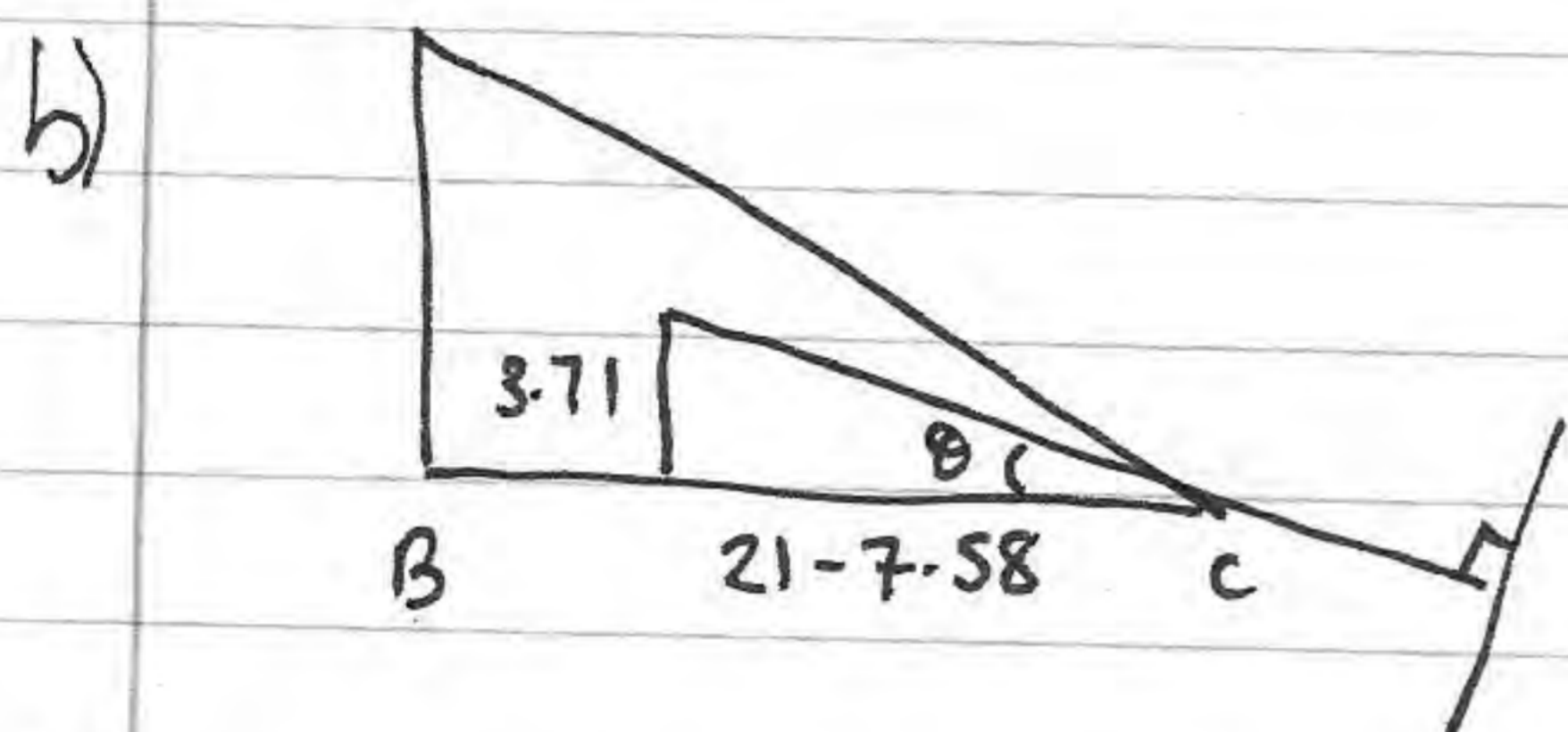


$$9\pi \mu g \times 5 + (126 - 9\pi) \mu g \times \bar{x} = 126 \mu g \times 7$$

$$\bar{x} = \frac{882 - 45\pi}{126 - 9\pi} = \underline{7.58 \text{ cm (3sf)}}$$

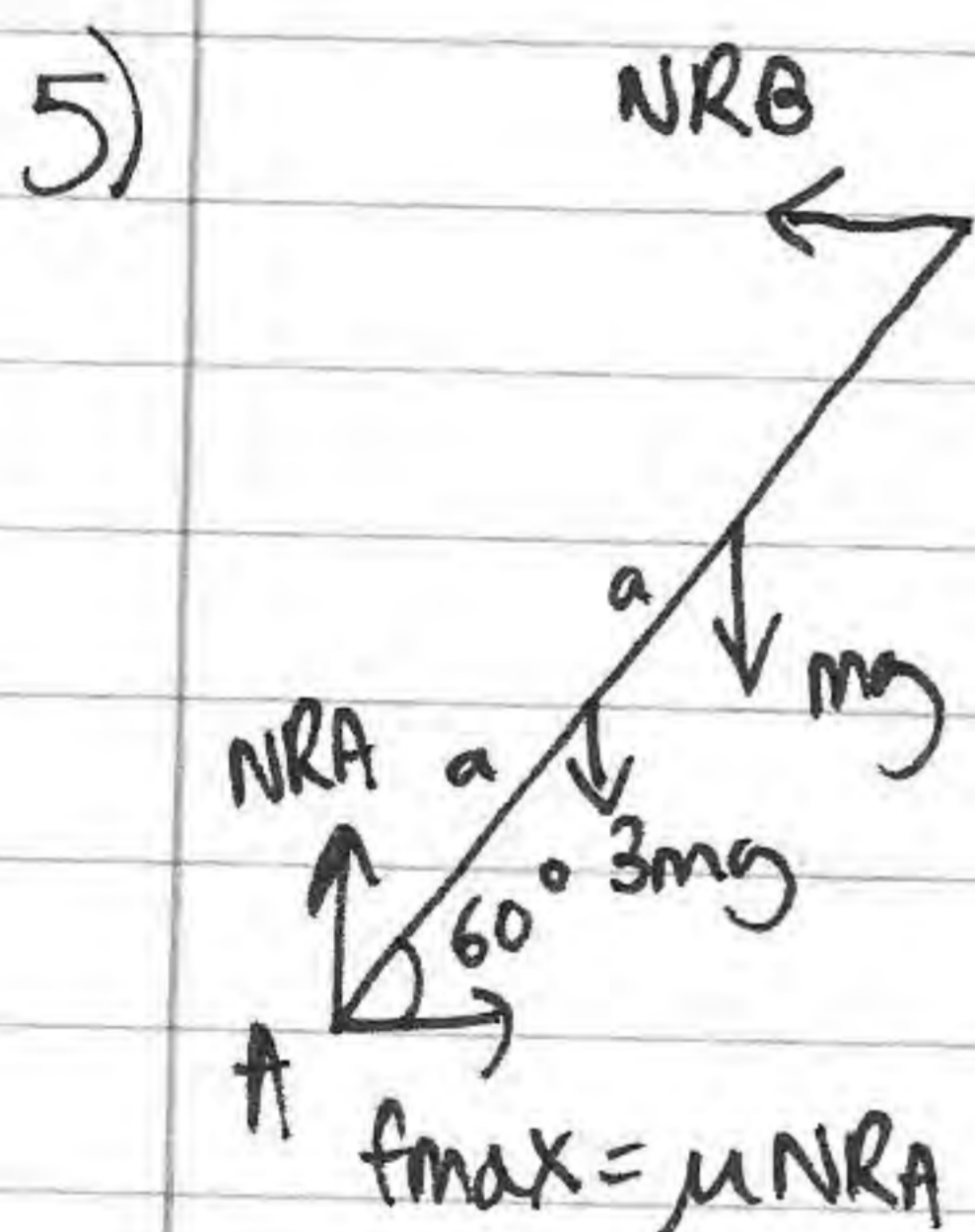
$$9\pi \mu g \times 5 + (126 - 9\pi) \mu g \times \bar{y} = 126 \mu g \times 4$$

$$\bar{y} = \frac{504 - 9\pi \times 5}{126 - 9\pi} = \underline{3.71 \text{ cm (3sf)}}$$



$$\theta = \tan^{-1} \left(\frac{3.71}{13.42} \right)$$

$$\theta = 15^\circ \text{ (nd)}$$



