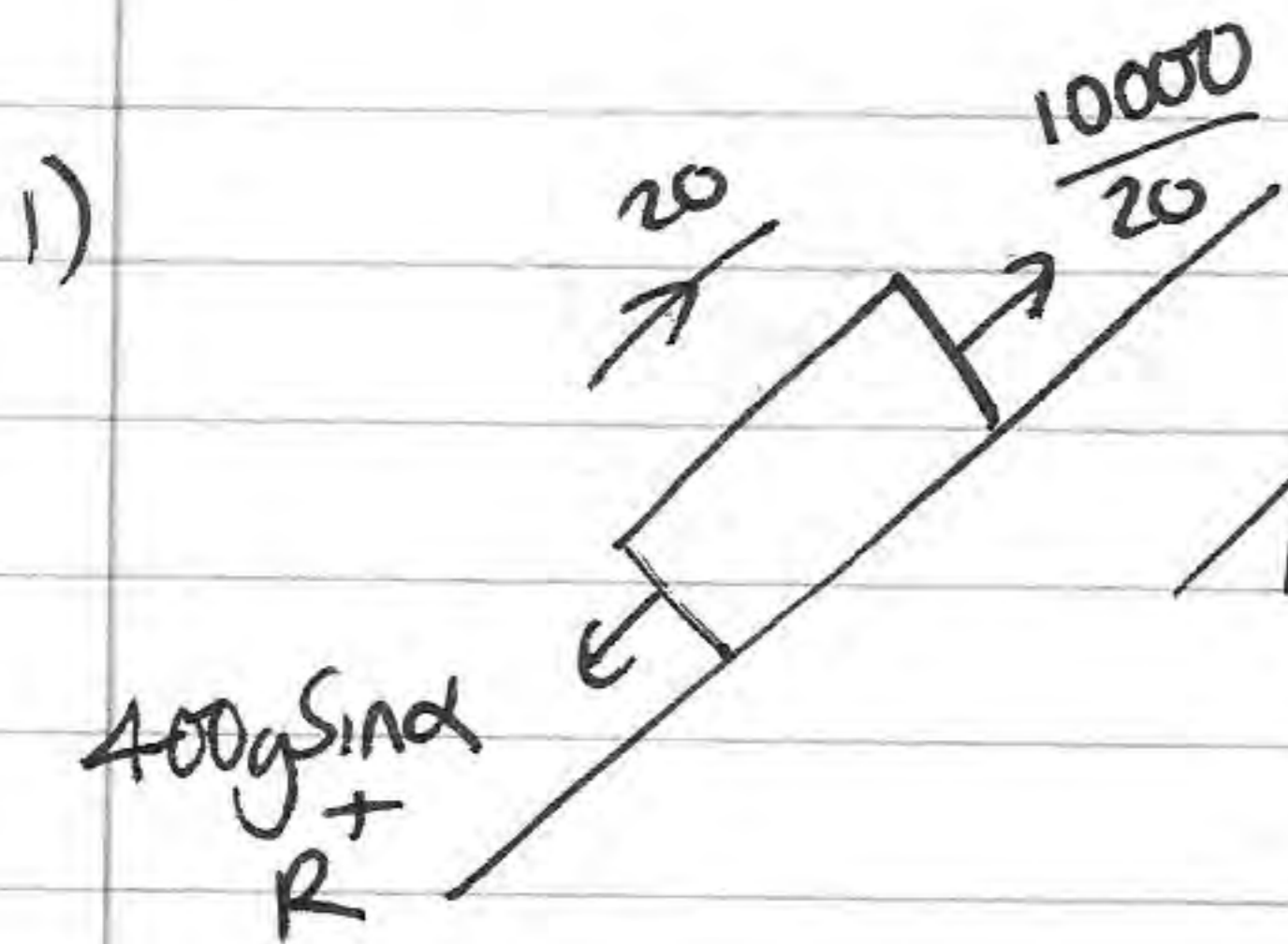M2 JAN 04

1)

