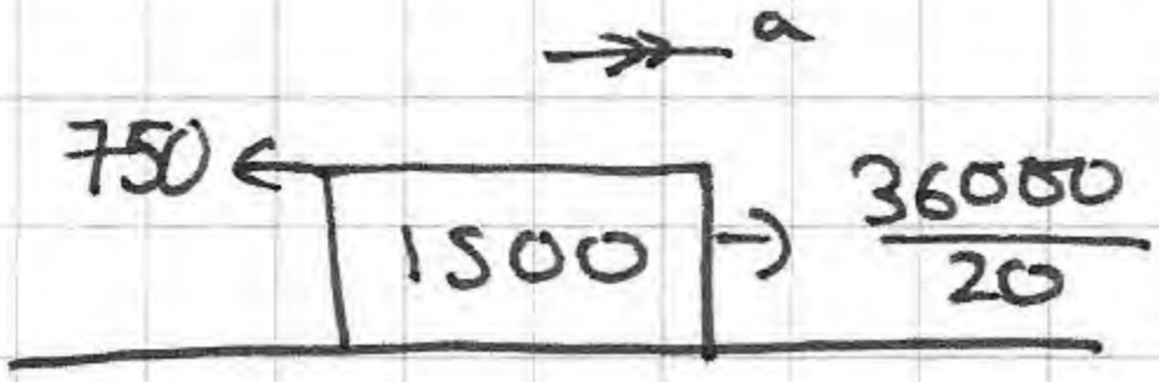
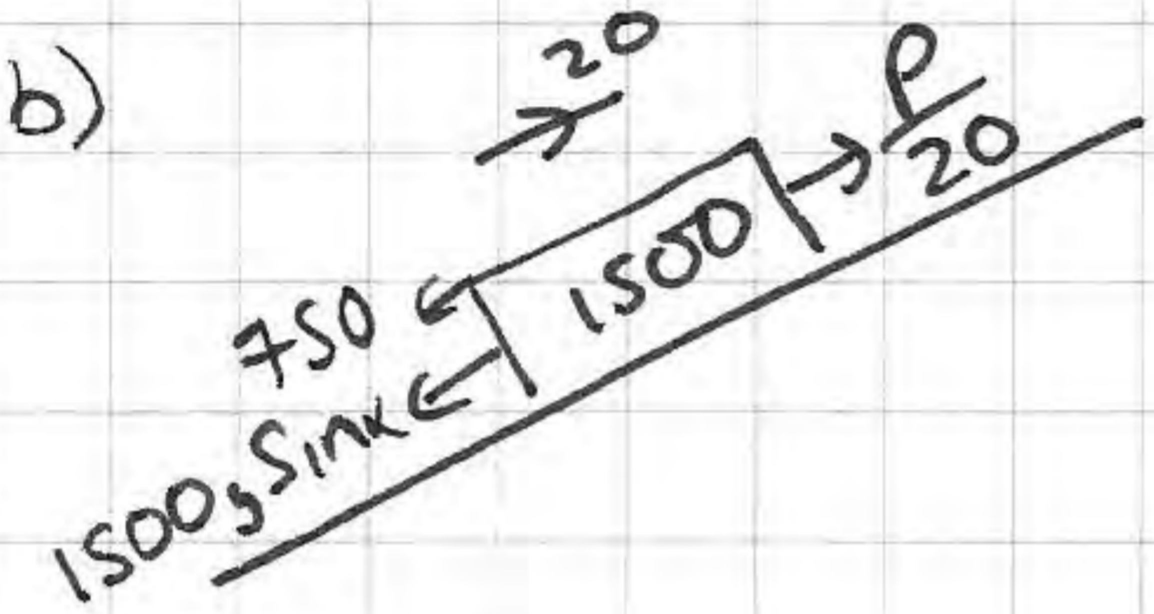
M2 JUNE 04

1) 

$\overrightarrow{R_f} = ma \Rightarrow \frac{36000}{20} - 750 = 1500a$

$\Rightarrow a = \underline{0.7 \text{ ms}^{-2}}$

b) 

$\overrightarrow{R_f} = 0 \Rightarrow \frac{P}{20} = 750 + 1500g\left(\frac{1}{10}\right)$

