M1 MAY 2010

1. $\underline{u} = \begin{pmatrix}-3\\2\end{pmatrix}$, $\underline{a} = 0.$, $\underline{s}_0 = \begin{pmatrix}-4\\-7\end{pmatrix}$ at $t=6$.

$\underline{s} = \underline{s}_0 + \underline{u}t + \tfrac{1}{2}\underline{a}t^2$, $t = -4$ seconds

$$\underline{s} = \begin{pmatrix}-4\\-7\end{pmatrix} + \begin{pmatrix}-3\\2\end{pmatrix}\underset{\uparrow -4\text{ sec}}{(-4)} = \begin{pmatrix}-4\\-7\end{pmatrix} + \begin{pmatrix}12\\-8\end{pmatrix} = \begin{pmatrix}8\\-15\end{pmatrix}.$$

At $t=2$, P is at $(8i - 15j)$ m.

Distance from origin $= \sqrt{8^2+15^2} = 17$ m

2. "$\longrightarrow$ positive v."

(a) Before $4u$ $\;-ku$ (P) (Q) m $\;3m$ After $-2u$ $\;\tfrac{1}{2}ku$ (P) (Q) m $\;3m$

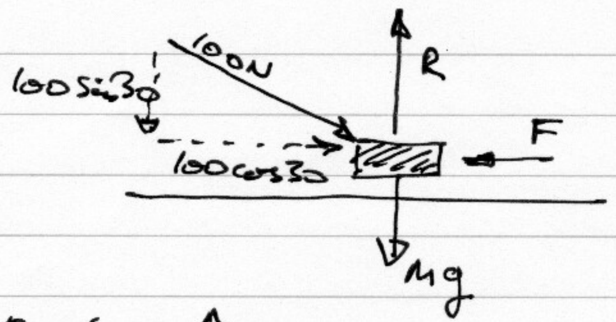
$m(4u) + 3m(-ku) = m(-2u) + 3m(\tfrac{1}{2}ku)$

$\div mu$: $4 - 3k = -2 + \tfrac{3}{2}k$

$6 = \tfrac{9}{2}k$, $k = 6 \times \tfrac{2}{9} = \tfrac{4}{3}$

(b) Impulse $Ft = mv - mu = m(-2u - 4u) = -6mu$, magnitude $6mu$ Ns.

3.



Constant speed $\therefore a = 0$

Resolve $\uparrow$:

$R - 100\sin 30 - mg = 0$, $R = 50 + mg$

Resolve $\rightarrow$

$100\cos 30 - F = 0$, sliding $\therefore F = F_{max} = \mu R = \tfrac{1}{2}(50 + mg)$

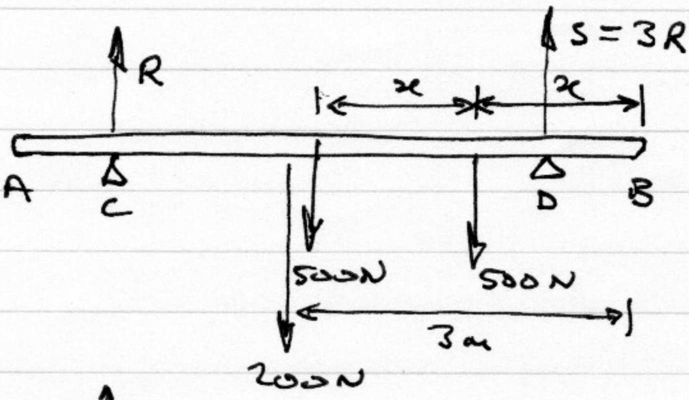
$100\cos 30 = \tfrac{1}{2}(50 + mg)$

$mg = 200\cos 30 - 50 = 123.2$N

$m = 123.2/9.8 = 12.57$ kg.

$= 12.6$ kg (3sf).

4.



Resolving ↑

$R + 3R = 200 + 500 + 500 = 1200\,N, \quad R = 300\,N$

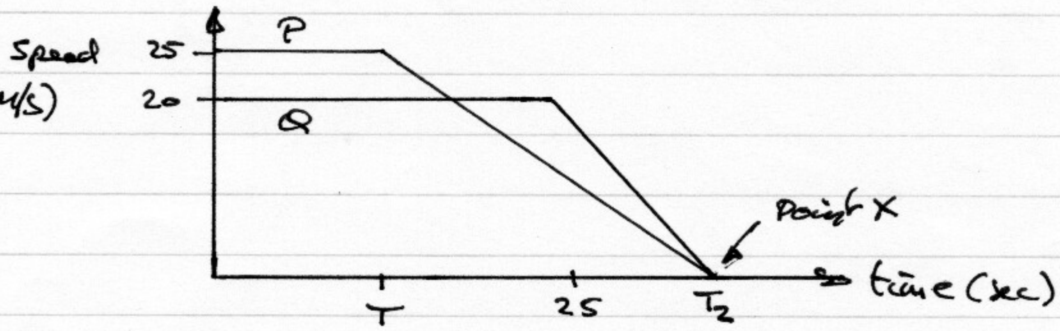
Moments ↺ about B : $S = 900\,N.$

$500x + 500(2x) + 200 \times 3 - 300 \times 5 - 900 \times 1 = 0$

$1500x = 900 + 1500 - 600 = 1800$

$\therefore x = \frac{1800}{1500} = 1.2\,m$, Tom is 1.2m from B.