$$Rf = 0 \Rightarrow \frac{10000}{20} = 400g\left(\frac{1}{14}\right) + R$$
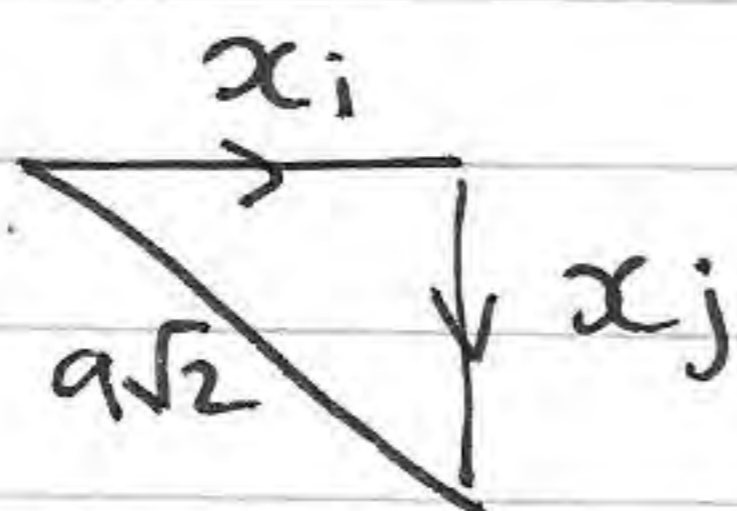
$$\Rightarrow R = 500 - \frac{200g}{7} \Rightarrow R = 220N$$

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

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

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

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 $= 29.25i - 31.5j$
$0.75V = 29.25i - 31.5j$
$V = 39i - 42j \ ms^{-1}$

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

$$\frac{1}{2}(2)(10^2 - v^2) = 2g(3\sin 30) \Rightarrow 100 - v^2 = 3g \Rightarrow V = \sqrt{100 -}$$
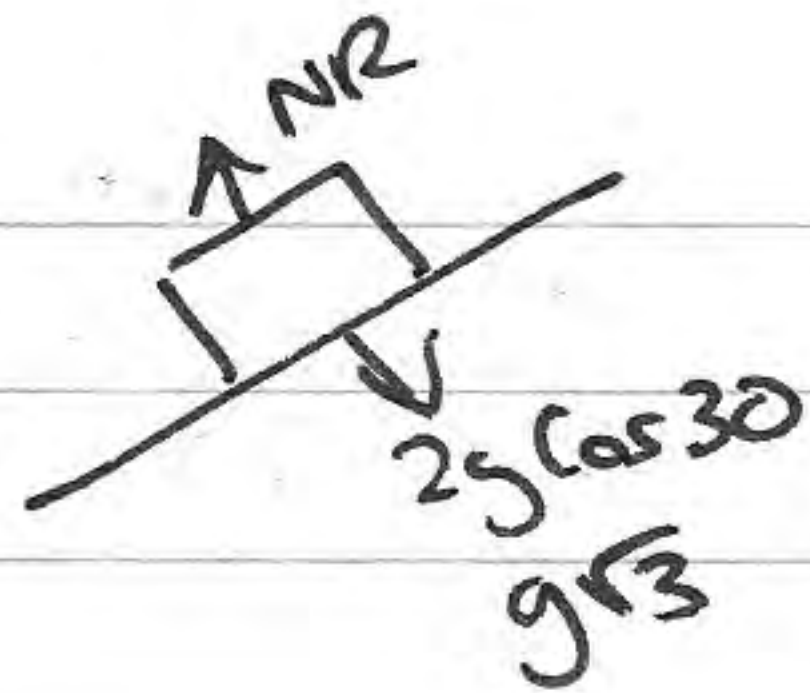
$$\Rightarrow V = 8.40 \ (3sf)$$