$\Rightarrow P = 20(750 + 150g) = 44400\text{w}$

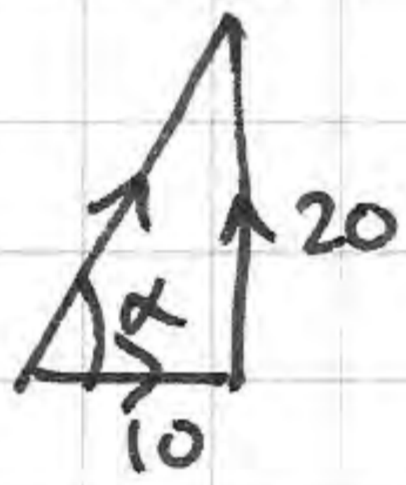
$\Rightarrow P = 44.4\text{kW (3sf)}$

2) Mom before $= 0.2(30i + 0j) = 6i + 0j$

$+ \text{ Impulse } = -4i + 4j$

$= \text{ mom after } = 2i + 4j = mV$

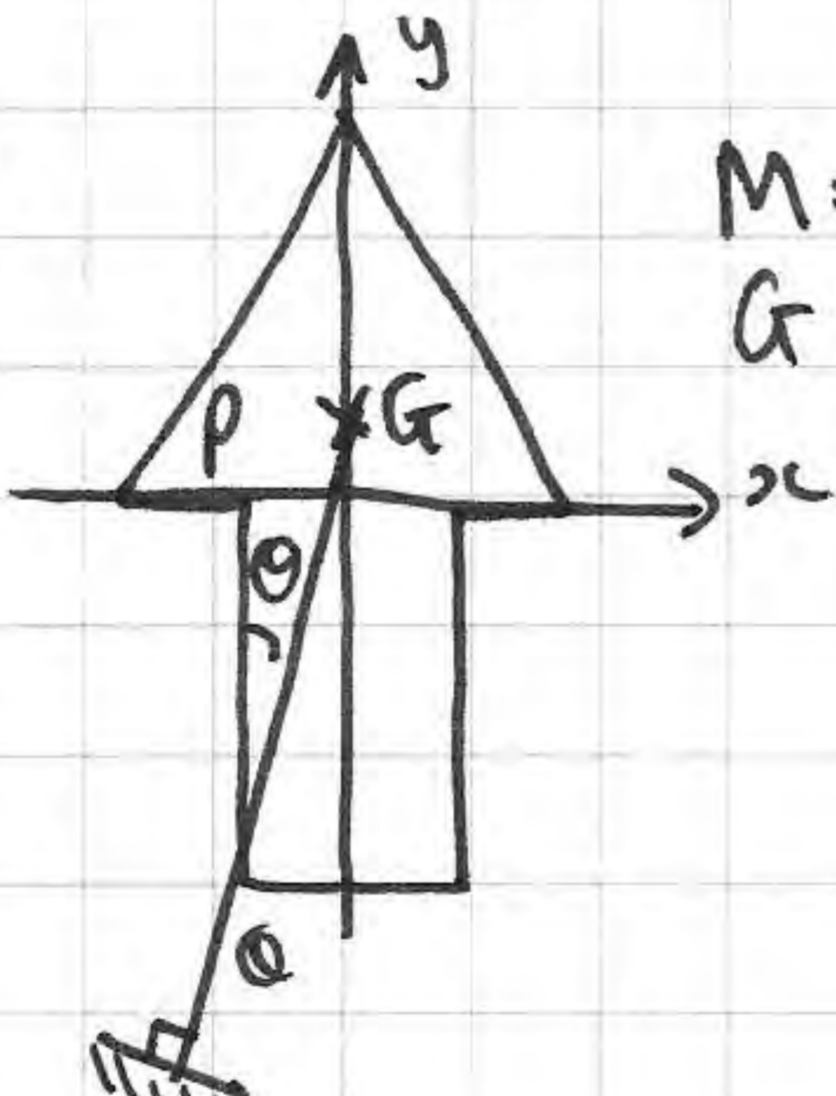
$\Rightarrow 0.2v = 2i + 4j \Rightarrow v = \underline{10i + 20j \text{ ms}^{-1}}$

b) 

$\alpha = \tan^{-1}\left(\frac{20}{10}\right) = 63.4^\circ$ (3sf) above horizontal

c) KE lost $= \frac{1}{2}(0.2)(30)^2 - \frac{1}{2}(0.2)\left(\sqrt{10^2 + 20^2}\right)^2$

