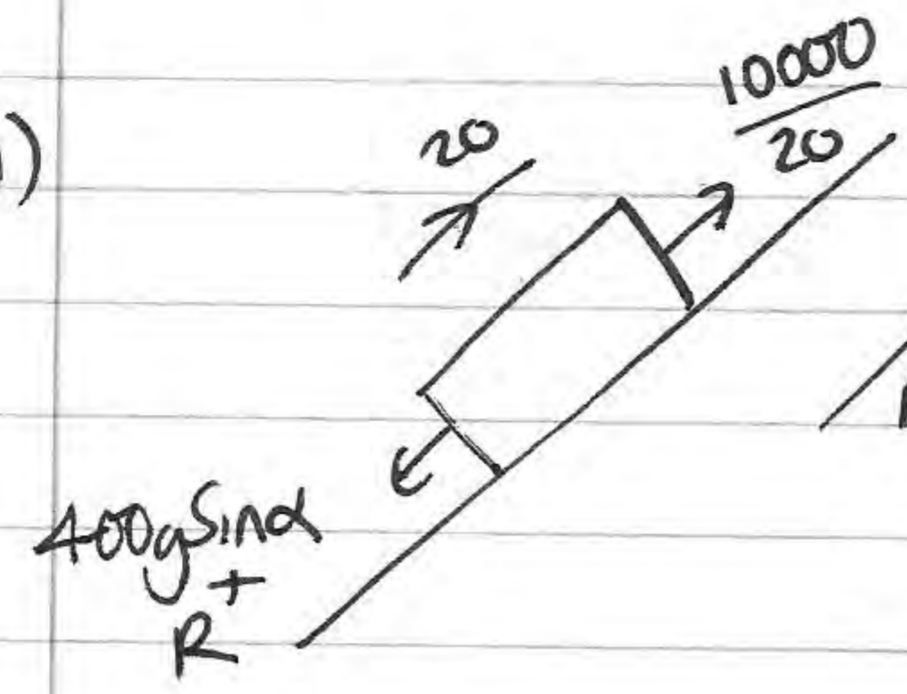
M2 JAN 04

1)



$\uparrow Rf = 0 \Rightarrow \frac{10000}{20} = 400g\left(\frac{1}{14}\right) + R$

$\Rightarrow R = 500 - \frac{200g}{7} \Rightarrow R = \underline{220N}$

2) $v = (t^2+2)i - 6tj$

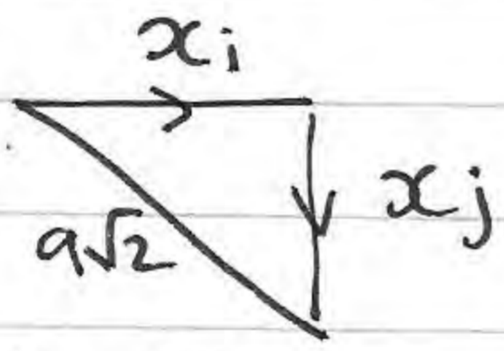
$a = \frac{dv}{dt} = 2ti - 6j$, $t=4 \Rightarrow a = 8i - 6j$ $|a| = 10 ms^{-2}$

$f = ma \Rightarrow |f| = 0.75 \times 10 = \underline{7.5N}$

b) $t=5$, $v = 27i - 30j$ $\Rightarrow$ Mom before $= 0.75(27i - 30j)$

$= 20.25i - 22.5j$

Impulse



$2x^2 = (9\sqrt{2})^2 \Rightarrow x^2 = 81$

$\Rightarrow x = 9$

Impulse $= 9i - 9j$

Mom before $= 20.25i - 22.5j$

$+$ Impulse $= 9i - 9j$

$\Rightarrow$ Mom after $= 29.25i - 31.5j$

$0.75v = 29.25i - 31.5j$

$v = \underline{39i - 42j \ ms^{-1}}$

3) Loss in KE = gain in PE (if smooth)

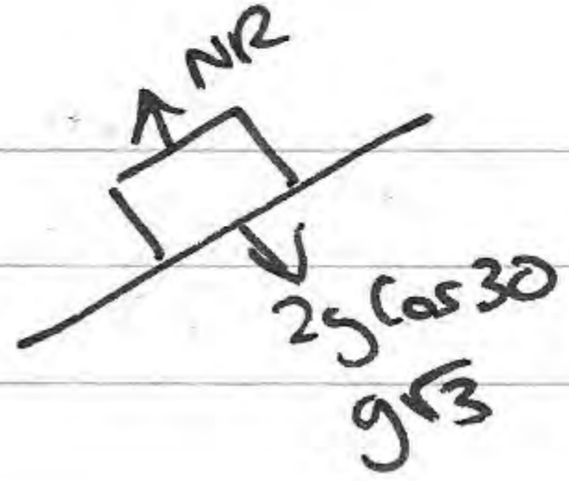
$\frac{1}{2}(2)(10^2 - v^2) = 2g(3\sin 30)$ $\Rightarrow 100 - v^2 = 3g \Rightarrow v = \sqrt{100-}$