$$R_f \uparrow = 0 \Rightarrow N_{RA} = 4mg \Rightarrow f_{\max} = \mu 4mg$$

$$R_f = 0 \Rightarrow f_{\max} = N_{RB} \Rightarrow \mu 4mg = N_{RB}$$

$$A \curvearrowright 3mg \times a \cos 60 + mg \times 2a \cos 60 = N_{RB} \times 4a \sin 60$$

$$\Rightarrow \frac{3}{2} mga + mga = \mu \times 8\sqrt{3} mga$$

$$\mu = \frac{2.5}{8\sqrt{3}} = \frac{5}{16\sqrt{3}} \quad (= \underline{0.18 \text{ (2sf)}})$$

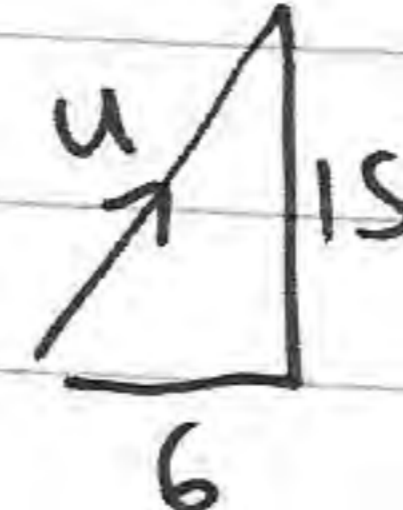
6) \vec{H} $x = 30$ $vel = 2u \Rightarrow t = \frac{30}{2u} = \frac{15}{u}$