$= \frac{1}{2}(0.2)[900 - 500] = \underline{40J}$

3) 

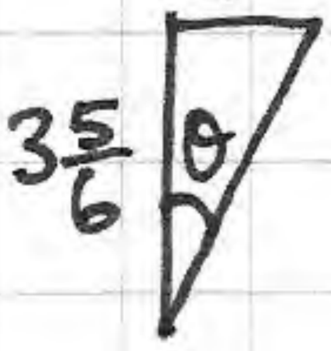
M = 18k
G $(0, \bar{y})$

M = 12k
g_1 (0, 2)

mass per cm^2 = k.

M = 6k
g_2 (0, -1.5)

$12\cancel{k} \times 2 + 6\cancel{k} \times -1.5 = 18\cancel{k}\,\bar{y} \Rightarrow \bar{y} = \frac{15}{18} = \frac{5}{6}$



b) $\tan\theta = \frac{1}{3\frac{5}{6}} \Rightarrow \theta = \tan^{-1}\left(\frac{6}{23}\right) = \underline{14.6^\circ}$ (1dp)

4) $V = (4t-7)i + (-5)j$

$S = \int v\,dt = (2t^2 - 7t + C_1)i + (-5t + C_2)j \qquad t=0 \quad S = 3i + 5j$

$\Rightarrow C_1 = 3 \quad C_2 = 5$

$S_p = (2t^2 - 7t + 3)i + (-5t + 5)j$

b) Constant vel $\Rightarrow$ pos Q = original pos + t (vel)

$S_q = (-7i) + t(2i - 3j)$

$S_q = (2t-7)i + (-3t)j$

(i) $2t^2 - 7t + 3 = 2t - 7$

$2t^2 - 9t + 10 = 0$

$(2t-5)(t-2)$

$\underline{\underline{t = 2\tfrac{1}{2}}} \quad \underline{\underline{t = 2}}$

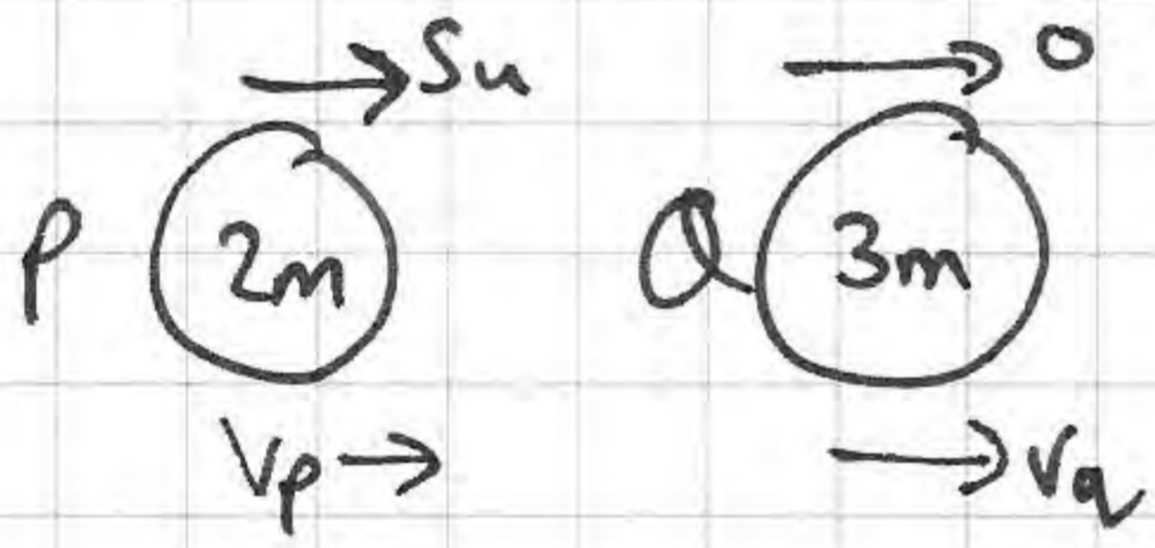
(j) $-5t + 5 = -3t$

$5 = 2t$

$\underline{\underline{t = 2.5}}$

(i)+(j) components are equal when $t = 2.5$, collide when $t = 2.5$.

