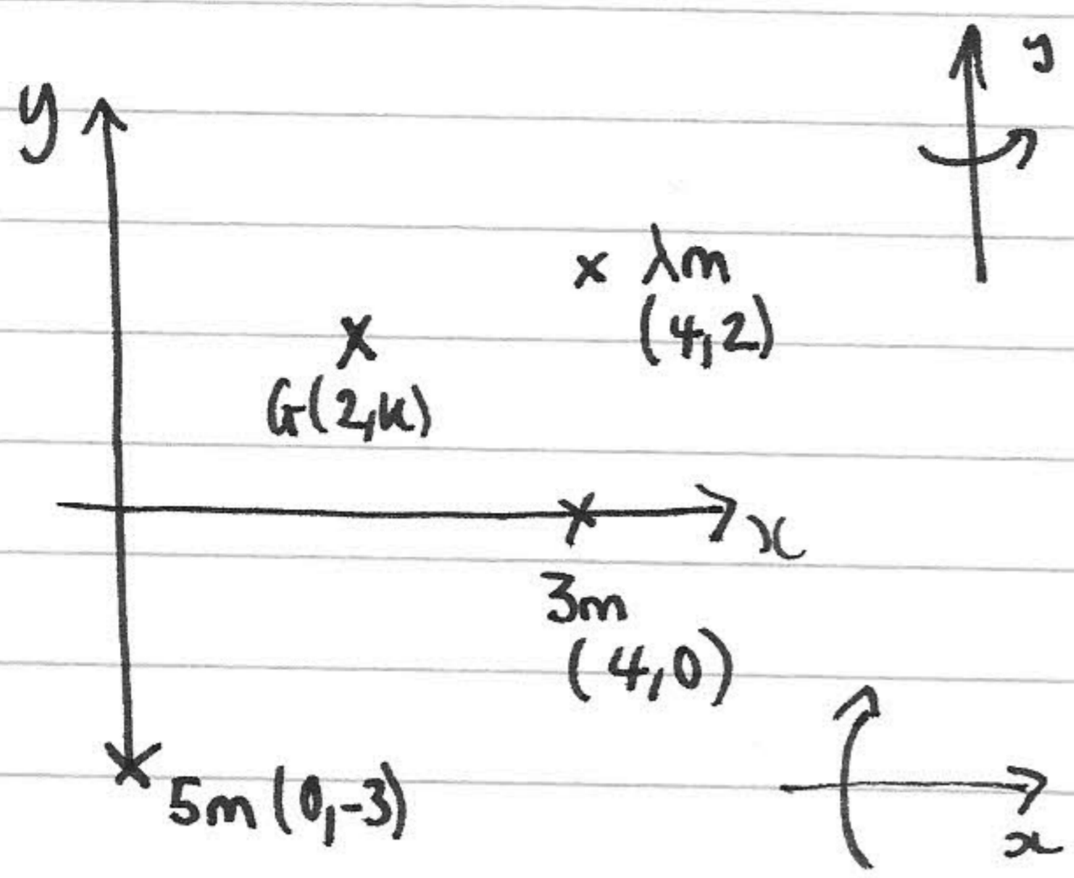
# M2 JAN03

1)







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

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

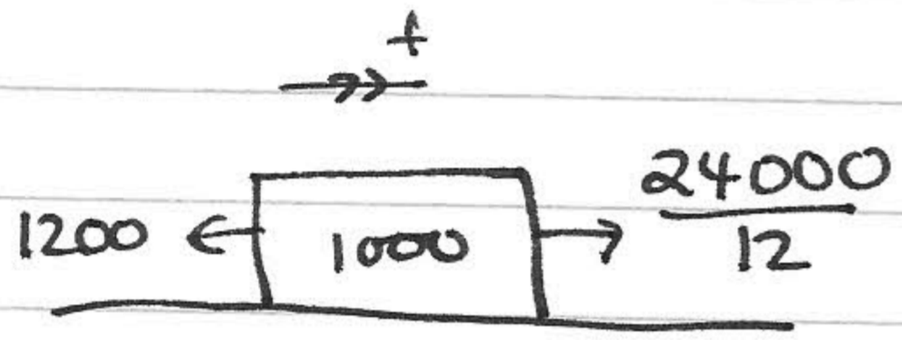
$12+4\lambda = 16+2\lambda \Rightarrow 2\lambda = 4 \Rightarrow \underline{\lambda = 2}$




