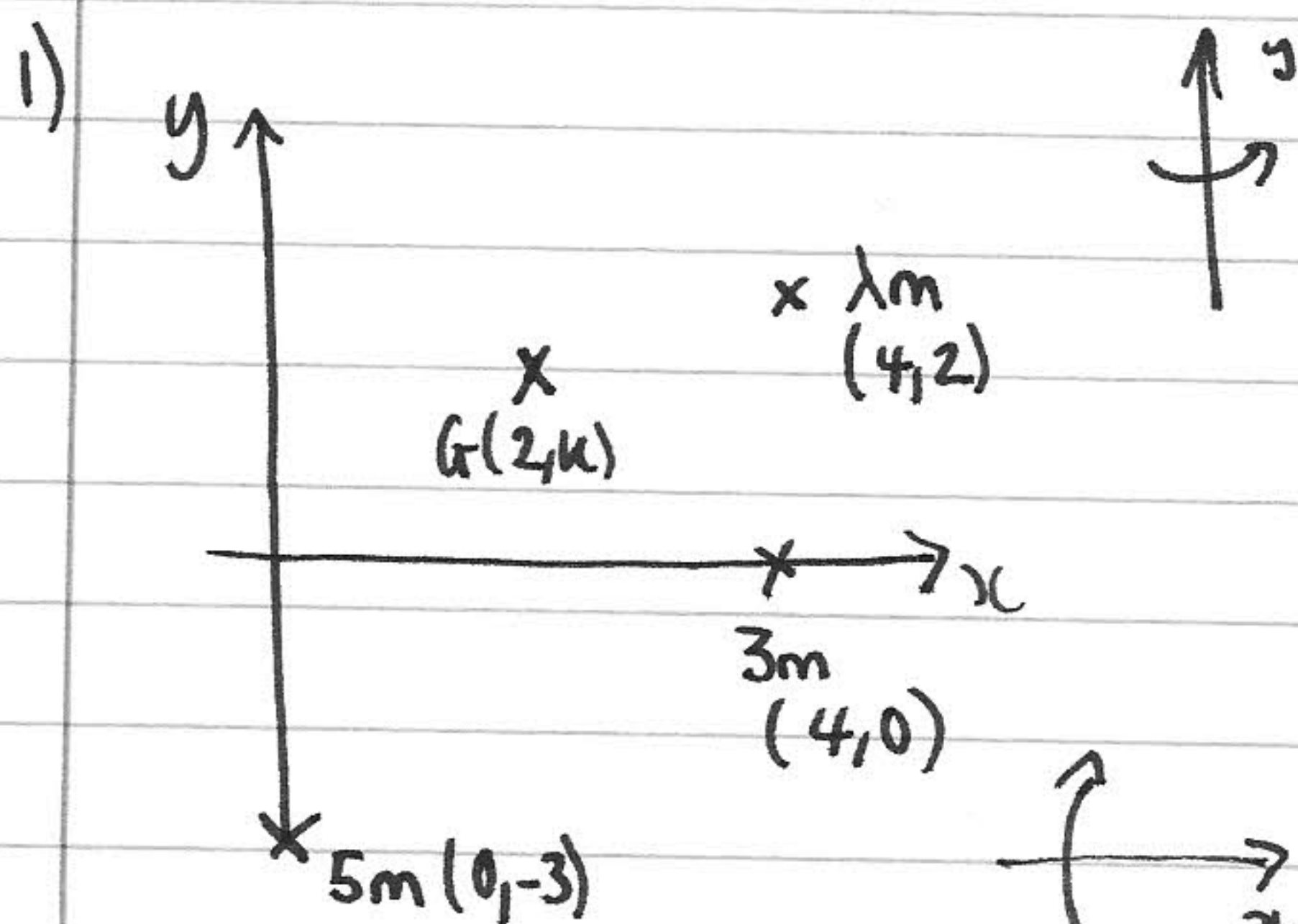


M2 JAN 03



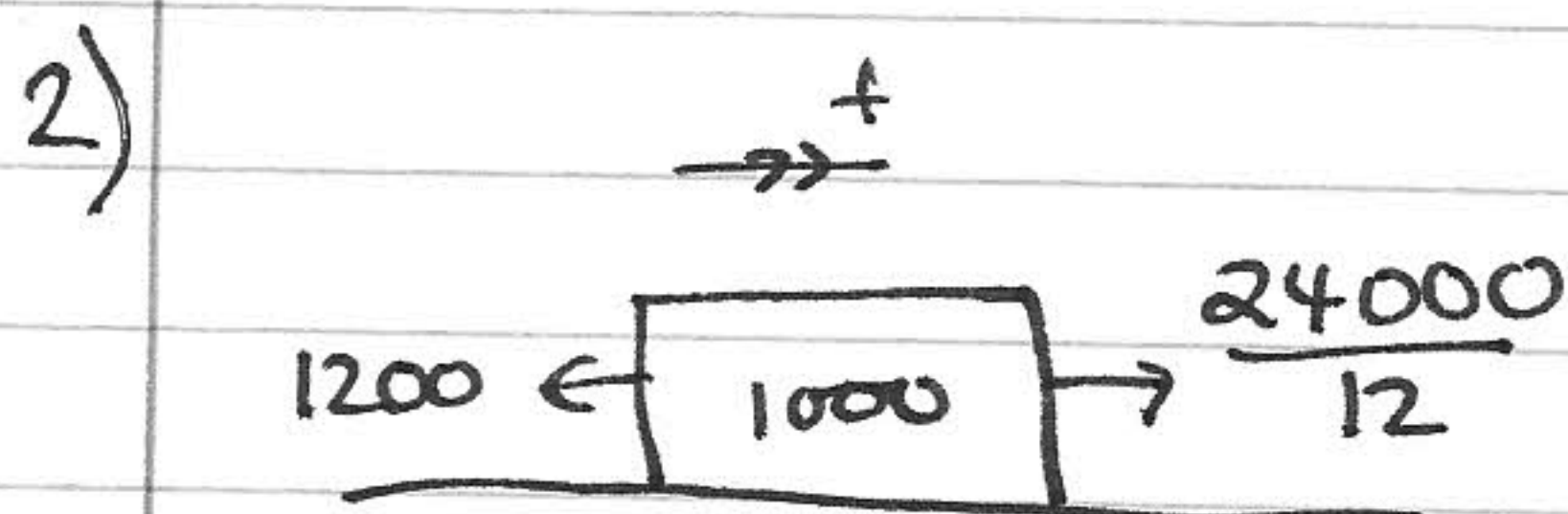
$$3mg \times 4 + \lambda mg \times 4 = (8 + \lambda)mg \times 2$$

$$(12 + 4\lambda)mg = (8 + \lambda) \times 2mg$$

$$12 + 4\lambda = 16 + 2\lambda \Rightarrow 2\lambda = 4 \Rightarrow \underline{\lambda = 2}$$