5)



CLM $\Rightarrow 10mu = 2mV_p + 3mV_q$

$10u = 2V_p + 3V_q$

$\Rightarrow V_p = 5u - \frac{3}{2}V_q$

$e = \frac{sep}{app} = \frac{V_q - V_p}{5u} \Rightarrow 5eu = V_q - (5u - \frac{3}{2}V_q)$

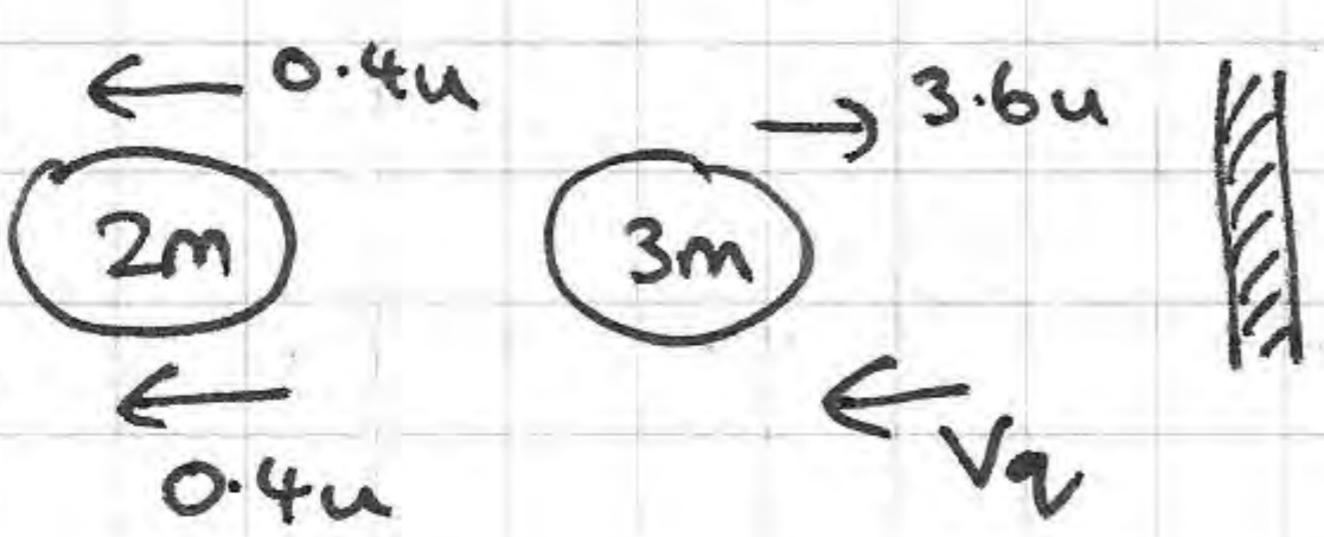
$\cancel{5}eu + \cancel{5}u = \frac{\cancel{5}}{2}V_q$

$\Rightarrow V_q = 2(eu + u) = 2u(e+1)$ #

b) $e = 0.4 \Rightarrow V_q = 2.8u \qquad V_p = 5u - \frac{3}{2}(2.8u) = 0.8u \rightarrow$

Since P is also moving towards the wall they must collide.

