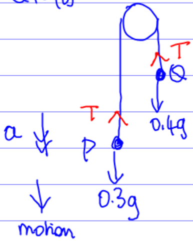
Mechanics 1
January 2006.

Q1. (i)



P: $0.3g - T = 0.3a$ Using F=ma downwards

Q: $T - 0.4g = 0.4a$ (M1) (A1) up

add the equations

$0.3g - T + T - 0.4g = 0.3a + 0.4a$

$0.3g - 0.4g = 0.7a$

$-0.1g = 0.7a$ (M1)

$a = \dfrac{-0.1 \times 9.8}{0.7} = -1.4 \text{ ms}^{-2}$ (A1)

(ii) u at P = 2.8 ms^{-1}.

$a = -1.4$

t ?

$s = 0$ displacement from initial to return is 0.

$s = ut + \frac{1}{2}at^2$ (M1)

$0 = 2.8t + \frac{1}{2}(-1.4)t^2$

$0 = 2.8t - 0.7t^2$

$0 = 0.7t(4 - t)$ (M1)

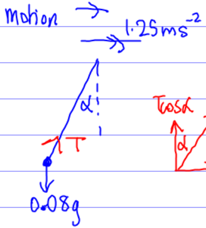
$2.8t = 0.7t^2$

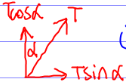
$4 = t$

either $t = 0$ or $t = 4$ seconds (A1)

initial. time to return.

Q2





(i) Using $F = ma$ Horizontally $a = 1.25$

$T\sin\alpha = 0.08 \times 1.25 = 0.1$

(ii) Using $F = ma$ vertically $a = 0$

$T\cos\alpha - 0.08g = 0$

$T\cos\alpha = 0.08 \times 9.8$

$\frac{T\sin\alpha}{T\cos\alpha} \doteq \tan\alpha = \frac{0.1}{0.08 \times 9.8} = 0.1276$

so $\tan^{-1}(0.12755) =$ $\alpha = 7.27°$ (3sf)

then $T = 0.790$ N (3sf)

Q3. $v = 7.2t - 0.45t^2$ $a = 0$ when $t = T$

(i) $\frac{dv}{dt} = 7.2 - 0.90t$ (M1)   also when $t = 0$ $s = 0$

$7.2 - 0.90T = 0$ (A1) $\left[t = T \ \frac{dv}{dt} = 0 \right]$

$T = \frac{7.2}{0.9}$ (M1) $= 8$ seconds (A1)

(ii) so when $t = 8$ (s) then $v = 7.2 \times 8 - 0.45 \times 64$ (B1)

$v = 28.8$ ms^{-1}.

(iii) $a = 0$ when $t \geq T$ ie constant speed.

before $t = 8$ variable acceleration.

$x = \frac{7.2t^2}{2} - \frac{0.45t^3}{3} + c$ (M1) (A1) However at start $t = 0$ vehicle at rest $x = 0$ (DM1)

before $t = 8$ seconds subs $t = 8$ above

$x = \frac{7.2}{2} \times 64 - \frac{0.45}{3} \times 512 = 153.6$ metres $\therefore c = 0$ (A1)

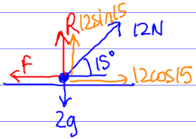
after $t = 8$ constant speed

speed $= \frac{\text{dist}}{\text{time}}$ $28.8 = \frac{\text{dist}}{(31 - 8)}$ distance $= 28.8 \times 23 = 662.4$ (B1)

Total dist $= 662.4 + 153.6$

$= 816$ metres. (A1)

Q4



(i) $F = 12\cos 15 = 11.6\text{ N}$ (3sf)

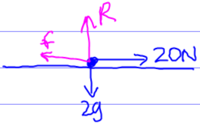
(ii) $R + 12\sin 15 = 2g$

$\therefore R = 2g - 12\sin 15$

$\therefore R = 16.5\text{ N}$ (3sf)

(iii) $F = \mu R$

$\therefore \mu = \frac{F}{R} = \frac{11.6}{16.5} = 0.703$ (3sf)



(iv) μ stays same, moving block.

$R = 2g$

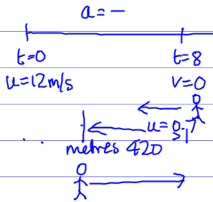
$20 - F = ma \qquad 20 - F = 2a$

However $F = \mu R = 0.703 \times 2g = 13.8\text{ N}$ (3sf)

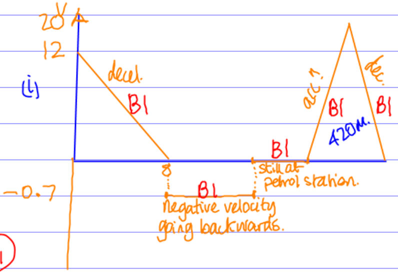
$20 - 13.8 = 2a$

$a = 3.11\text{ ms}^{-2}$

Q5.