$$5mg \times -3 + 2mg \times 2 = 10mg \times k$$

$$-11mg = 10mg \times k \quad \underline{k = -1.1}$$



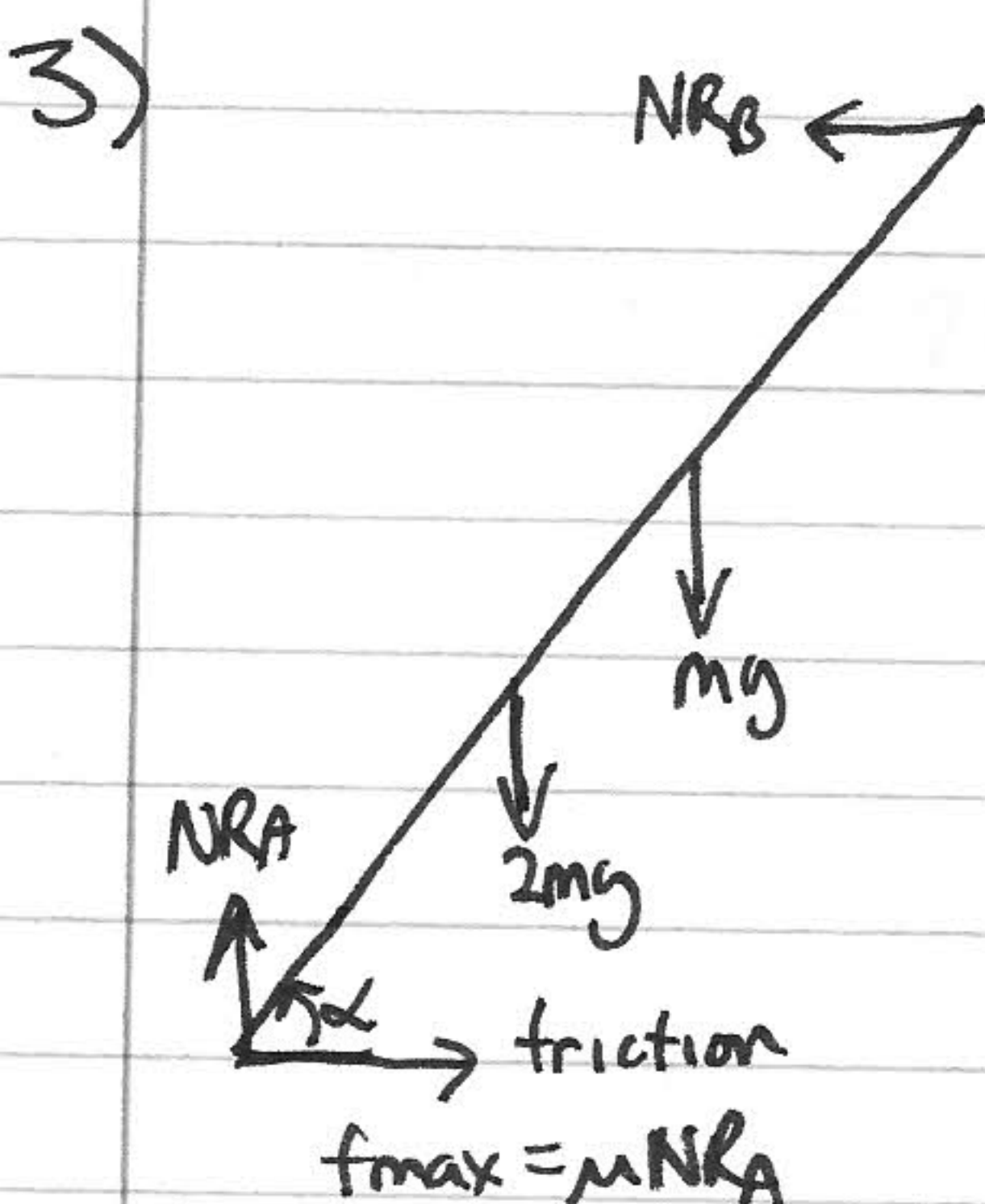
$$\vec{R}f = ma \Rightarrow 2000 - 1200 = 1000a$$

$$\Rightarrow \underline{a = 0.8 \text{ ms}^{-2}}$$

b) KE lost = Wd against Res

$$\frac{1}{2}(1000)14^2 = 1200d \Rightarrow d = \frac{245}{3}$$

c) Resistance would vary with speed.



$$\tan \alpha = \frac{4}{3} \quad \sin \alpha = \frac{4}{5}$$

$$\cos \alpha = \frac{3}{5}$$

$$\text{At } 2mg \times \frac{1}{2} \alpha \left(\frac{3}{5} \right) + mg \times \alpha \left(\frac{3}{5} \right) = NR \times 2\alpha \left(\frac{4}{5} \right)$$