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

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

$$51 - 3\mu NR = 3g$$
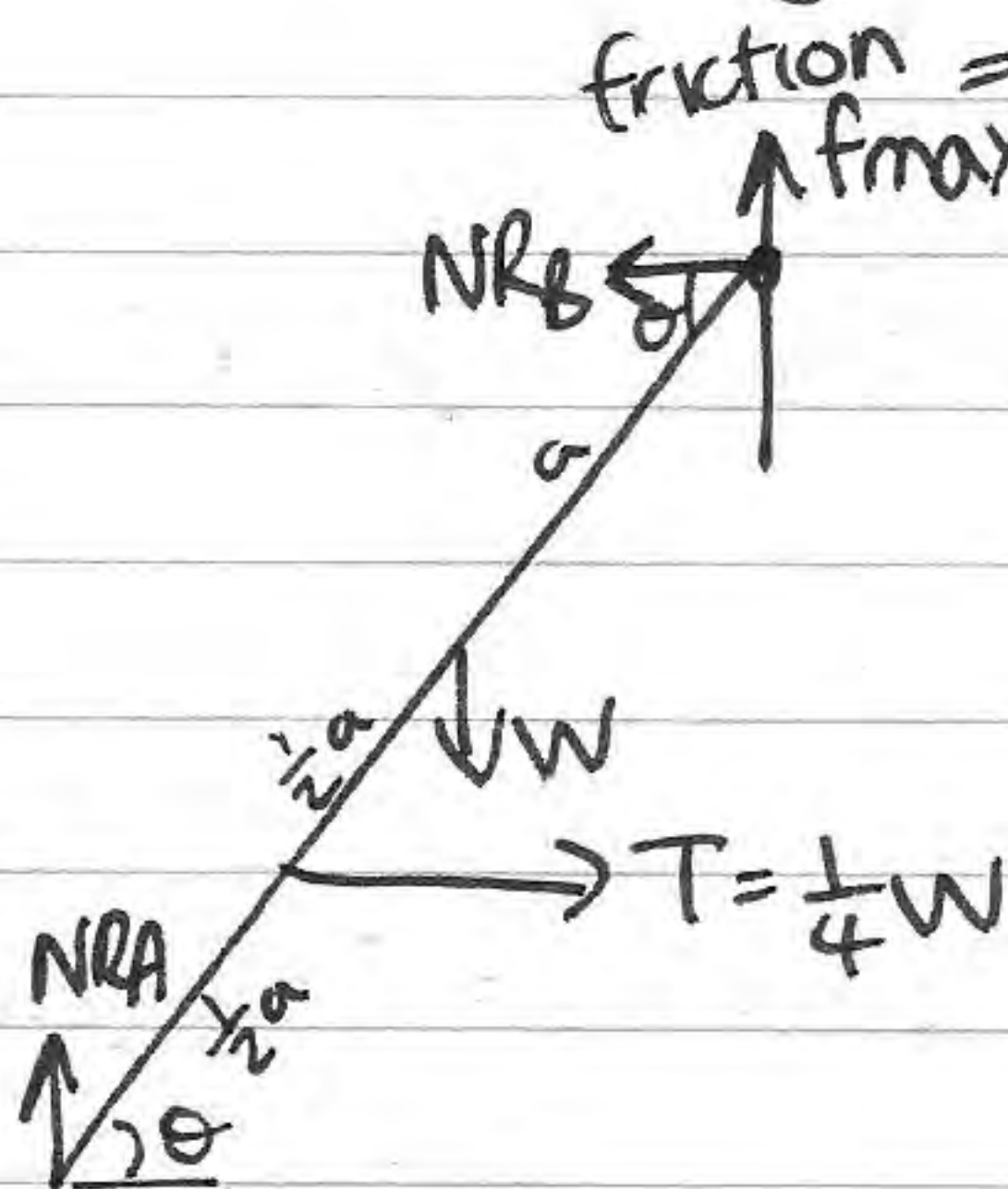
$$\Rightarrow 51 - 3\mu(g\sqrt{3}) = 3g$$

$$\Rightarrow \mu = \frac{51 - 3g}{3\sqrt{3}g} = 0.42 \ (2sf)$$

NR (up), $2g\cos30$, $g\sqrt{3}$ (down the slope)

4)

friction = $f_{max} = \mu NR_B$ if limiting

NR_B, f_{max}, a, $\frac{1}{2}a$, W (down), $T = \frac{1}{4}W$, NR_A, $\frac{1}{2}a$, θ

$\sqrt{5}$, 2, 1, θ

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

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

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

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

$\Rightarrow \frac{1}{\sqrt{5}}\alpha W + \frac{3}{4\sqrt{5}}\alpha W = N_{RA} \times \frac{2}{\sqrt{5}}\alpha$
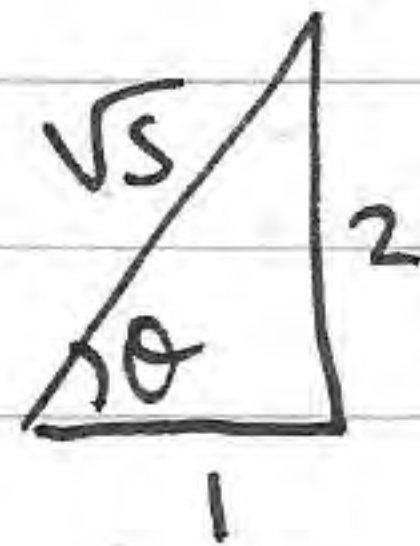
$\Rightarrow W + \frac{3}{4}W = 2N_{RA} \Rightarrow 2N_{RA} = \frac{7}{4}W \Rightarrow \underline{N_{RA} = \frac{7}{8}W}$

