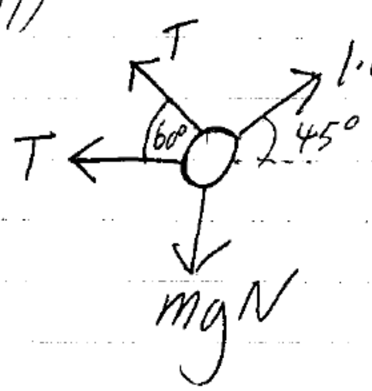
M1 (4728 OCR) June 200

① (i) The ring is smooth

(ii)



Resolving Horizontally –

$T + T\cos 60 = 1.6\cos 45$

(as ring in equilibrium, forces must cancel out.)

Giving $T = \dfrac{1.6 \times \frac{\sqrt{2}}{2}}{(1 + \frac{1}{2})}$

$= \dfrac{1.6\sqrt{2}}{3} = 0.754\text{N}$

(iii) Resolving Vertically :–

$mg = T\sin 60 + 1.6\sin 45$

$= 0.754 \times \frac{\sqrt{3}}{2} + \frac{1.6\sqrt{2}}{2}$

$= 1.78$

So $\boxed{m = 0.182\text{ kg}}$

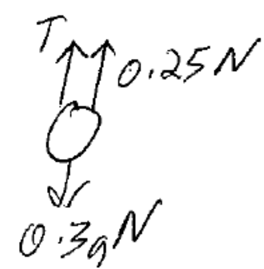
② (i) By Newton's 2nd law $F = ma$, & applying this to

A gives: $0.2g + T - 0.4 = 0.2a$ (1)

& B gives: $0.3g - (T + 0.25) = 0.3a$ (2)

A :–

B. –



② (ii) Adding equations (1) & (2) gives:-

$$0.5g - 0.65 = 0.5a.$$

Giving $\boxed{a = 8.5\,ms^{-2}}$

Then using (T) gives $T = 0.2 \times 8.5 - 0.2g + 0.4$

$$= \boxed{0.14N}$$

③ (i) Conservation of momentum gives:-

$$0.1 \times 4 - 0.2 \times 3 = 0.1 \times (-u) + 0.2 \times (3.5 - u)$$

ie. $$-0.2 = 0.7 - 0.3u.$$

so $$0.3u = 0.9$$

ie. $$\boxed{u = 3}$$

(ii) For P:- $u = 3ms^{-1}$, $v = 0$, $a = -5ms^{-2}$, so using $v^2 = u^2 + 2as$ gives:-

$$s_P = \frac{-3^2}{2 \times -5} = \underline{0.9m}$$

For Q:- $u = 0.5ms^{-1}$, $v = 0$ & $a = -5ms^{-2}$, so the same equation gives:-

$$s_Q = \frac{-0.5^2}{2 \times -5} = 0.025m$$

So total distance is $s_P + s_Q = 0.925m$.

④ (i) During first 0·8s we can use $s = ut + \frac{1}{2}at^2$ to get:-

$$2 = 0{\cdot}8u + 0{\cdot}32a \qquad (A)$$

At the beginning of the next 1·2s the speed will be $u + 0{\cdot}8a$ (using $v = u + at$), so using $s = ut + \frac{1}{2}at^2$ with <u>this</u> value for u:-

$$6 = 1{\cdot}2(u + 0{\cdot}8a) + 0{\cdot}72a$$

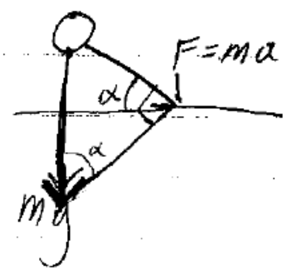
i.e. $$6 = 1{\cdot}2u + 1{\cdot}68a \qquad (B)$$

Now $2 \times (B) - 3 \times (A)$ gives:-

$$6 = 2{\cdot}4a$$

So $\boxed{a = 2{\cdot}5\,ms^{-2}}$

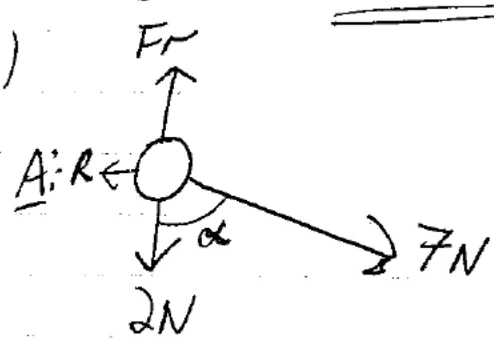
(ii)



$$ma = mg \sin\alpha$$

So $\alpha = \sin^{-1}\left(\frac{2{\cdot}5}{9{\cdot}8}\right) = 14{\cdot}8°$

⑤ (i)



