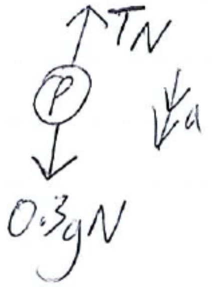
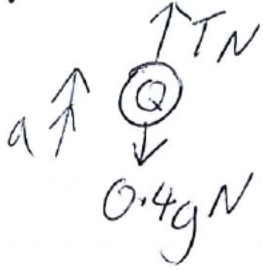
M1 Exam January 2006

(1) (i)



Using $F=ma$:- $0.3g - T = 0.3a$ (A)



Using $F=ma$ $\therefore$ $T - 0.4g = 0.4a$ (B)

Adding equations (A) & (B) gives :-

$$-0.1g = 0.7a.$$

Giving $\underline{a = -1.4}$.

(ii) Acceleration is constant so can use $s = ut + \frac{1}{2}at^2$.

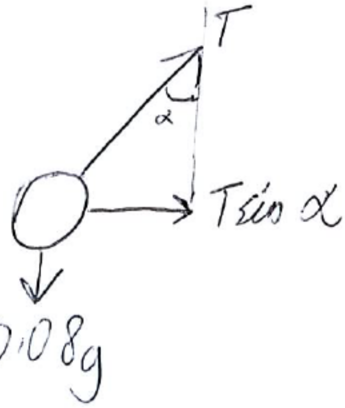
ie. $s = 2.8t + \frac{1}{2} \times (-1.4) \times t^2$

$= t(2.8 - 0.7t)$.

So $s=0$ when $t=0$ or $(2.8-0.7t)=0$

ie $\underline{t = 4s}$

(2)



By Newtons 2nd Law $F=ma$

so $T\sin\alpha = 0.08 \times 1.25$

$= \underline{0.1}$ (A)

(2) (ii) Vertical forces on the object must cancel as there is no vertical movement (Newton's 1st),
so

$$0.08g = T\cos\alpha \quad (B)$$

Dividing equation (A) by equation (B) gives

$$\frac{0.1}{0.08g} = \frac{T\sin\alpha}{T\cos\alpha} = \tan\alpha, \text{ so } \alpha = \tan^{-1}\left(\frac{0.1}{0.08g}\right).$$
$$= 7.23^\circ$$

Then (A) gives $T = \frac{0.1}{\sin\alpha} = \underline{0.79N}$

(3) (i) $a = \frac{dv}{dt} = 7.2 - 0.9t$

$a = 0$ when $0.9t = 7.2$
ie. when $\underline{t = 8s}$ (so $\underline{T=8}$)

(ii) When $t = T$ $\quad V = 7.2T - 0.45T^2$
$= 7.2 \times 8 - 0.45 \times 64$
$= \underline{28.8ms^{-1}}$

(iii) Between $t = 8s$ & $t = 31s$ motorcycle travels

$28.8 \times (31 - 8) = 662.4m$

For first 8 seconds we use that $s = \int v\,dt$,
ie.

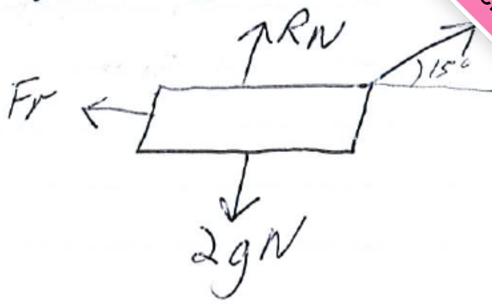
$$s = \int 7.2t - 0.45t^2\,dt = 3.6t^2 - 0.15t^3 (+C)$$

(but $C = 0$ since $s = 0$ when $t = 0$)

So when $t = 8$, $s = 3.6 \times 8^2 - 0.15 \times 8^3 = 153.6m$

So total distance is $662.4 + 153.6 = \underline{816m}$

(4) (i) As block is at rest there is no resultant force (Newton's 1st).