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

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

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

$\text{friction} \leq f_{max}$

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

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

5) $\boxed{V\uparrow}$ $u\uparrow = 3u$ $s = ut + \tfrac{1}{2}at^2$

$a\nwarrow = -9.8$ $0 = 3ut - 4.9t^2$

$s\uparrow = 0$ $0 = t(3u - 4.9t) \Rightarrow t = \dfrac{3u}{4.9}$

$\boxed{H}$ $vel = 2u$ $x = 735$ $t = \dfrac{3u}{4.9}$

$$735 = 2u\left(\frac{3u}{4.9}\right) \Rightarrow 6u^2 = 3601.5$$
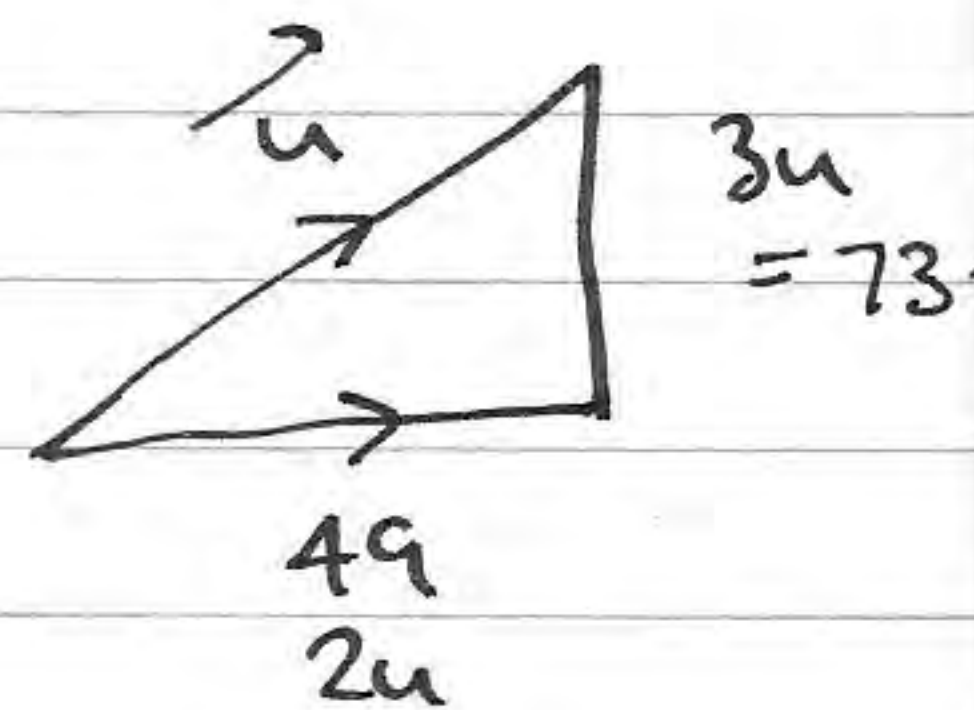$$\Rightarrow u^2 = 600.25$$
$$\Rightarrow u = 24.5\,ms^{-1} \quad \#$$

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

c) Loss in KE = gain in PE

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

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

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

[right side triangle diagram]

u $3u = 73\cdot$

49

$2u$

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

$u = 88.336...$

6)

$\xrightarrow{\;u\;}$ $\xrightarrow{\;0\;}$

$A\,\boxed{m}$ $B\,\boxed{3m}$

$\rightarrow v_A$ $\rightarrow v_B$

CLM $\Rightarrow mu = mv_A + 3mv_B$

$\Rightarrow u = v_A + 3v_B$

$\Rightarrow v_A = u - 3v_B$

$e = \dfrac{sep}{app} = \dfrac{v_B - v_A}{u}$ $\Rightarrow eu = v_B - (u - 3v_B)$