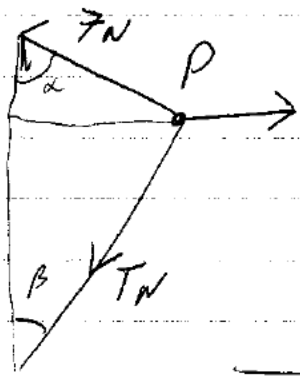
Resolving vertically:-

$$Fr = 2 + 7\cos\alpha$$
$$= 3{\cdot}96N$$

Resolving horizontally:- $R = 7\sin\alpha$
$$= \underline{6{\cdot}72N}$$

Now $Fr = \mu R$ gives:- $\boxed{\mu = 0{\cdot}589 \text{ (3d.p.)}}$

(5) (ii)



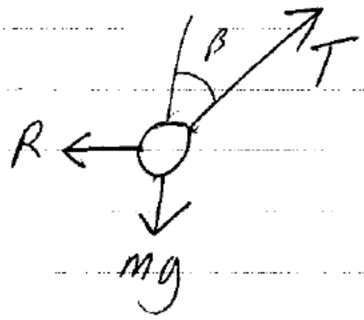
Resolving vertically:-

$7\cos\alpha = T\cos\beta$

ie, $1.96 = T\cos\beta$.

(iii)

Bi:-



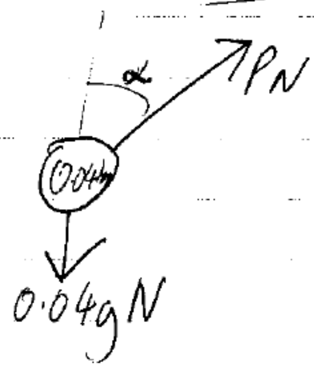
Resolving vertically:-

$T\cos\beta = mg$

ie $1.96 = 9.8m$

ie $\boxed{m = 0.2\text{kg}}$

(6) (i)



(a) $P\cos\alpha = 0.04g$
(By resolving vertically)

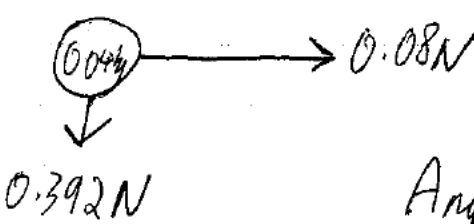
so $\boxed{P = 0.417}$ (to 3d.p)

(b) Resultant is $P\sin\alpha = \boxed{0.143\text{N}}$ (to 3d.p)

(c) $F=ma$ gives $0.143 = 0.04a$

so $\boxed{a = 3.57\text{ms}^{-2}}$ (to 3s.f.)

(ii)



$\sqrt{0.08^2 + 0.392^2} = \boxed{0.4\text{N}}$

Angle is $\tan^{-1}\left(\frac{0.392}{0.08}\right) = \boxed{78.5^\circ \text{ below horizontal}}$

7 (i) Using $s=\frac{1}{2}(u+v)t$ 3 times gives:-

$$\frac{1}{2}(0+16)\times 200+\frac{1}{2}(16+25)\times 300+\frac{1}{2}(25+0)\times 100$$

$$=1600+6150+1250=\boxed{9000m}$$

(ii) $a=\frac{u-v}{t}=\frac{25}{100}=\boxed{0.25ms^{-2}}$

(iii) $a=\frac{dv}{dt}$, so $\boxed{a=(1200t-3t^2)\times 10^{-6}\ ms^{-2}}$

(iv) when $t=550$, $a=(1200\times 550-3\times 550^2)\times 10^{-6}$

$$=-0.2475ms^{-2}$$

So Q's deceleration is $\boxed{0.0025ms^{-2}}$ less than P's.

(v) Maximum velocity occurs when $\frac{dv}{dt}=0$,

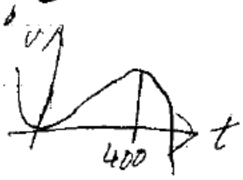
ie when $(1200t-3t^2)\times 10^{-6}=0$

ie. $t(1200-3t)=0$

This is true only when $t=0$ or $t=\frac{1200}{3}=400s$,

But $t=0$ gives the <u>minimum</u> velocity (of $0ms^{-1}$),

so maximum must occur at $t=400$:-



(vi) $s_Q=\int v\,dt=(200t^3-\frac{1}{4}t^4)\times 10^{-6}+C$

(But $C=0$ since at $t=0$ $s_Q=0$)

At $t=400$ $s_Q=200\times 400^3+\frac{1}{4}\times 400^4=\underline{6400m}$

At $t=400$ $V_P=16+\frac{2}{3}(25-16)=22ms^{-1}$ (as 400 is $\frac{2}{3}$ of way from 200 to 500.)

So $s_P=\frac{1}{2}(0+16)\times 200+\frac{1}{2}(16+22)\times 200=\underline{5400m}$. So Q is $\boxed{1000m}$ further on.