M1 Exam May 2006 (OC

① Momentum before collision:-

$$(1200+m)\times 3 - 1200\times 3 = 3m \text{ Ns}$$

Momentum after collision:-

$$(1200+m)\times 0 + 1200\times 5 = 6000 \text{ Ns}$$

Conservation gives $3m = 6000$

so $m = 2000\text{kg}$.

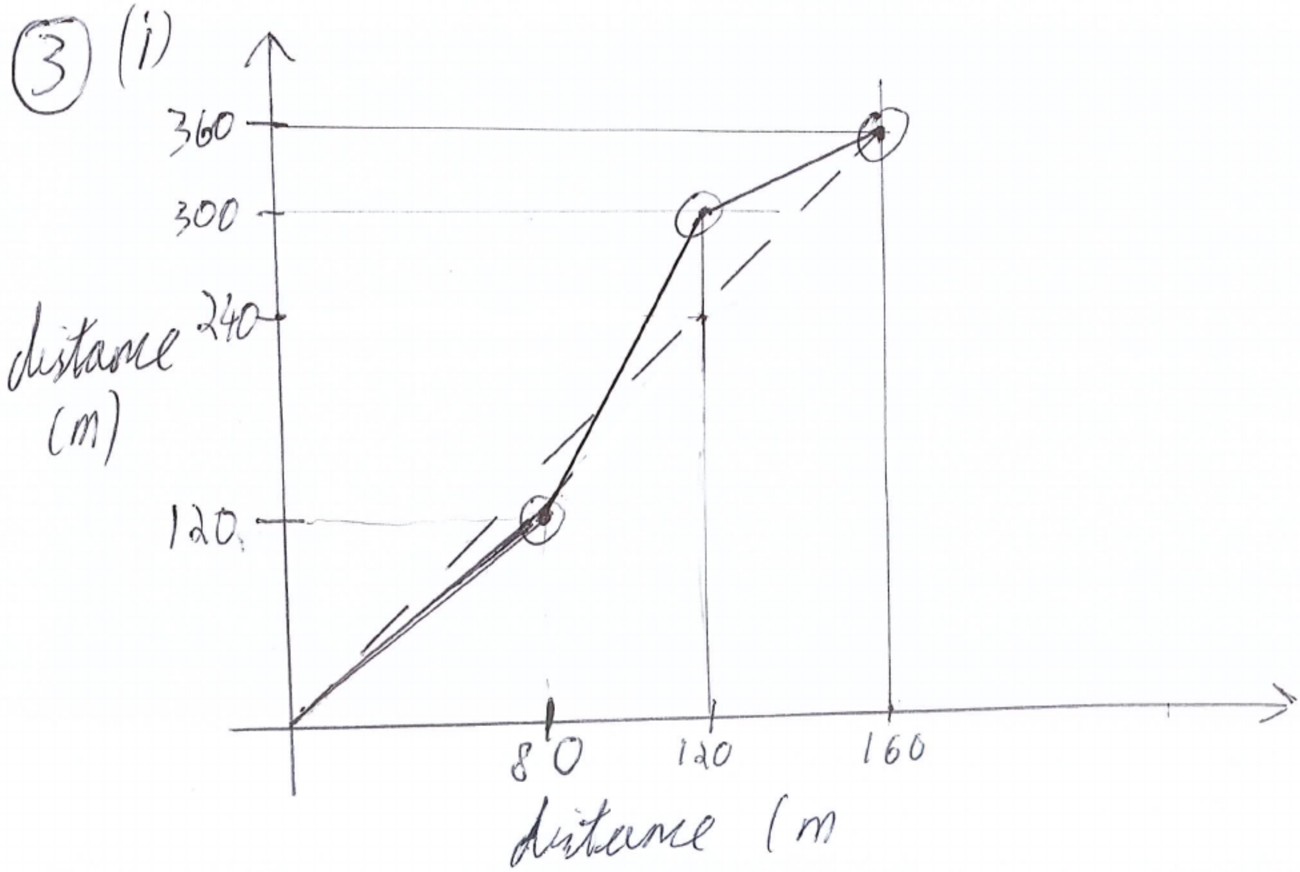
② (i) Horizontal forces cancel, so

$$6.5\sin\theta = 2.5.$$

ie. $\theta = \sin^{-1}\left(\frac{2.5}{6.5}\right) = 22.6^\circ$

(ii) $R = 6.5\cos\theta = 6.5\cos(22.6) = 6$

③ (i)



③ (cont) (i) $\frac{120}{1.5} = 80s$, $\frac{180}{4.5} = 40s$, $\frac{60}{1.5} = 40s$,

so times are $t=80$, $t=120$ & $t=160$

(iii) At $t=80$ the man has gone 120m & the woman $80 \times \left(\frac{360}{160}\right) = 80 \times 2.25 = 180m$, so the woman is 60m ahead.

Her speed is $2.25ms^{-1}$ & the man's is $4.5ms^{-1}$.

Using $s_m = 4.5t'$ & $s_w = 2.25t'$ we want to know when $s_m = s_w + 60$