$\Rightarrow eu + u = 4v_B$

$\Rightarrow v_B = \tfrac{1}{4}u(e+1) \quad \#$

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

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

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

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

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

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

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

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

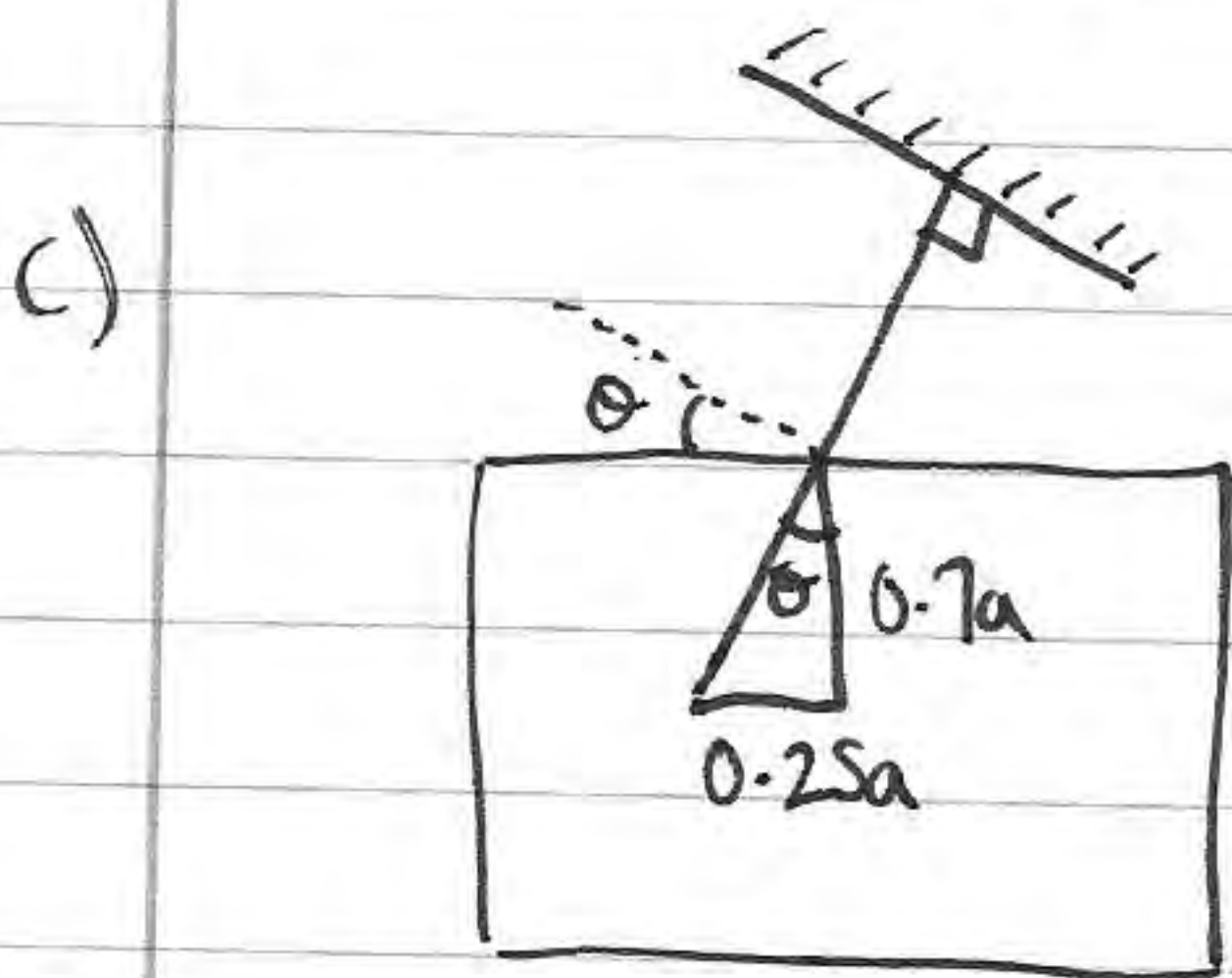$$\Rightarrow 36e^2 = 4 \qquad \Rightarrow e^2 = \frac{1}{9} \qquad \Rightarrow e = \frac{1}{3}$$

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

7) $\uparrow^y$ \quad $4mg \times 0 + mg \times 5a + 2mg \times 5a + 3mg \times 2 \cdot 5a = 10mg \times \bar{x}$