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

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

2)




$\overrightarrow{RF} = ma \Rightarrow 2000 - 1200 = 1000f$

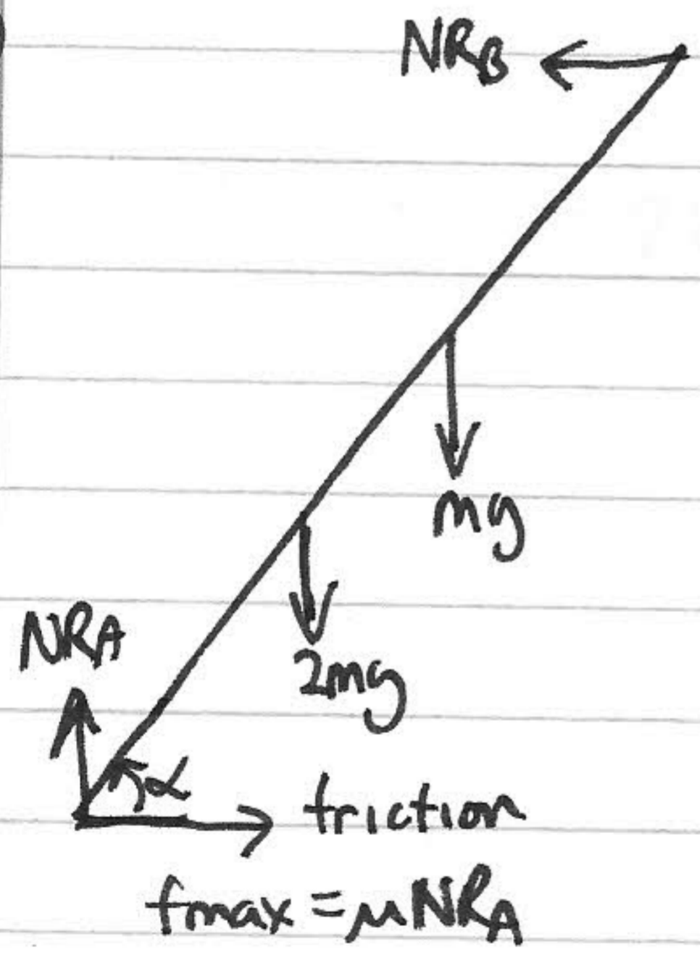
$\Rightarrow f = \underline{0.8\,ms^{-2}}$

b) KE lost = Wd against Res

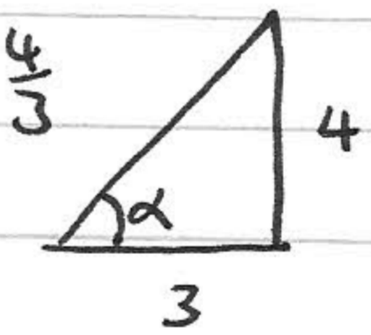
$\frac{1}{2}(1000)14^2 = 1200d \qquad \Rightarrow d = \frac{245}{3}$

c) Resistance would vary with speed.

3)




$\tan\alpha = \frac{4}{3}$




$\sin\alpha = \frac{4}{5}$

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

$\overset{\curvearrowright}{A} \quad 2mg \times \frac{1}{2}\cancel{a}\left(\cancel{\tfrac{3}{5}}\right) + mg \times \cancel{a}\left(\cancel{\tfrac{3}{5}}\right) = NR \times 2\cancel{a}\left(\cancel{\tfrac{4}{5}}\right)$