Resolving horizontally:-

$Fr = 12\cos 15$
$= \underline{11 \cdot 6N}$ (to 3s.f)

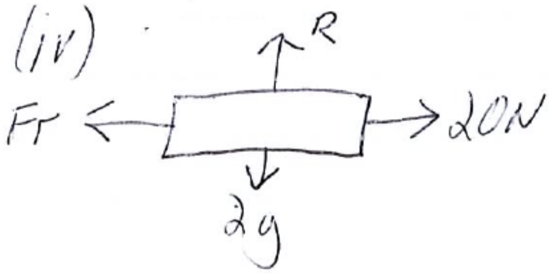
(ii) Resolving Vertically:- $2g = R + 12\sin 15$

so $R = 2 \times 9 \cdot 8 - 12\sin 15$
$= \underline{16 \cdot 5N}$ (to 3s.f)

(iii) $Fr = \mu R$ (as block is on point of sliding, friction is maximal.)

So $\mu = \frac{11 \cdot 6}{16 \cdot 5} = 0 \cdot 703$ (to 3s.f).

(iv)



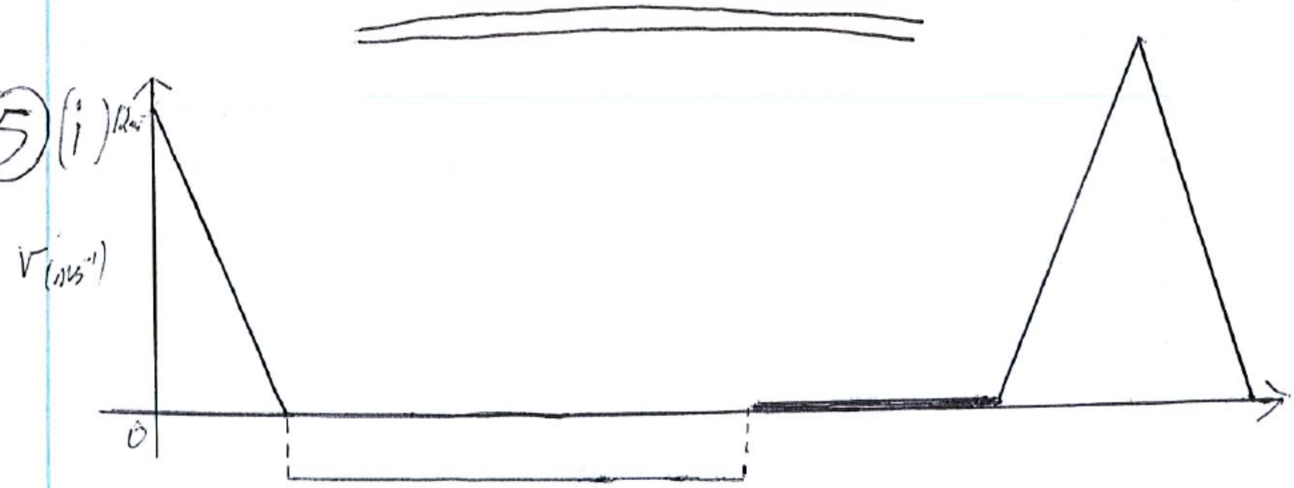
Now $R = 2g = 19 \cdot 6N$,

so $Fr = 13 \cdot 8N$ (to 3s.f)

Using $F = ma$:- $20 - 13 \cdot 8 = 2a$

so $\underline{a = 3 \cdot 11ms^{-2}}$ (to 3s.f.)