$\vec{v} \uparrow$ $u \uparrow = 5u$ $a = -9.8$ $s = -47.5$ $t = \frac{15}{u}$

$$-47.5 = (5u) \left(\frac{15}{u} \right) - 4.9 \left(\frac{15}{u} \right)^2 \Rightarrow 4.9 \left(\frac{15}{u} \right)^2 = 122.5$$

$$\Rightarrow u^2 = 9 \Rightarrow u = 3 \Rightarrow t = \frac{15}{3} = \underline{5 \text{ sec}}$$

6 b) $u=3$ from (a) $\vec{u} = 6$ $u^2 = 15^2 + 6^2$
 $u^2 = 261$

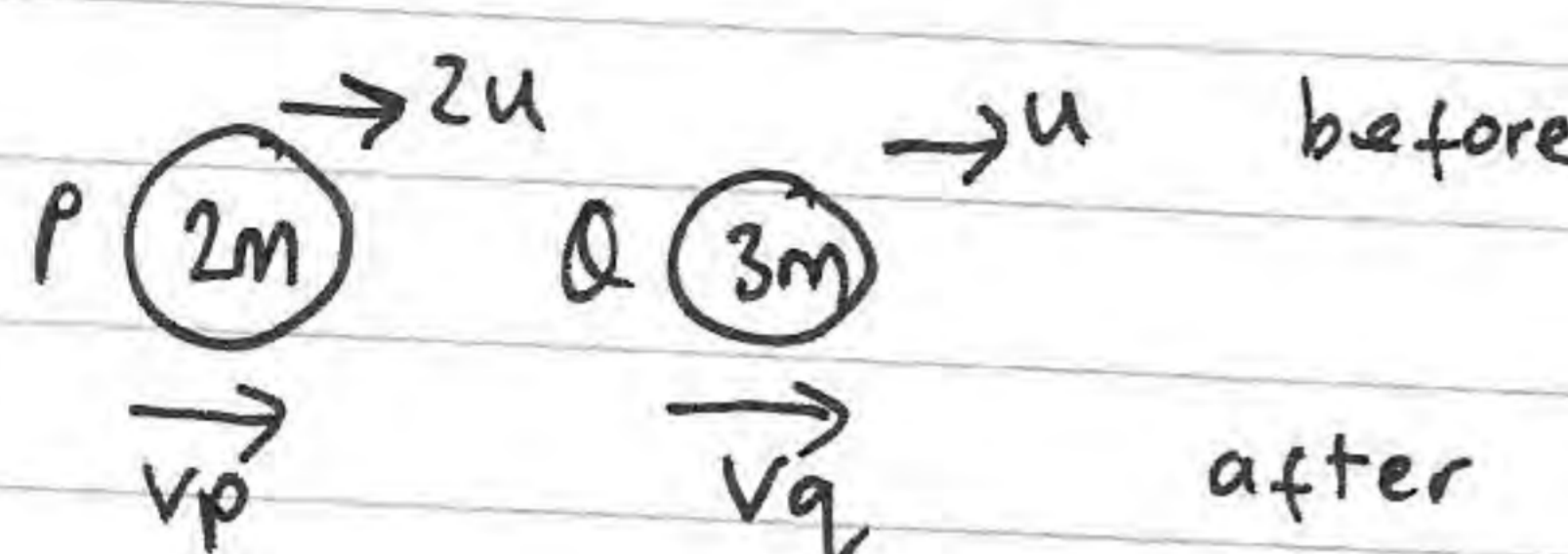


c) $KE_{\text{gained}} = PE_{\text{lost}}$

$$\frac{1}{2}m(v^2 - 261) = mg(47.5)$$

$$\Rightarrow v^2 - 261 = 931 \Rightarrow v^2 = 1192 \Rightarrow v = 34.5 \text{ ms}^{-1} (3 \text{sf})$$

7)