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

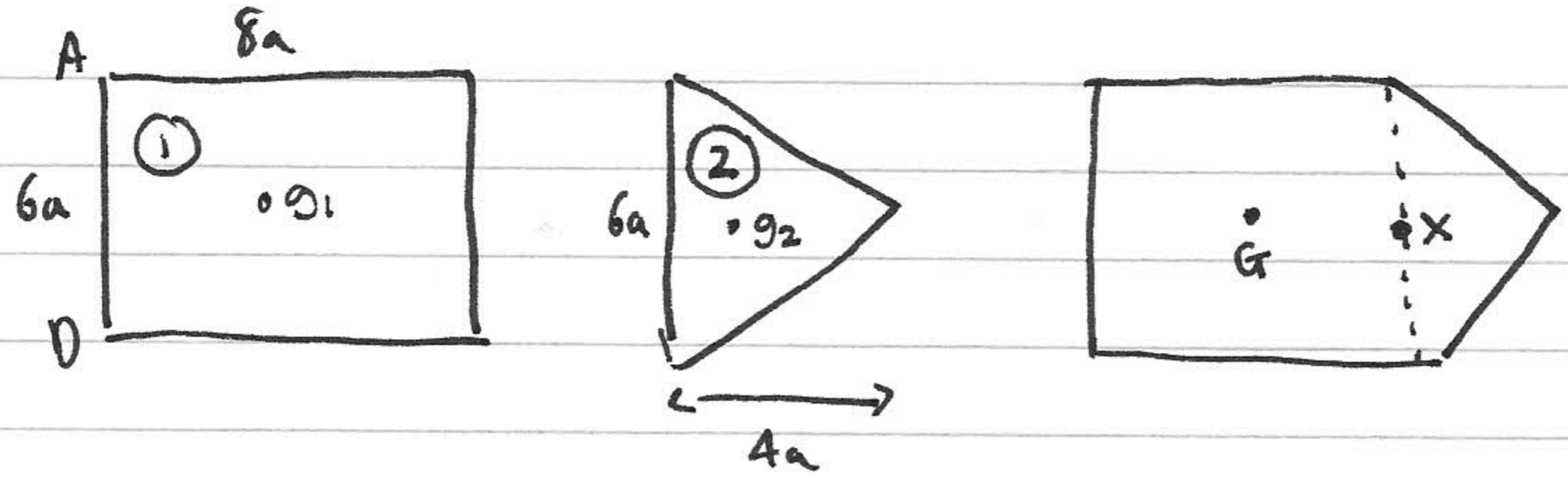
$\overrightarrow{RF} = 0 \Rightarrow NR_B = f_{max} = \mu NR_A \qquad \mu \times NR_A = \frac{3}{4}mg$

$RF\uparrow = 0 \Rightarrow NR_A = 3mg \Rightarrow \mu \times 3\cancel{mg} = \frac{3}{4}\cancel{mg} \Rightarrow \underline{\mu = \frac{1}{4}}$

friction $\leq f_{max} \Rightarrow f_{max} \geq \frac{1}{4}$

www.mymathscloud.com
My Maths Cloud

4)




$M_1 \quad 48a^2k \qquad M_2 = 12a^2k \qquad M = 60a^2k$

$g_1(4a, 3a) \qquad g_2\left(\left(8+\frac{4}{3}\right)a, 3a\right) \qquad M(\bar{x}, 3a)$