c) $e = 0.8 \Rightarrow V_q = 3.6u$, $V_p = 5u - \frac{3}{2}(3.6u) = -0.4u$

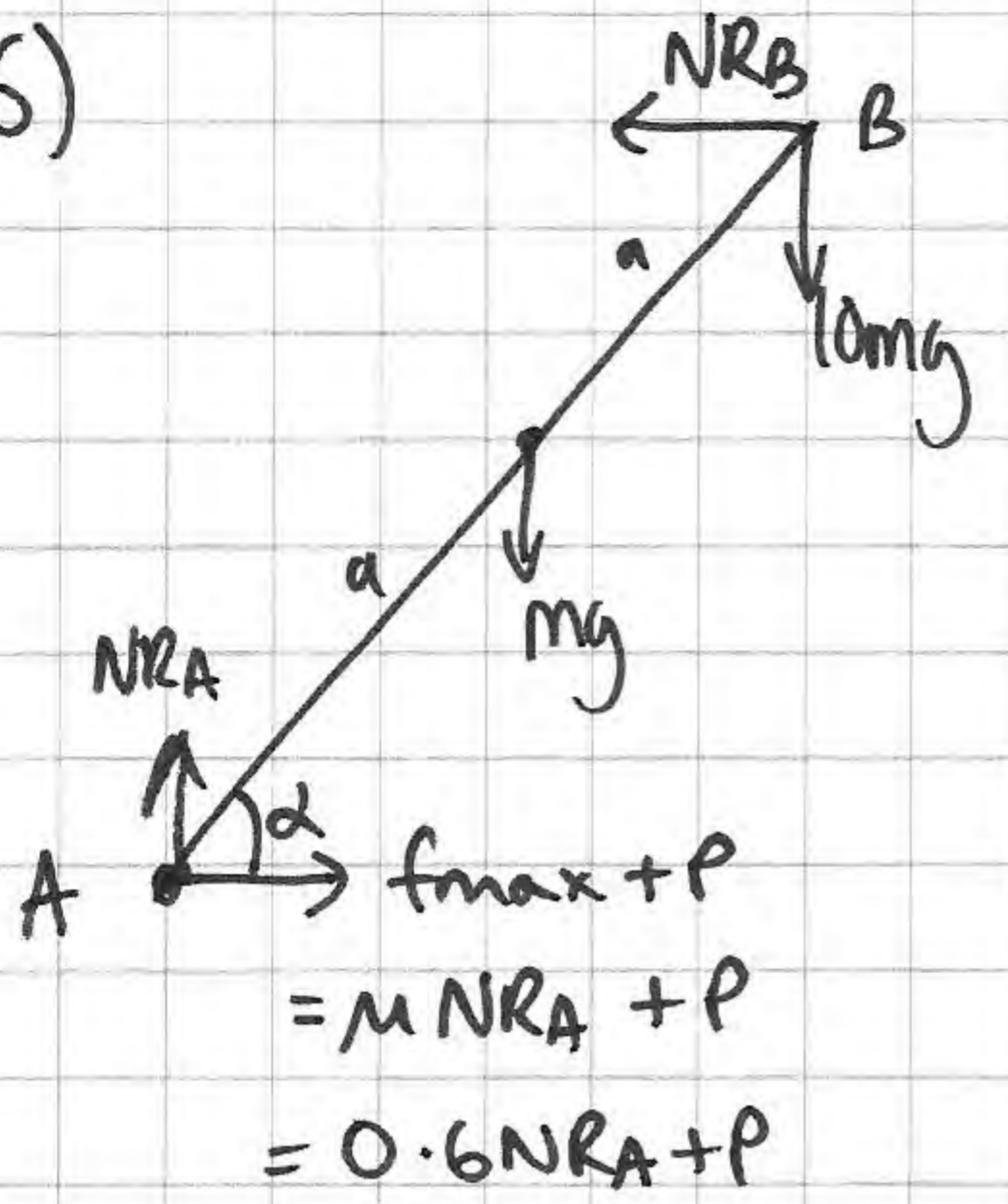


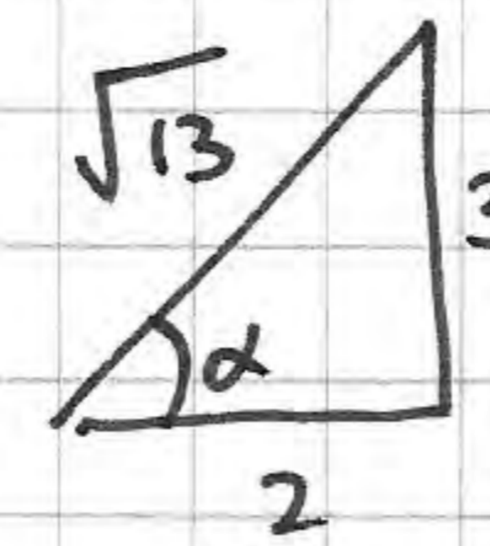
Collide again if $\overleftarrow{V_q} > \overleftarrow{0.4u}$

$f = \frac{V_q}{3.6u} \Rightarrow V_q = 3.6uf \qquad 3.6\cancel{u}f > 0.4\cancel{u}$

$\Rightarrow f > \frac{1}{9}$

6)