$e = \frac{v_q - v_p}{u} = \frac{1}{2}$
 $\Rightarrow 2v_q - 2v_p = u$

CLM $\Rightarrow 4mu + 3mu = 2mv_p + 3mv_q$ $2v_p = 2v_q - u$

$$\Rightarrow 7mu = m(2v_q - u) + 3mv_q$$

$$\Rightarrow 7mu = 5mv_q - mu$$

$$\Rightarrow 8mu = 5mv_q \Rightarrow v_q = \frac{8}{5}u$$

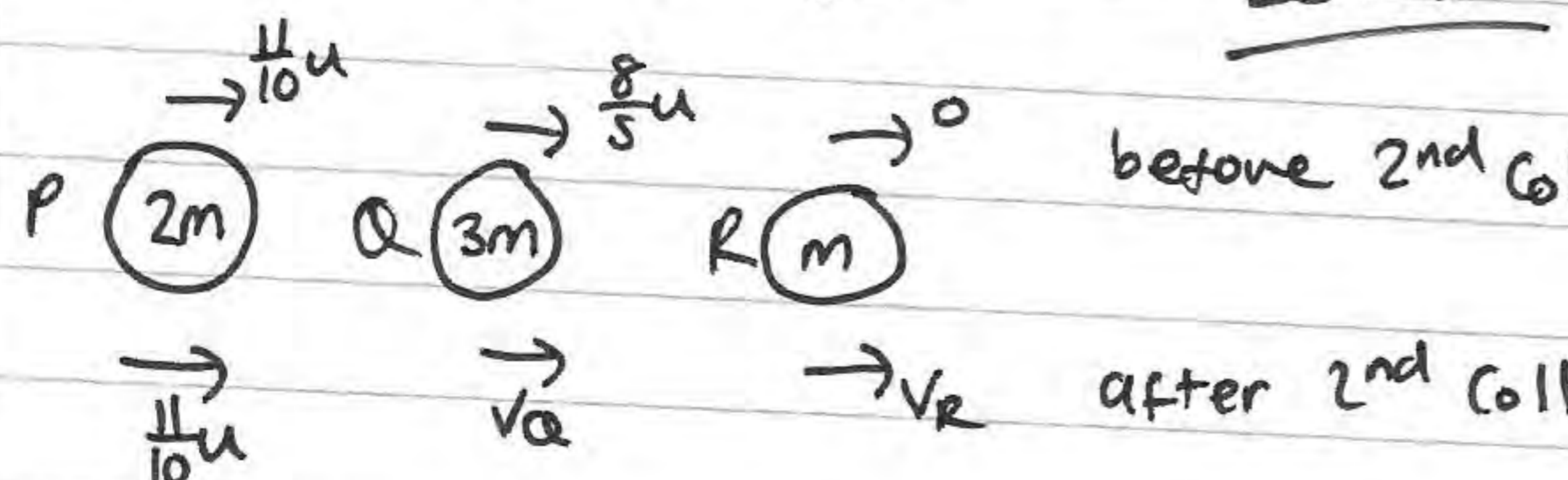
b) $KE_{\text{before}} = \frac{1}{2}(2m)(2u)^2 + \frac{1}{2}(3m)u^2 = 4mu^2 + \frac{3}{2}mu^2 = \frac{11}{2}mu^2$

$$2v_p = 2\left(\frac{8}{5}u\right) - u \Rightarrow 2v_p = \frac{11}{5}u \Rightarrow v_p = \frac{11}{10}u$$

$$KE_{\text{after}} = \frac{1}{2}(2m)\left(\frac{11}{10}u\right)^2 + \frac{1}{2}(3m)\left(\frac{8}{5}u\right)^2 = \frac{121}{100}mu^2 + \frac{96}{25}mu^2 = \frac{101}{20}mu^2$$

$$KE_{\text{lost}} = \frac{11}{2}mu^2 - \frac{101}{20}mu^2 = \frac{9}{20}mu^2$$

c)



before 2nd coll $\rightarrow 0$
 after 2nd coll $\rightarrow v_r$

if Q collides into P again $v_q < \frac{11}{10}u$

$$e_{QR} = \frac{v_r - v_q}{\frac{8}{5}u} = e \Rightarrow v_r - v_q = \frac{8}{5}ue \Rightarrow v_q = v_r - \frac{8}{5}ue$$

$$v_r = v_q + \frac{8}{5}ue$$

CLM $\frac{24}{5}mu + 0 = 3mv_q + mv_r$

$$\Rightarrow 24mu = 15mV_a + 5V_R m$$

$$5V_R = 5V_a + 8ue$$

$$\Rightarrow 24mu = 15mV_a + (5V_a + 8ue)m$$

$$\Rightarrow 24mu = 20mV_a + 8mue$$

$$\Rightarrow 6u = 5V_a + 2eu$$

$$\Rightarrow \frac{6u - 2eu}{5} = V_a \quad \Rightarrow V_a = \frac{2}{5}u(3-e) \quad V_a < \frac{11}{10}u$$

$$\frac{2}{5}u(3-e) < \frac{11}{10}u \quad \Rightarrow 3-e < \frac{55}{20} \quad \Rightarrow \frac{5}{20} < e$$

$$\therefore e > \frac{1}{4} \quad \frac{1}{4} < e \leq 1$$