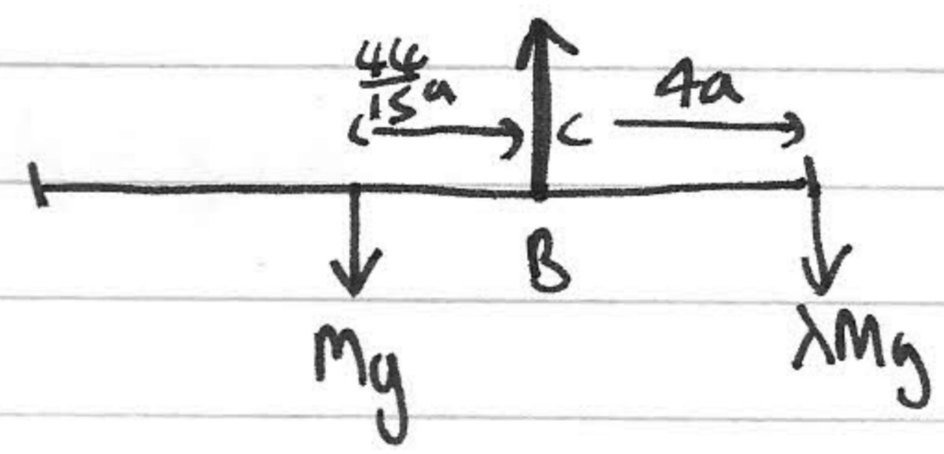
A D

$$48\cancel{a^2}\cancel{k}\cancel{g} \times 4a + 12\cancel{a^2}\cancel{k}\cancel{g} \times \frac{28}{3}a = 60\cancel{a^2}\cancel{k}\cancel{g}\,\bar{x}$$

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

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

b)




$B \circlearrowleft \quad \cancel{M}\cancel{g} \times \frac{44}{15}\cancel{a} = \lambda\cancel{M}\cancel{g} \times 4\cancel{a}$

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

5) $a = 4t - 8$

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

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

b) at rest $\Rightarrow V = 0 \qquad 2t^2 - 8t + 6 = 0 \Rightarrow t^2 - 4t + 3 = 0$

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

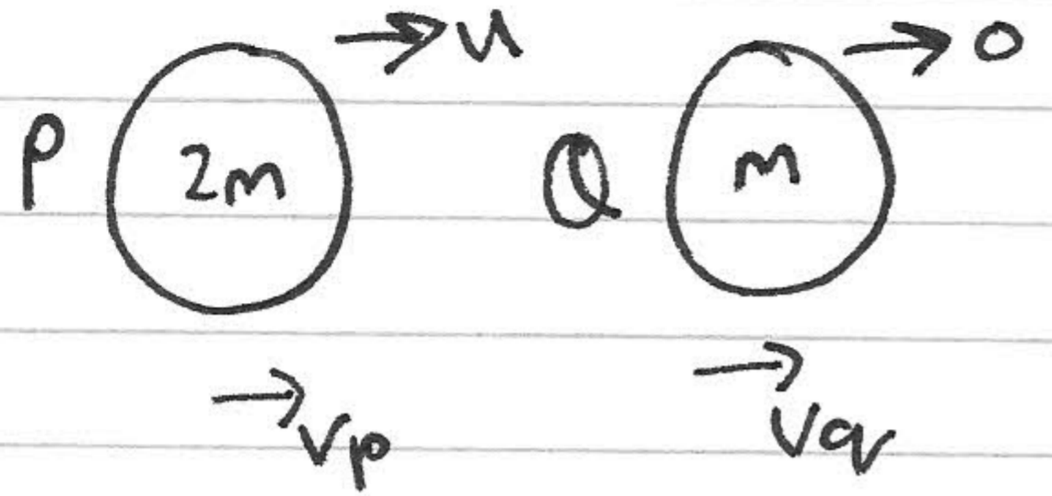
$t = 3, t = 1$

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

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

www.mymathscloud.com
My Maths Cloud

6)




$v_q > v_p$

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

$\Rightarrow 3v_q - 3v_p = u$

$3v_q = u + 3v_p$

CLM $\Rightarrow 2\cancel{m}u = 2\cancel{m}v_p + \cancel{m}v_q$ $\times 3$ $6u = 6v_p + 3v_q$