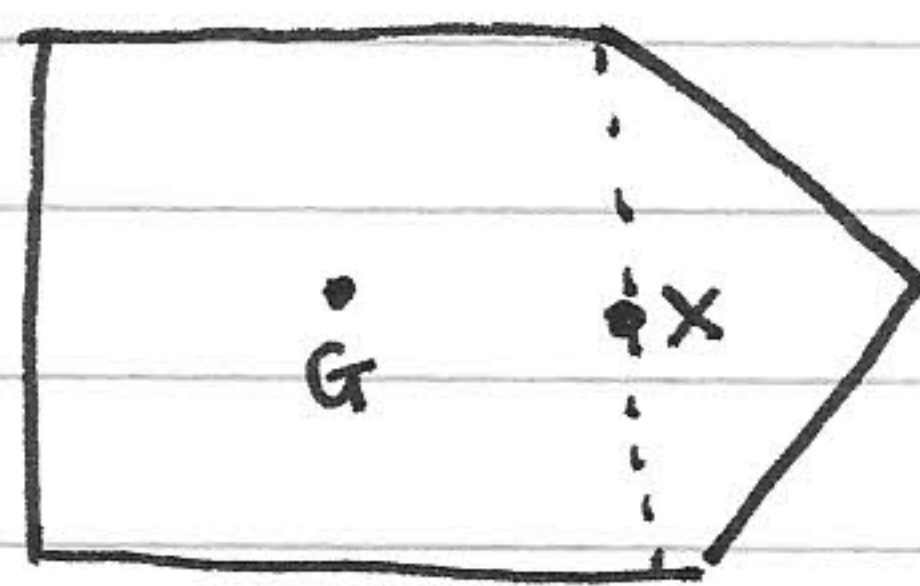
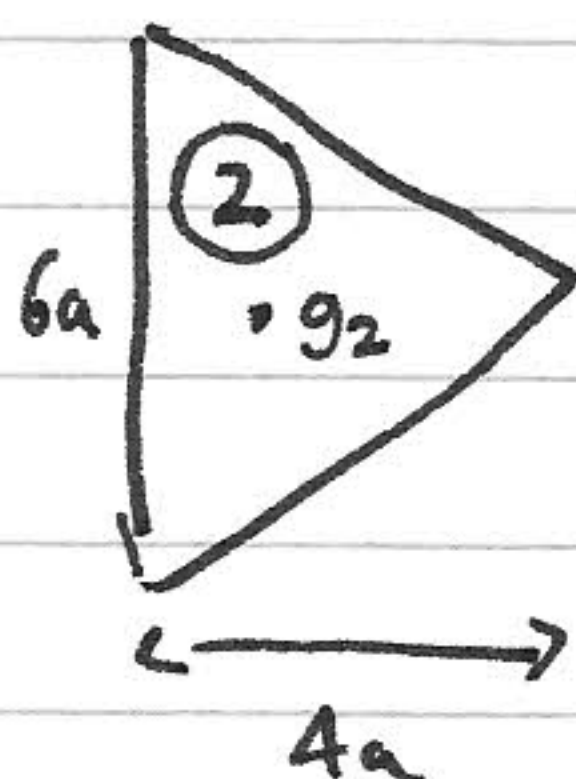
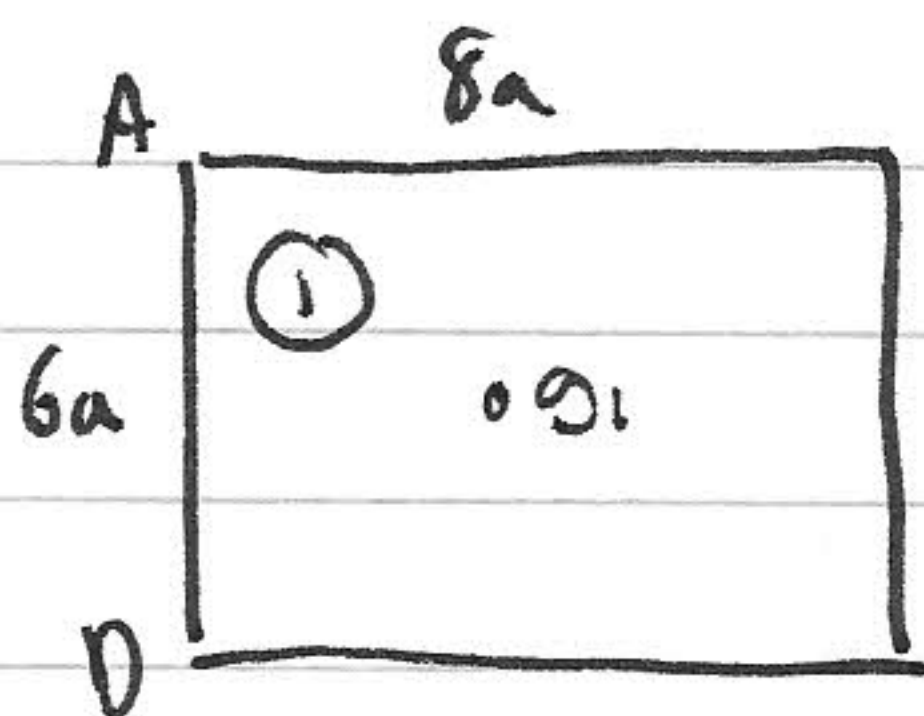
$$\Rightarrow 3mg + 3mg = 8NR \Rightarrow \underline{NR = \frac{3}{4}mg}$$