ie. $4.5t' = 2.25t' + 60$

ie. $2.25t = 60$

ie. $t' = 26\frac{2}{3}s$.

Add this to the 80s to get $t = 106\frac{2}{3}s$.

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④ (i) $2 \times 10 = 20m$

(ii) Since $s = \int v\,dt$, displacement after 10 seconds is given by $s = \int 0.03t^2 - 0.3t + 2$

$= 0.01t^3 - 0.15t^2 + 2t + C$

To find C we use that at $t=10$, $s=20$:

$20 = 0.01 \times 1000 - 0.15 \times 100 + 2 \times 10 + C$.

so $C = 5$.

4 (iii) $a = \frac{dv}{dt} = 0.06t - 0.3.$

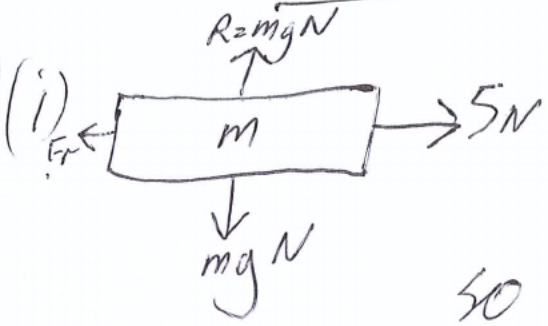
So $a = 0.6$ when $0.6 = 0.06t - 0.3$

i.e. $t = \frac{0.9}{0.06} = \underline{15s}.$

So $s = 0.01 \times 15^3 - 0.15 \times 15^2 + 2 \times 15 + 5$

$= \underline{35m}$

5 (i)



Since block is on point of slipping $Fr = \mu R$, & $\mu = 0.2$

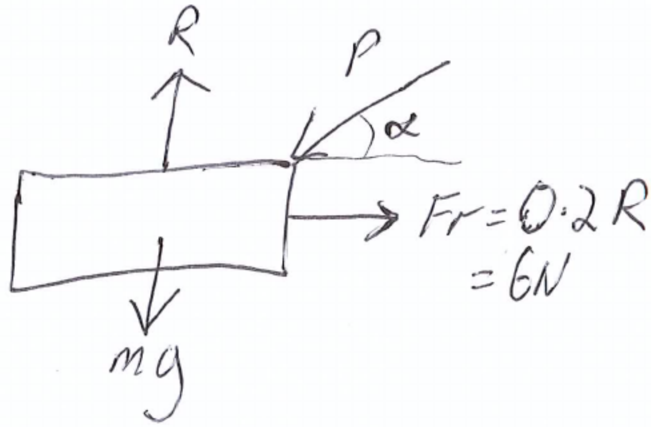
so $Fr = 0.2mg$.