(i)



ii) $V = u + at$

$0 = 12 + a8$ (M1)

$a = -\frac{12}{8} = -1.5\ ms^{-2}$ (A1)

(iii) car = 8 secs.

walk = 600 secs.

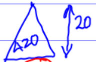
still = 250 secs.

m. acc/dec = 42 secs.

Total Time = 900 seconds (A1)

Walk $sp = \frac{d}{t}$ $\quad 0.7 = \frac{420}{t}$ $\quad t = \frac{420}{0.7} = 600s$

motorbike.



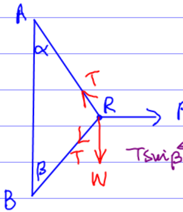
(M1)

$\frac{1}{2}$ base x height = area

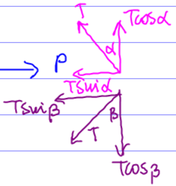
$420 = \frac{1}{2} \times base \times 20$

$base = \frac{840}{20} = 42$ (B1) (B1)

Q6.



(i) Show $\alpha < \beta$ $(\alpha \not> \beta)$

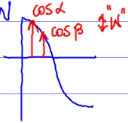


Vertically the forces ↑ = forces ↓

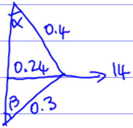
$T\cos\alpha \stackrel{?}{=} T\cos\beta + W$

So $\cos\alpha > \cos\beta$

$\alpha < \beta$



(ii)



Horizontal Forces

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

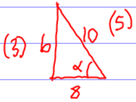
$0.6T + 0.8T = 14$

$1.4T = 14$

$T = 10\text{ N}.$

$\sin\alpha = \frac{0.24}{0.4} = 0.6 \quad \frac{6}{10}$

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



3,4,5

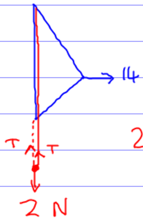
5,12,13

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

$0.8T = 0.6T + W$

$W = 0.2T = 2\text{ N}.$

(iii) $P=0$

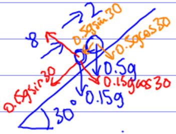


Ring falls directly beneath B.

$2T=2$

$T=1$ N.

Q7.



before $\rightarrow 8\,m/s$ $\quad 2\,m/s$

A $\quad$ B

after $0\,m/s$ $\quad v\,m/s$

(i) consider conservation of momentum (M1) (B1)

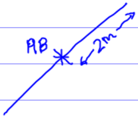
$8 \times 0.15g\sin30 + 2 \times 0.5g\sin30 = 0 + V\,0.5g\sin30$ (B1)

$(m_1u_1 + m_2u_2) = (m_1v_1 + m_2v_2)$

$1.2 + 1 = 0.5V$

$2.2 = \frac{1}{2}V$

$V = 4.4\ m/s.$ (A1)



For B use "u" = 4.4

$v = 0$

$a = ?\ -4.9$

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

$0 = 4.4^2 + 2(-4.9)s$

To find 'a' for B use $F = ma$ upwards

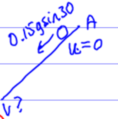
$-0.5g\sin30 = 0.5a$ (M1)

$a = -9.8 \times \sin30 = -4.9\ ms^{-2}$. (A1)

(M1) (A1) ft

$s = \frac{4.4^2}{9.8} = 1.976$ metres $<$ 2metre to Q.

(ii) When does A arrive at P?



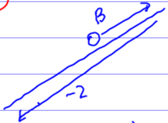
$a = g\sin 30 \downarrow$

$a = -4.9\ ms^{-2}$

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

$-2 = 0 + \frac{1}{2} \times (-4.9)t^2$ (M1)

$t = 0.904$ seconds. (A1)



going up $a = -4.9$ (decelerating)

going down $a = 4.9$ (accelerating)

When does B arrive at P?

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

from collision point $s = -2$ (same as for A)

but $u = 4.4$ m/s on B going after collision

$-2 = 4.4t - \frac{14.9}{2}t^2$ (M1)

(M1) (A1)

$t = \frac{8.8 \pm 12.4836}{9.8} = 2.1718$ or < 0 (not possible)

(A1)

Difference in time $= 2.1718 - 0.904 = 1.27$ seconds.