$$\vec{R}f = 0 \Rightarrow NR = f_{\max} = \mu NR \quad \mu \times NR = \frac{3}{4}mg$$

$$Rf \uparrow = 0 \Rightarrow NR = 3mg \Rightarrow \mu \times 3mg = \frac{3}{4}mg \Rightarrow \underline{\mu = \frac{1}{4}}$$

$$\text{friction} < f_{\max} \Rightarrow f_{\max} > \frac{1}{4}$$

4)



$$M_1 = 48a^2k$$

$$g_1 (4a, 3a)$$

$$M_2 = 12a^2k$$

$$g_2 \left(\left(8 + \frac{4}{3} \right) a, 3a \right)$$

$$M = 60a^2k$$

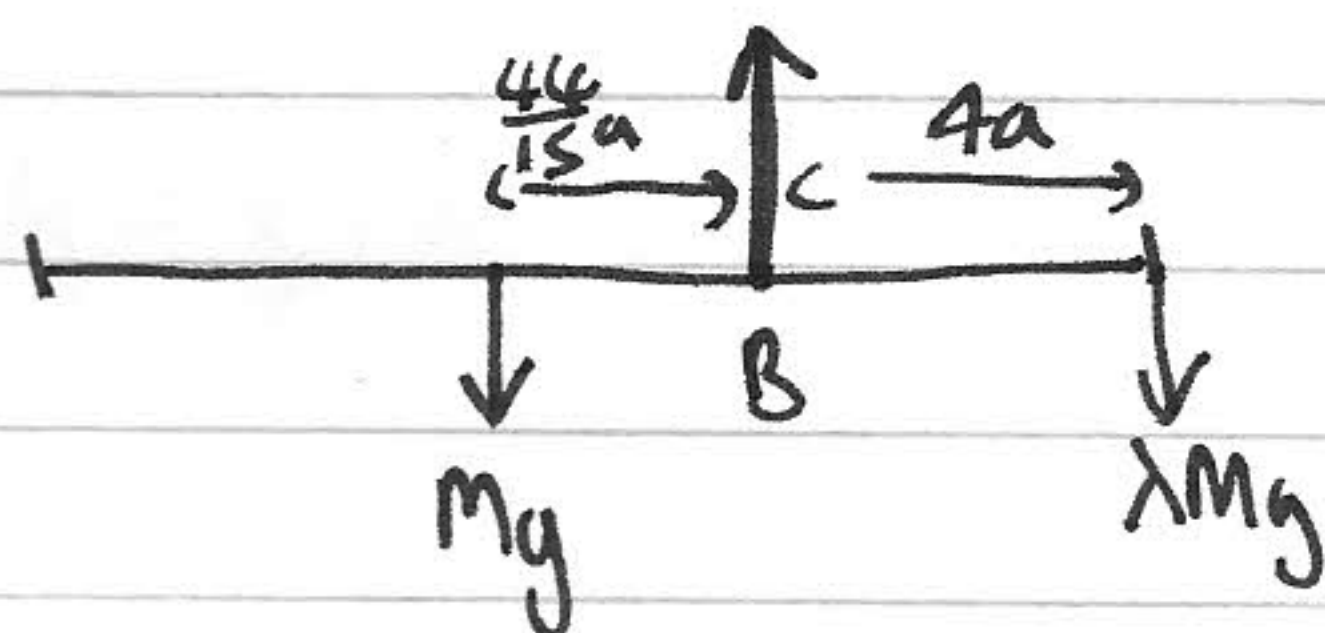
$$M (\bar{x}, 3a)$$

$$A \uparrow \quad 48a^2k \times 4a + 12a^2k \times \frac{28}{3}a = 60a^2k \bar{x}$$