$\Rightarrow v = \underline{8.40}$ (3sf)

b) Loss in KE − wd against friction = PE gain

$\Rightarrow \frac{1}{2}(2)(10^2 - 7^2) - f_{max} \times 3 = 2g(1.5)$

$$5l - 3\mu NR = 3g$$

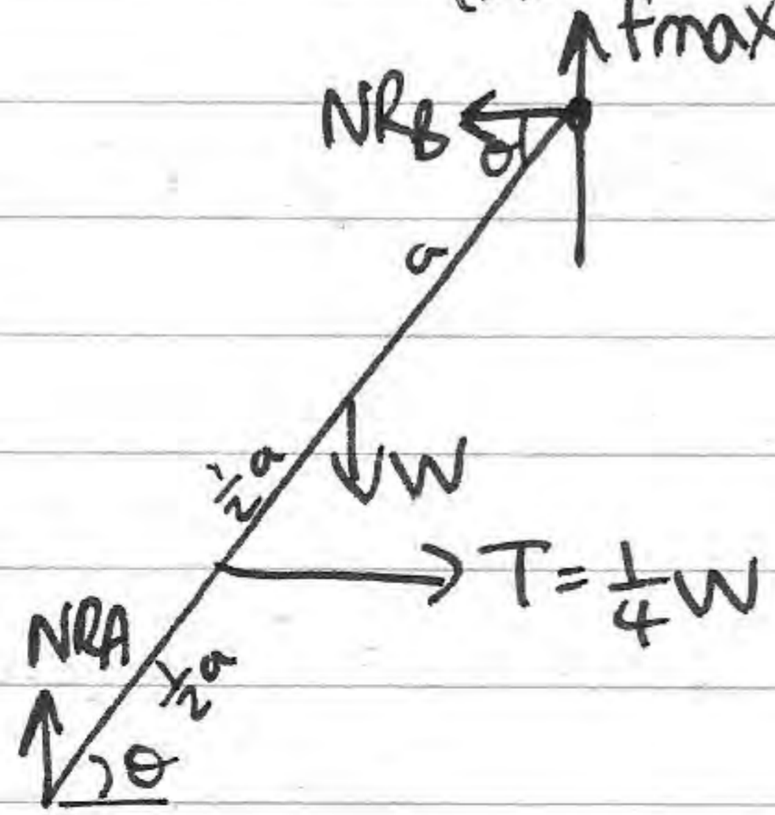


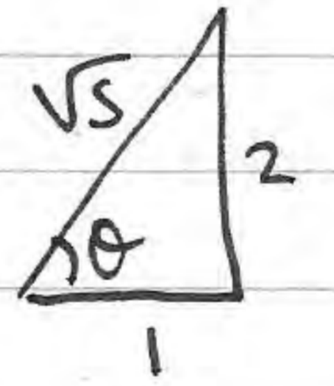
$$\Rightarrow 5l - 3\mu(g\sqrt{3}) = 3g$$

$$\Rightarrow \mu = \frac{5l - 3g}{3\sqrt{3}g} = \underline{0.42} \text{ (2sf)}$$

4)

friction = $F_{max} = \mu NRB$ if limiting





$\tan\theta = \frac{2}{1}$

$\sin\theta = \frac{2}{\sqrt{5}}$

$\cos\theta = \frac{1}{\sqrt{5}}$

B) $W \times a\cos\theta + \frac{1}{4}W \times \frac{3}{2}a\sin\theta = N_{RA} \times 2a\cos\theta$

$\Rightarrow \frac{1}{\sqrt{5}}aW + \frac{3}{4\sqrt{5}}aW = N_{RA} \times \frac{2}{\sqrt{5}}a$

$\Rightarrow W + \frac{3}{4}W = 2N_{RA} \Rightarrow 2N_{RA} = \frac{7}{4}W \Rightarrow N_{RA} = \frac{7}{8}W$

b) $\vec{R_f} = 0 \Rightarrow N_{RB} = \frac{1}{4}W$

$R_f \uparrow = 0 \Rightarrow N_{RA} + \text{friction} = W \Rightarrow \text{friction} = W - \frac{7}{8}W$