But as equilibrium is maintained $Fr = 5$.

So $0.2mg = 5$

so $\underline{m = 2.55}$

(ii) (a)



Now

$R = mg + P\sin\alpha$ (1)

Also $P\cos\alpha = 6$ (2)

$0.2R = 6$,

so $R = 30N$.

So (1) gives $P\sin\alpha = 30 - mg = 5.01$ (3)

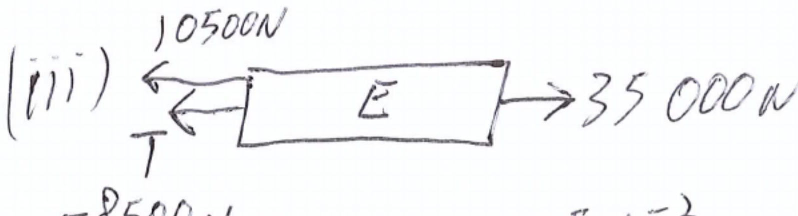
(3) ÷ (2) then gives $\tan\alpha = \frac{5.01}{6}$, so $\alpha = 39.8°$

5 (ii) (b) Thus (2) gives $P = \frac{6}{\cos\alpha} = \underline{7.81}$

6 (i) Total resistance $= 1500 + 3000 + 10500$
$= 15\ 000\text{N}$.

By Newton's 2nd Law this will produce an acceleration in the direction opposite to the motion (ie. deceleration) <u>unless</u> it is cancelled out by a driving force greater than (or equal) 15 000N. With a lower driving force there will be a deceleration.

(ii) Total force $= 35\ 000 - 15\ 000 = 20\ 000\text{N}$
Using $F = ma$, $20\ 000 = 80\ 000 \times a$
so $a = \frac{2}{8} = \underline{0.25\text{ms}^{-2}}$.

(iii) 

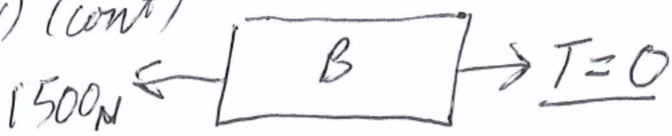
$F = 35000 - 8500 - 10500\text{N} = 16\ 000\text{N}$

so $F = ma$ gives:- $16000 = E \times 0.25$

so $\underline{E = 64\ 000\text{kg}}$.

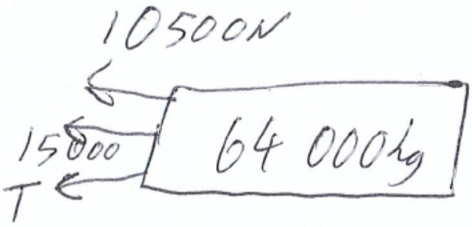
(iv) Now $F = -30\ 000\text{N}$, so $F = ma$ gives:-
$-30\ 000 = 80\ 000a$, so $a = -0.375\text{ms}^{-2}$

6 (iv) (cont)



The resistance is the only force on B, & so $1500 = B \times 0.375$ (F=ma again), so $B = 4000\text{kg}$.

(v) Force on engine:

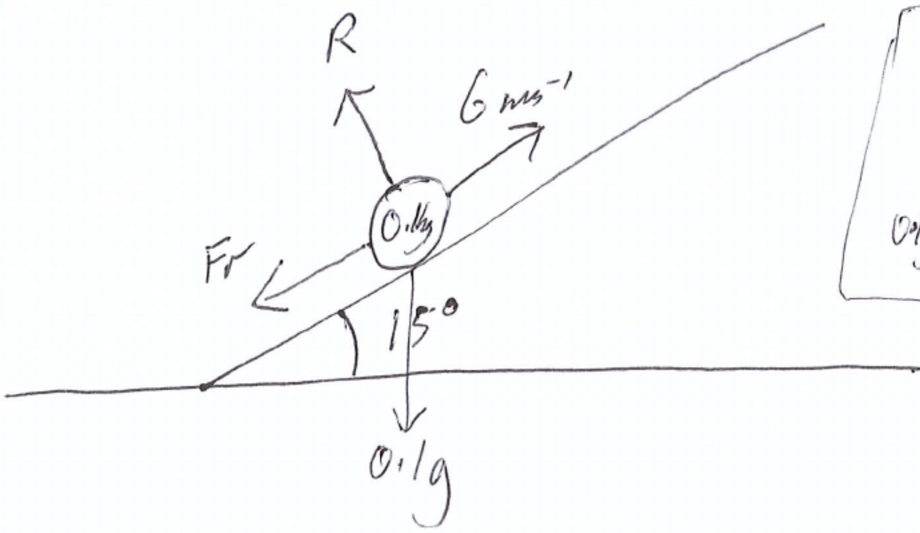


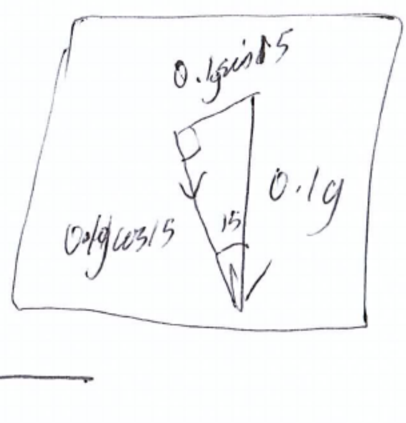
So F=ma gives $10\,500 + 15000 + T = 64\,000 \times 0.375$

So $T = 24\,000 - 10\,500 - 15\,000$
$= -1500\text{N}$

So coupling is not pulling engine back, but pushing it forward.

7 (i)





$R = 0.1g\cos 15 = 0.0966g$ (to 3sf.) $= 0.9466$

As $u = 6$, $v = 0$ & $t = 1.5$, $v = u + at$ gives

$a = -\frac{6}{1.5} = -4\text{ms}^{-2}$

(7) (i) (cont) Thus $F = ma$ gives

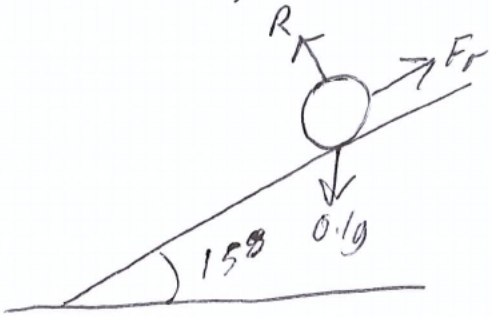
$$F = 0.1 \times 4 = 0.4N$$

Now $F = Fr + 0.1g\sin 15 =$

So $Fr = 0.4 - 0.1g\sin 15 = 0.146$ (to 3s.f.)

Then $Fr = \mu R$ gives $\mu = \frac{0.146}{0.9466} = \underline{0.155}$ (to 3s.f)

(ii)



We still have $R = 0.9466$,

So $Fr \leq 0.155 \times 0.9466$

$= 0.146N$

But the force parallel to the slope due to gravity is $0.1g\sin 15 = 0.256N$, which is greater than maximal friction, giving an overall force of $0.256 - 0.146 = 0.1076N$ <u>down</u> the slope, leading to acceleration by Newtons 2nd law.

(iii) $F = ma$ gives $a = 1.076 ms^{-2}$.

Now $s = \frac{1}{2}(u+v)t$ gives that particle is $\frac{1}{2} \times (6+0) \times 1.5 = 4.5m$ from A when it stops.

Then $v^2 = u^2 + 2as$ gives $v = \sqrt{0 + 2 \times 1.076 \times 4.5}$

$= 3.11 ms^{-1}$