$$D \quad 192a + 112a = 60\bar{x} \Rightarrow \bar{x} = \frac{76}{15}a$$

$$GX = 8a - \frac{76}{15}a = \frac{44}{15}a \quad \#$$

b)



$$\text{BC} \quad Mg \times \frac{44}{15}a = \lambda Mg \times 4a$$

$$\frac{44}{15} = 4\lambda \Rightarrow \lambda = \frac{11}{15}$$

5)

$$a = 4t - 8$$

$$v = \int a dt = 2t^2 - 8t + c \quad v = 6, t = 0 \Rightarrow c = 6$$

$$\Rightarrow v = 2t^2 - 8t + 6$$

b)

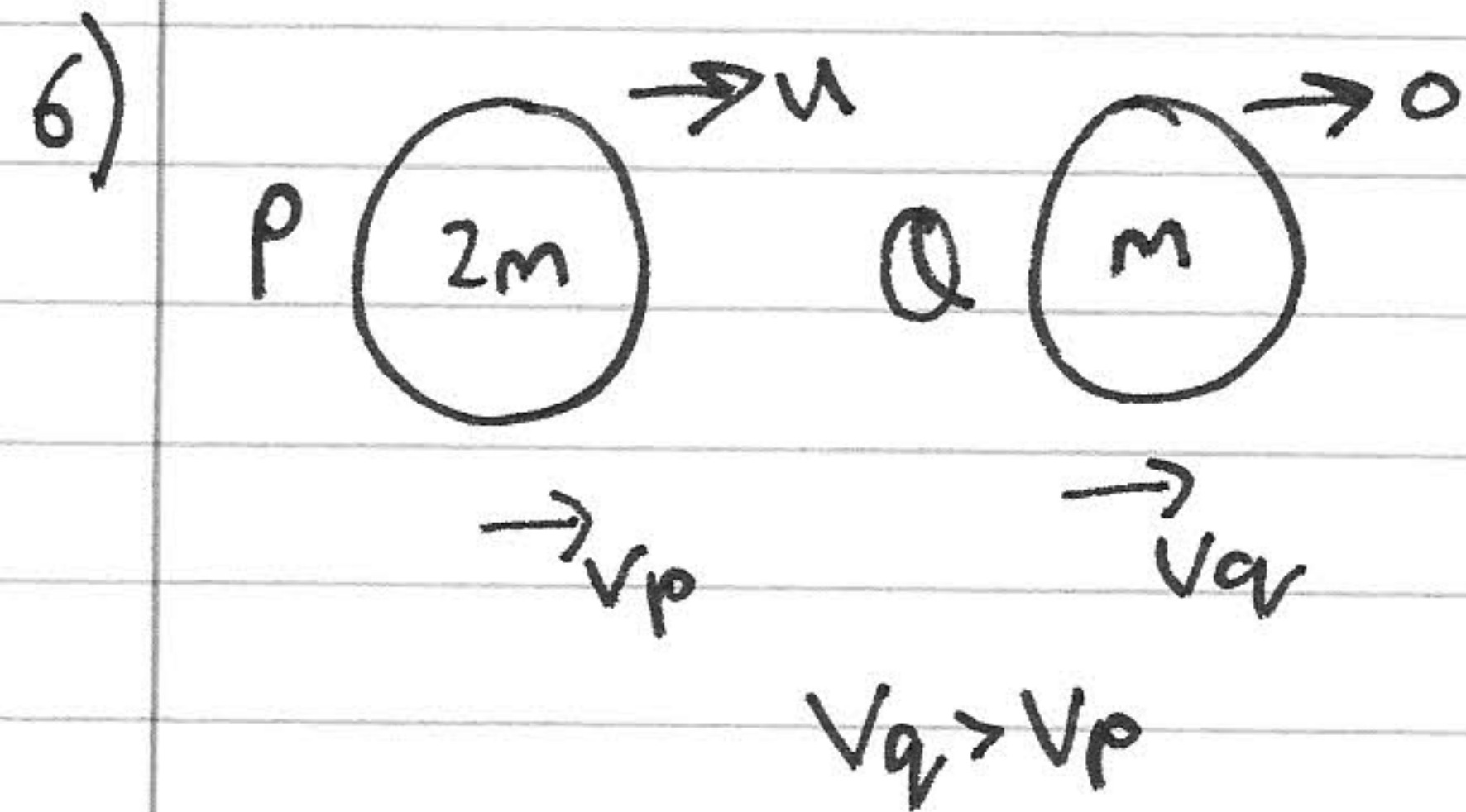
$$\text{at rest} \Rightarrow v = 0 \quad 2t^2 - 8t + 6 = 0 \Rightarrow t^2 - 4t + 3 = 0$$