$\Rightarrow \text{friction} = \frac{1}{8}W$

friction $\leq$ fmax

$\Rightarrow \frac{1}{8}W \leq \mu N_{RB} \Rightarrow \frac{1}{8}W \leq \mu \frac{1}{4}W \Rightarrow \mu \geq \frac{4}{8}$

$\Rightarrow \mu \geq \frac{1}{2}$

5) (V↑) $u\uparrow = 3u$ $\quad a\uparrow = -9.8$ $\quad s\uparrow = 0$

$s = ut + \frac{1}{2}at^2$

$0 = 3ut - 4.9t^2$

$0 = t(3u - 4.9t) \Rightarrow t = \frac{3u}{4.9}$

(H) $Vel = 2u \quad x = 735 \quad t = \frac{3u}{4.9}$

$735 = 2u\left(\frac{3u}{4.9}\right) \Rightarrow 6u^2 = 3601.5$

$\Rightarrow u^2 = 600.25$

$\Rightarrow u = 24.5 ms^{-1}$ #

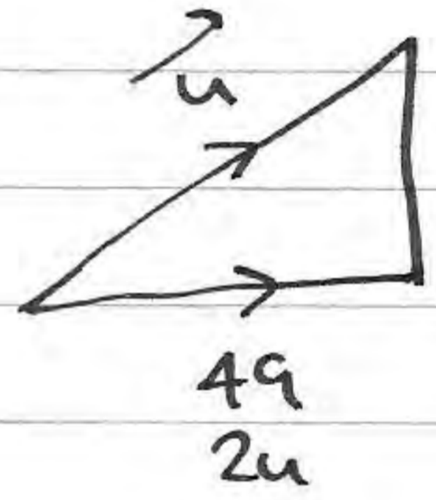
b) $t = \frac{3(24.5)}{4.9} = 15 sec$

c) Loss in KE = gain in PE

$\frac{1}{2}m(88.336...^2 - 65^2) = mgh$

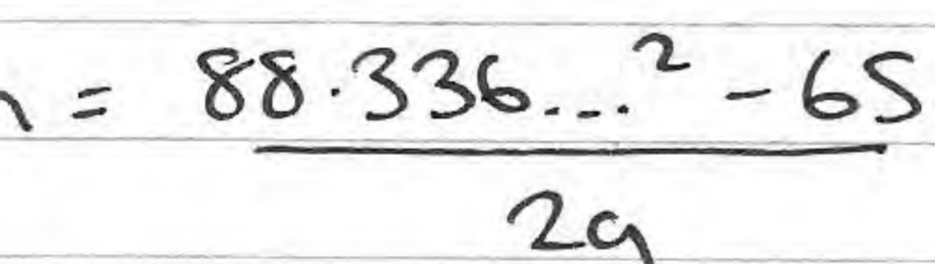
$h = \frac{88.336...^2 - 65^2}{2g}$

$\Rightarrow h = 183 m \ (3sf)$



$u = \sqrt{49^2 + 73.5}$

$u = 88.336...$

6) 

CLM $\Rightarrow mu = mV_A + 3mV_B$

$\Rightarrow u = V_A + 3V_B$

$\Rightarrow V_A = u - 3V_B$

$e = \frac{Sep}{app} = \frac{V_B - V_A}{u}$

$\Rightarrow eu = V_B - (u - 3V_B)$

$\Rightarrow eu + u = 4V_B$

$\Rightarrow V_B = \frac{1}{4}u(e+1)$ #

b) $V_A = u - 3V_B = u - 3\left(\frac{1}{4}u(e+1)\right)$

$\Rightarrow V_A = u - \frac{3}{4}ue - \frac{3}{4}u \Rightarrow \frac{1}{4}u - \frac{3}{4}ue$

$\Rightarrow V_A = \frac{1}{4}u(1-3e) \Rightarrow \text{Speed}_A = \left|\frac{1}{4}u(1-3e)\right|$

c) $\frac{1}{2}m\left(\frac{1}{4}u(1-3e)\right)^2 + \frac{1}{2}(3m)\left(\frac{1}{4}u(e+1)\right)^2 = \frac{1}{6}mu^2$

$\Rightarrow \frac{1}{32}u^2(1-3e)^2 + \frac{3}{32}u^2(e+1)^2 = \frac{1}{6}u^2$

$$(1-3e)^2 + 3(e+1)^2 = \frac{32}{6} = \frac{16}{3}$$

$$\Rightarrow 3(1-3e)^2 + 9(e+1)^2 = 16$$

$$\Rightarrow 3 - 18e + 27e^2 + 9e^2 + 18e + 9 = 16$$

$$\Rightarrow 36e^2 = 4 \quad \Rightarrow e^2 = \frac{1}{9} \quad \Rightarrow e = \frac{1}{3}$$

d) $V_A = \frac{1}{4}u(1-3e)$ If $e = \frac{1}{3}$ $V_A = \frac{1}{4}u(1-3(\frac{1}{3})) = 0$