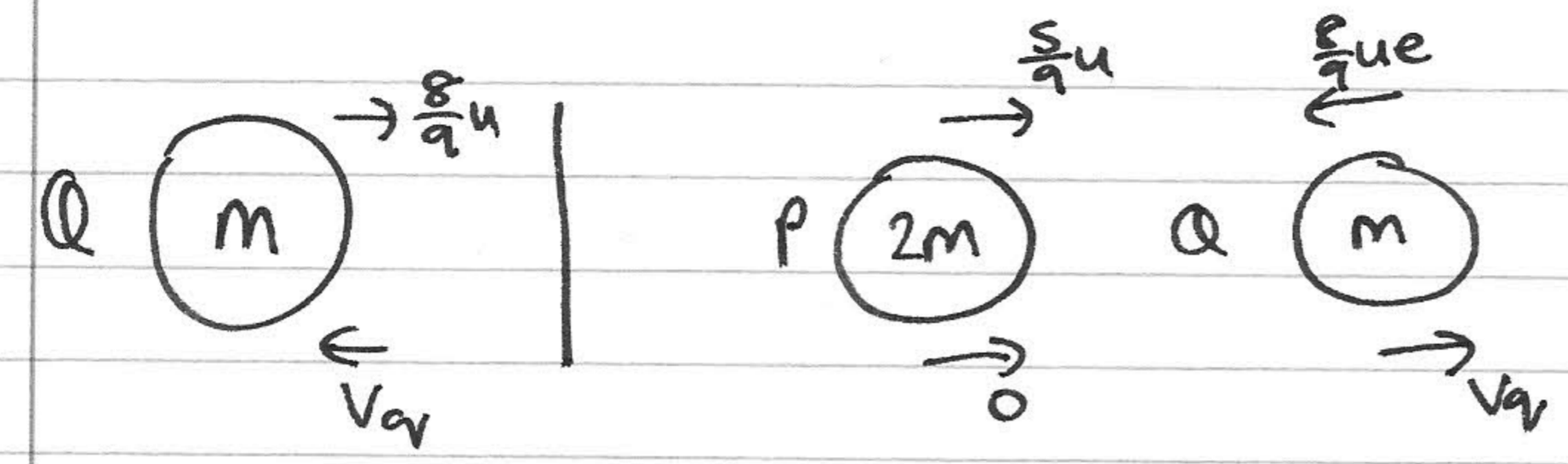
$\Rightarrow 6u = 9v_p + u$

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

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

www.mymathscloud.com
My Maths Cloud

www.mymathscloud.com
My Maths Cloud




$e = \frac{V_q}{\frac{8}{9}u}$

$\Rightarrow V_q = \frac{8}{9}ue$

$e = \frac{1}{3} = \frac{V_q}{\frac{5}{9}u + \frac{8}{9}ue} = V_q = \frac{5}{27}u + \frac{8}{27}ue$

CLM $\Rightarrow \frac{10}{9}\cancel{m}u - \frac{8}{9}\cancel{m}ue = \cancel{m}V_q$

$\Rightarrow \frac{5}{27}\cancel{u} + \frac{8}{27}ue = \frac{10}{9}\cancel{u} - \frac{8}{9}\cancel{u}e$

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

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

7) Mom B before $= 0.4(-20i + 4j) = -8i + 1.6j$ Ns
Mom B after $= 0.4(15i + 16j) = 6i + 6.4j$ Ns

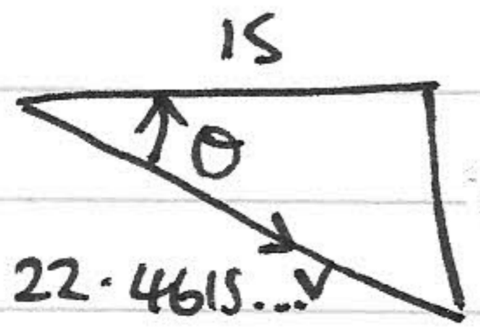
$\Rightarrow$ Impulse $= 14i + 4.8j$ Ns

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

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

Initial KE $= \frac{1}{2}(0.4)(\sqrt{481})^2 = 96.2$ J
Initial PE $= (0.4)g(1.2) = 4.704$ J
$\Rightarrow$ final KE $= 100.904$ J $= \frac{1}{2}(0.4)v^2$
$\Rightarrow v = 22.4615\ldots \simeq 22.5$ (3f)

c)




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

$\theta = 48.1°$ below Horizontal

e) air resistance, wind, spin of ball.