$$(t-3)(t-1) = 0$$

$$t = 3, t = 1$$

$$\int_1^3 v dt = \int_1^3 (2t^2 - 8t + 6) dt$$

$$= \left[\frac{2}{3}t^3 - 4t^2 + 6t \right]_1^3 = 0 - \frac{8}{3} = -\frac{8}{3} \Rightarrow \text{dist} = \frac{8}{3} \text{ m}$$



$$e = \frac{1}{3} = \frac{S_{\text{sep}}}{a_{\text{app}}} \Rightarrow \frac{v_q - v_p}{u} = \frac{1}{3}$$

$$\Rightarrow 3v_q - 3v_p = u$$

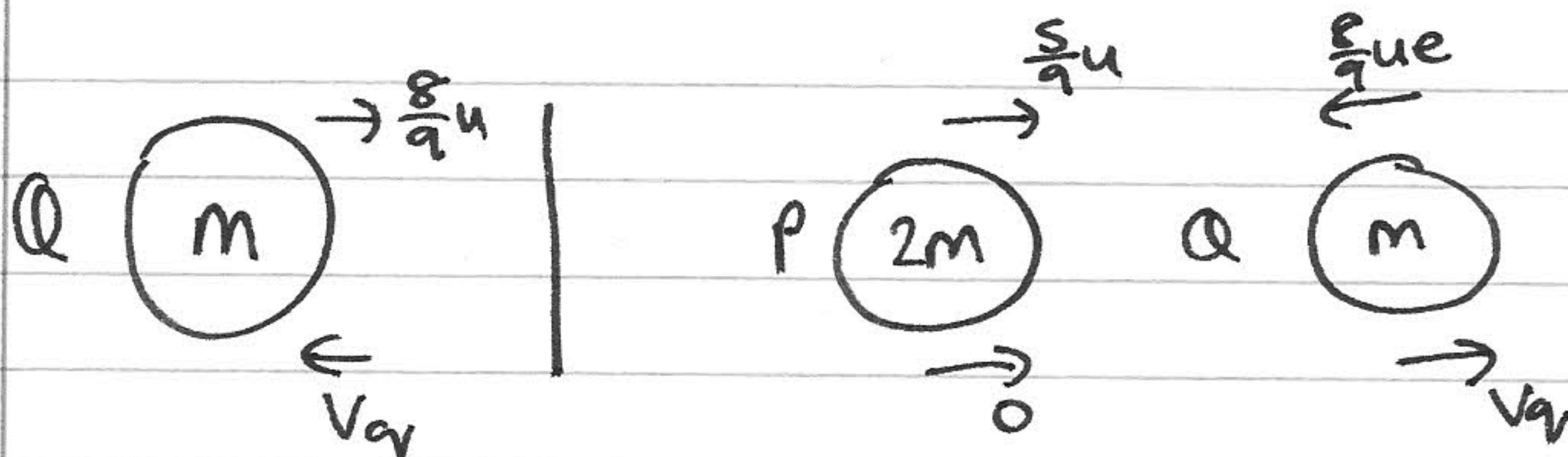
$$3v_q = u + 3v_p$$

$$\text{CLM} \Rightarrow 2mu = 2mv_p + mv_q \quad (\times 3) \quad 6u = 6v_p + 3v_q$$