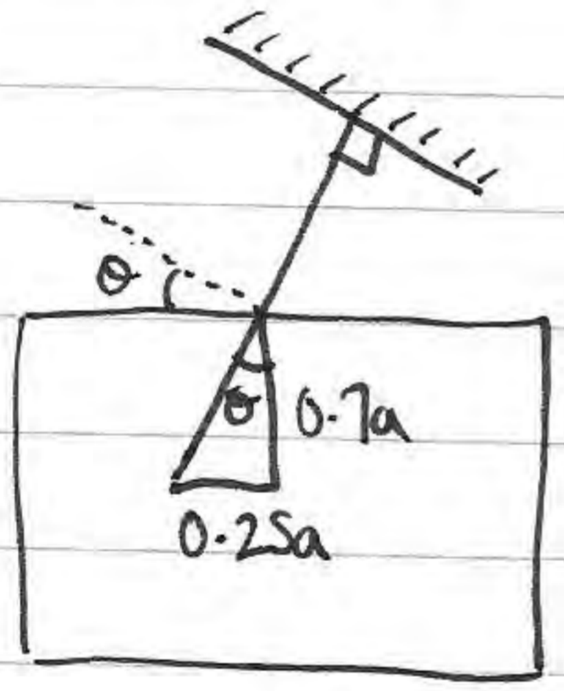
7) $\uparrow^y$ $4mgx0 + mgx5a + 2mgx5a + 3mgx2.5a = 10mg \times \bar{x}$

~~220mg~~ $22.5a = 10\bar{x} \Rightarrow \bar{x} = 2.25a$ //

b) $\rightarrow^x$ $4mgx0 + mgx0 + 2mgx2a + 3mgxa = 10mg \times \bar{y}$

$\Rightarrow 7a = 10\bar{y} \quad \Rightarrow \bar{y} = 0.7a$

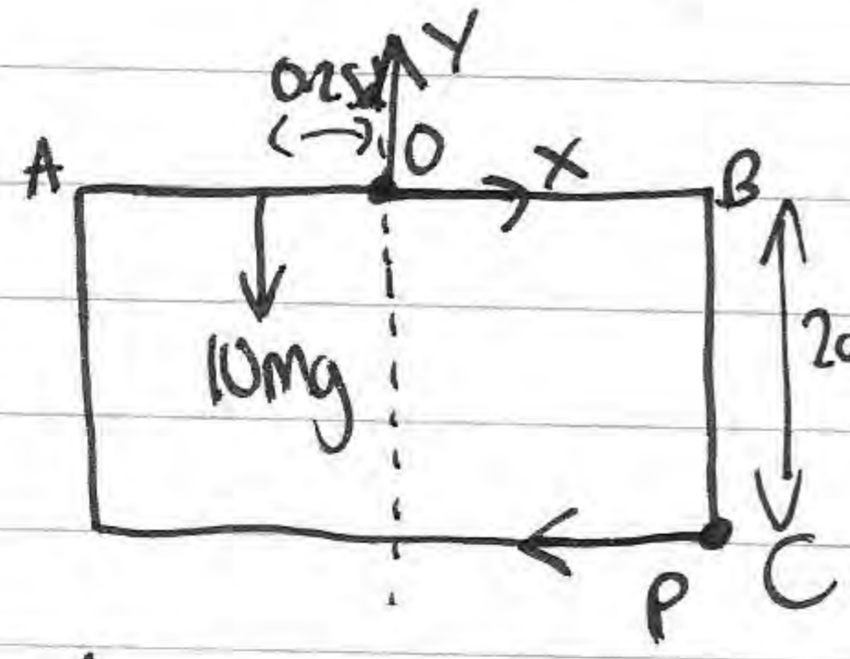
c)



$\theta = \tan^{-1}\left(\frac{0.25a}{0.7a}\right)$

$\theta = 20°$ (nλ)

d)

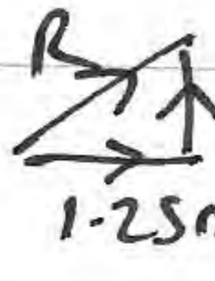


↺ $10mg \times 0.25a = P \times 2a$

$\Rightarrow 2.5mg = 2P$

$\Rightarrow P = 1.25mg$ N

e) $Rf\uparrow = 0 \Rightarrow Y = 10mg$ $\vec{Rf} = 0 \Rightarrow X = P = 1.25mg$



$R = \sqrt{(10ms)^2 + (1.25ms)^2} = 10.1ms$ (3sf)