(5) (i)



5 (ii) $\frac{12}{8} = \underline{1.5ms^{-2}}$

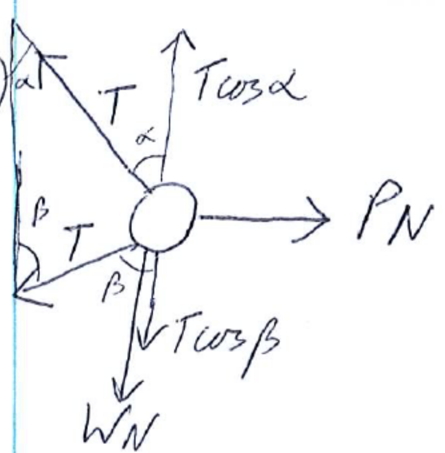
(iii) Walking:- $t = \frac{s}{v} = \frac{420}{0.7} = 600s$

Motorcycle:- Use $s = \frac{1}{2}(u+v)t$ to get:-

$$t = \frac{210 \times 2}{0 + 20} = 21s \text{ accelerating,}$$

& symmetrically 21s decelerating.

Thus total time is $8 + 600 + 250 + 21 + 21 = \underline{900s}$

6 

(i) Resolving vertically as system is in equilibrium forces must cancel out (by Newtons 1st Law) & so

$$W + T\cos\beta = T\cos\alpha$$

(Tension in both BR & AR is the same as ring is smooth.)

Since W is positive $T\cos\beta < T\cos\alpha$

so $\cos\beta < \cos\alpha$

As $0 \leq \alpha, \beta \leq 90°$ & cos is a <u>decreasing</u> function on this interval, this gives $\underline{\beta > \alpha}$.

(ii)(a) Resolving horizontally we get:-

$$T\sin\alpha + T\sin\beta = 14$$

⑥ (ii) (a) (cont) Now $\sin\alpha = \frac{0.24}{0.4} = 0.6$

$$\& \ \sin\beta = \frac{0.24}{0.3} = 0.8$$

So $T(0.6 + 0.8) = 14$ & $\underline{T = 10N}$.

(b) $W = T\cos\alpha - T\cos\beta$

$$= 10 \times (\cos\alpha - \cos\beta)$$
$$= 10 \times (\cos(\sin^{-1} 0.6)) - \cos(\sin^{-1}(0.8)))$$
$$= \underline{2N}$$

(iii) (a) R is hanging directly below A & B.

(b)

$$2T = 2$$
$$\text{So } T = \underline{1N}$$

⑦ (i) Total momentum before collision :-

$$8 \times 0.15 + 2 \times 0.5 = 2.2 Ns$$

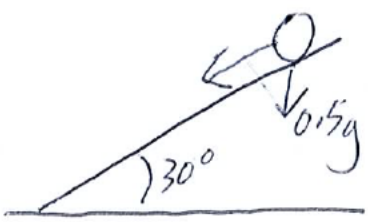
After collision :-

$$0 \times 0.15 + 0.5u = 0.5u$$

(where u is speed of B up the slope).

Conservation of momentum gives :- $0.5u = 2.2$

So $\underline{u = 4.4 ms^{-1}}$



Acceleration is $-g\sin 30 = -4.9 ms^{-2}$

So the distance B travels before it stops (when $v = 0$) is given by

$v^2 = u^2 + 2as$, so $s = \frac{v^2 - u^2}{2a} = \frac{-4.4^2}{2 \times (-4.9)} = \underline{1.98m}$

(7)(i) (cont) As the collision occurs at the midpoint of PQ, this is 2m from Q, & so B does not reach Q.

(ii) A has $u=0$, $a=4.9\,ms^{-2}$ & $s=2m$

So $v^2=u^2+2as$

gives $v=\sqrt{2\times4.9\times2}=4.427\,ms^{-1}$

& then $s=\frac{1}{2}(u+v)t$ gives

$$t_A=\frac{2\times2}{(0+4.427)}=0.904\,s.$$

B has $u=-4.4\,ms^{-1}$ $a=4.9\,ms^{-1}$ $s=2$,

Again $v^2=u^2+2as$ gives $v=\sqrt{(-4.4)^2+2\times4.9\times2}$
$=6.242\,ms^{-1}$.

& then $s=\frac{1}{2}(u+v)t$ gives

$$t_B=\frac{2\times2}{(-4.4+6.242)}=2.172\,s.$$

$t_B-t_A=\underline{1.27\,s}$