$$\Rightarrow 6u = 9v_p + u$$

$$\Rightarrow v_p = \frac{1}{9}(6u - u) \Rightarrow v_p = \frac{5}{9}u$$

$$v_q = \frac{1}{3}(u + 3v_p) = \frac{1}{3}\left(u + \frac{15}{9}u\right) = \frac{1}{3}\left(\frac{24}{9}u\right) = \frac{8}{9}u \quad \neq$$



$$e = \frac{v_{qr}}{\frac{8}{a}u}$$

$$\Rightarrow v_q = \frac{8}{a}ue$$

$$e = \frac{1}{3} = \frac{v_q}{\frac{5}{a}u + \frac{8}{a}ue} = v_q = \frac{5}{27}u + \frac{8}{27}ue$$

$$CLM \Rightarrow \frac{10}{a}mu - \frac{8}{a}mue = mv_q$$

$$\Rightarrow \frac{5}{27}u + \frac{8}{27}ue = \frac{10}{a}u - \frac{8}{a}ue$$

$$(\times 27) \quad 5 + 8e = 30 - 24e \Rightarrow 32e = 25 \Rightarrow e = \frac{25}{32}$$

Q is now moving towards the wall again, and will bounce back towards P which is at rest.

$$7) \text{ Mom B before} = 0.4(-20i + 4j) = -8i + 1.6j \text{ Ns}$$

$$\text{Mom B after} = 0.4(15i + 16j) = 6i + 6.4j \text{ Ns}$$

$$\Rightarrow \text{Impulse} = 14i + 4.8j \text{ Ns}$$

$$|\text{Impulse}| = \sqrt{14^2 + 4.8^2} = 14.8 \text{ Ns}$$

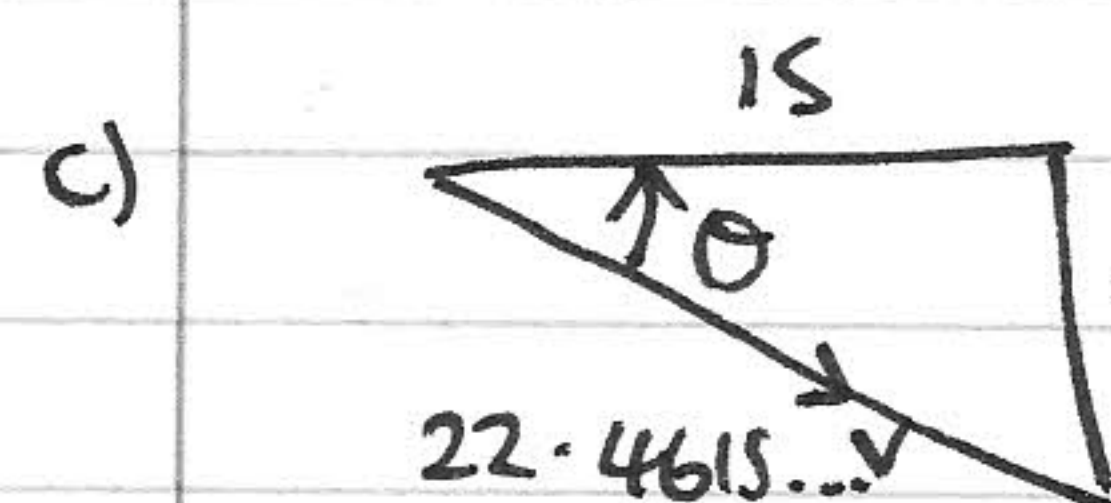
$$b) \quad u = 15i + 16j = \sqrt{481}$$

$$\text{Initial KE} = \frac{1}{2}(0.4)(\sqrt{481})^2 = 96.2 \text{ J}$$

$$\text{Initial PE} = (0.4)g(1.2) = 4.704 \text{ J}$$

$$\Rightarrow \text{Final KE} = 100.904 \text{ J} = \frac{1}{2}(0.4)v^2$$

$$\Rightarrow v = 22.4615... \approx 22.5 \text{ (3sf)}$$



$$\theta = \cos^{-1}\left(\frac{15}{22.4615...}\right)$$

e) air resistance, windy spin of ball.

$$\theta = 48.1^\circ \text{ below horizontal}$$