$\cancel{22 \cdot mg}$ + $\quad 22 \cdot 5a = 10\bar{x} \quad \Rightarrow \bar{x} = 2 \cdot 25a$ #
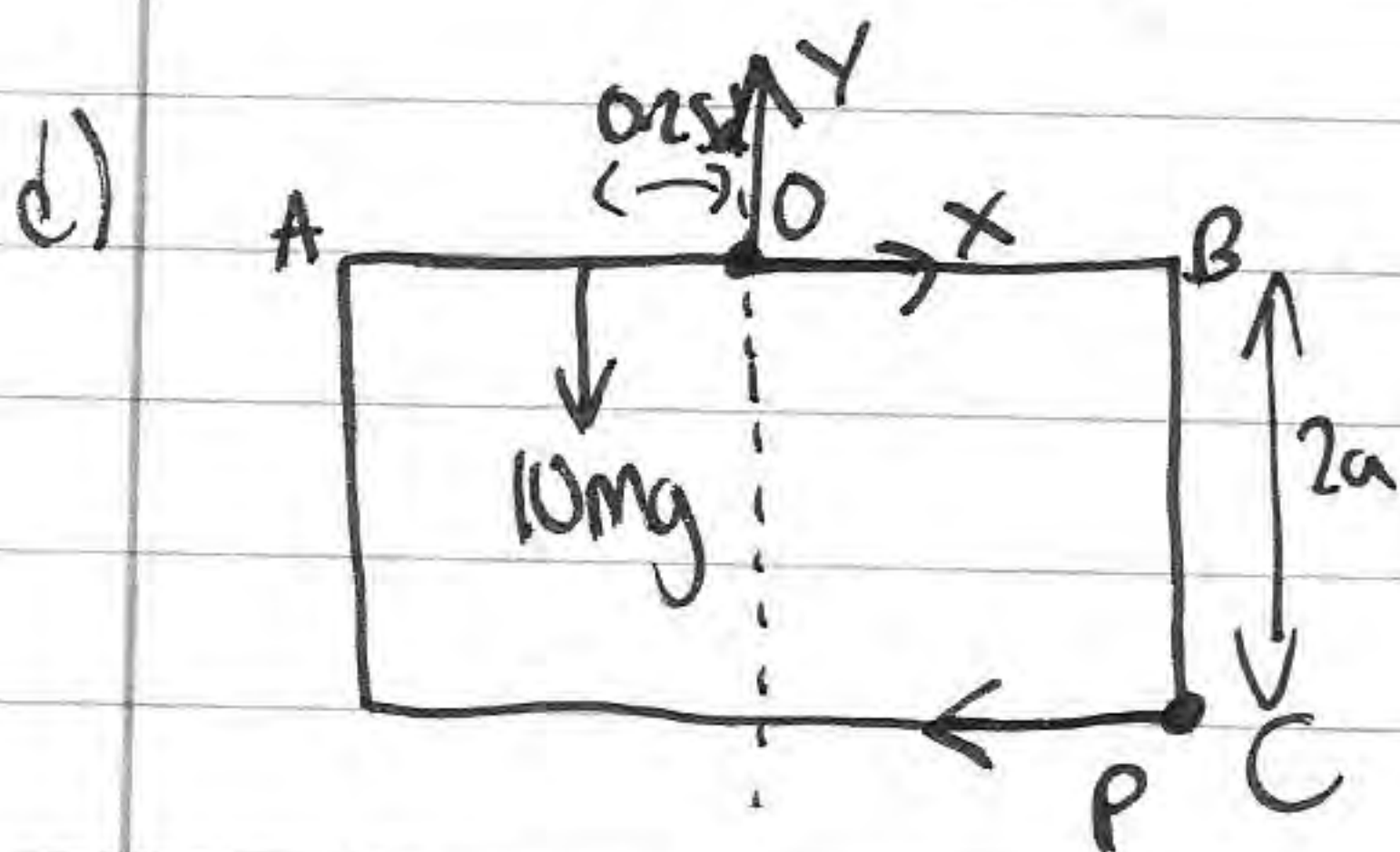
b) $\xrightarrow{x}$ \quad $4mg \times 0 + mg \times 0 + 2mg \times 2a + 3mg \times a = 10mg \times \bar{y}$

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

c)

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

$$\theta = 20° \text{ (n}\lambda\text{)}$$

d)

ⓐ $10mg \times 0.25a = P \times 2a$

$$\Rightarrow 2.5mg = 2P$$

$$\Rightarrow P = 1.25mg \text{ N}$$

e) $R + \uparrow = 0 \Rightarrow Y = 10mg$ \quad $\vec{RF} = 0 \Rightarrow X = P = 1.25mg$

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