$\sin\alpha = \frac{3}{\sqrt{13}}$ $\quad \cos\alpha = \frac{2}{\sqrt{13}}$

A↺ $mg \times a\cos\alpha + 10mg \times 2a\cos\alpha = NR_B \times 2a\sin\alpha$

$\frac{2}{\cancel{\sqrt{13}}} mg\cancel{a} + \frac{40}{\cancel{\sqrt{13}}} mg\cancel{a} = \frac{6}{\cancel{\sqrt{13}}} \cancel{a} \, NR_B$

$\Rightarrow 42mg = 6NR_B \Rightarrow NR_B = \underline{7mg}$ #

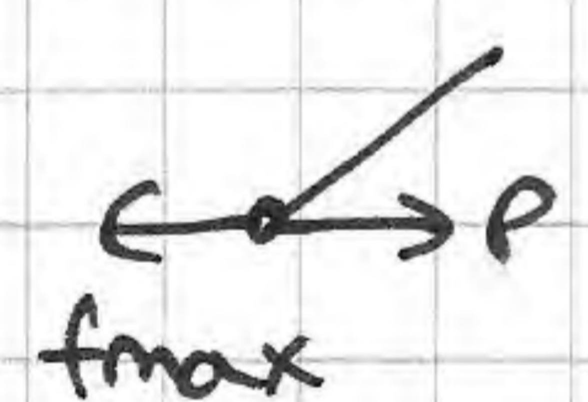
$R_f \uparrow = 0 \quad NR_A = 11mg \quad \Rightarrow \quad f_{max} = \mu NR_A = 6.6mg.$

$\overrightarrow{R_f} = 0 \quad f_{max} + P = NR_B \Rightarrow 6.6mg + P = 7mg \Rightarrow P = \underline{0.4mg}$

$P = 0.4mg$ when at limiting equilibrium, friction = fmax

$\therefore P \geq 0.4mg$

However, if P is large, ladder will slip towards wall, reversing the frictional force



at limiting equilibrium

$P - f_{max} = NR_B$

$P = 7mg + 6.6mg$

$P = 13.6mg$

$\therefore \quad 0.4mg \leq P \leq 13.6mg$

7a) $KE_A + PE_A$ - Wd against Res = $KE_B + PE_B$

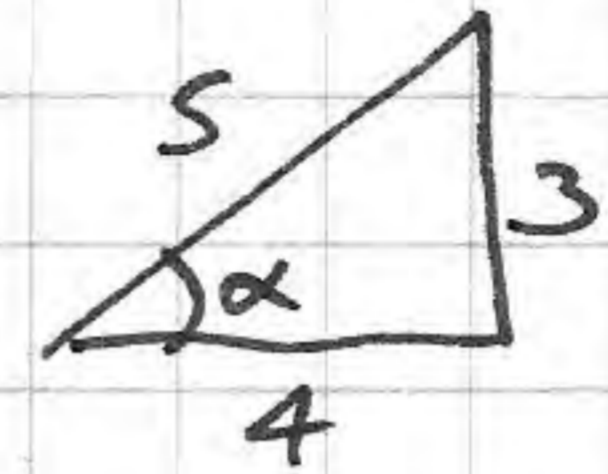
$\Rightarrow$ PE lost - Wd against Res = KE gain

$\Rightarrow 80g(24.4) - R \times 60 = \frac{1}{2}(80)(20)^2 \Rightarrow R = 52.2N$ (3sf)

b) V↑ $\quad u\uparrow = 20\sin\alpha = 12$

$a\uparrow = -9.8$

$s\uparrow = -8.1$



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

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

$s = ut + \frac{1}{2}at^2 \Rightarrow -8.1 = 12t - 4.9t^2 \Rightarrow 4.9t^2 - 12t - 8.1 = 0$

$t = \frac{12 + \sqrt{12^2 - 4(4.9)(-8.1)}}{9.8} \Rightarrow \underline{t = 3\text{sec}}$.

c) $\overrightarrow{H}$ $\quad$ Vel $= 20\cos\alpha = 16 \qquad t = 3 \qquad x = 16 \times 3 = 48\text{m}$

d) $KE_A + PE_A = KE_B + PE_B$

$\Rightarrow PE_{lost} = KE_{gain} \Rightarrow 80g(8.1) = \frac{1}{2}(80)(v^2 - 20^2)$

$\Rightarrow v^2 - 400 = 158.76$

$\Rightarrow v = \underline{23.6\text{ms}^{-1}}$ (3sf)