5.
(a)



(b) Same area under each line (= 800 m).

Find T_2 first (Q) : $25 \times 20 + (T_2 - 25)\left(\frac{20+0}{2}\right) = 800$

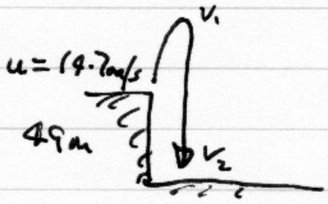
$T_2 - 25 = \frac{800 - 500}{10} = 30$

$\therefore T_2 = 55$ sec.

c Then for P : $T \times 25 + (55 - T)\left(\frac{25+0}{2}\right) = 800$

$25T(1 - 1/2) = 800 - 25 \times 55/2 = 112.5$

$T = 112.5/12.5 = 9$ sec.

6(a) 

At peak, $v_1 = 0$

$v_1^2 = u^2 + 2as$, $\quad 0 = 14.7^2 + 2(-9.8)s$

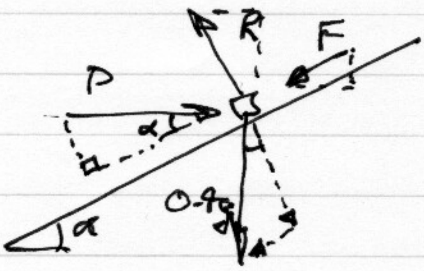
$\therefore s = 3.32m$

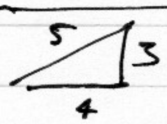
(b) when hits ground, $v_2^2 = u^2 + 2as$

$= 14.7^2 + 2(-9.8)(-49) = 1176,$

$v_2 = \pm 34.3\ m/s$, speed $34.3\,m/s$

(c) $v = u + at$, $t = \dfrac{v-u}{a} = \dfrac{-34.3 - 14.7}{-9.8} = 5$ sec.

7.(a) 



$\tan\alpha = 3/4$

$\sin\alpha = 3/5$

$\cos\alpha = 4/5$

<u>Resolve ↑</u>, (then P does not matter):

$R\cos\alpha - F\sin\alpha - 0.4g = 0$

<u>Limiting equilibrium</u>

$\therefore F = F_{max} = \mu R = \frac{1}{3}R$

$\therefore \frac{4}{5}R - \frac{1}{3} \times \frac{3}{5}R = 0.4g$

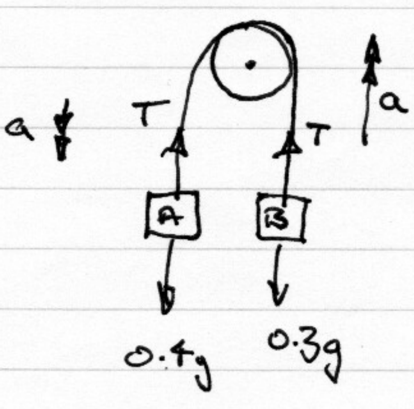
$= \frac{3}{5}R, \quad R = \frac{5}{3} \times 0.4g$

$R = 6.533\,N.$

(b) <u>Resolve →</u> $\quad P - R\sin\alpha - F\cos\alpha = 0$

$\therefore P = \frac{3}{5}R + \frac{1}{3} \times \frac{4}{5}R$

$P = 5.662\,N$

8.(a) 

<u>Motion of A</u> $\quad 0.4g - T = 0.4a$

<u>Motion of B</u> $\quad T - 0.3g = 0.3a$

×3

×4, $4T - 1.2g = 1.2a$ } subtract

$1.2g - 3T = 1.2a$

$7T - 2.4g = 0$

$T = \frac{2.4}{7}g = 3.36\,N$

8 (b) <u>For A</u> $0.4a = 0.4g - T$

$$a = g - \frac{T}{0.4} = g\left(1 - \frac{6}{7}\right) = \frac{1}{7}g = 1.4\,m/s^2$$

(c) B is moving upwards, need to know its height & speed.

$a = 1.4\,m/s^2$.

After 0.5 sec, $v = u + at = 0.7\,m/s$ upwards.

$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(1.4)\,0.5^2 = 0.175\,m$.

Then falls $1 + 0.175 = 1.175\,m$.

<u>Either</u> $s = ut + \frac{1}{2}at^2$, $\underbrace{1.175 = -0.7t + \frac{1}{2}(9.8)t^2}_{\text{same direction, downwards.}}$ upwards

$4.9t^2 - 0.7t - 1.175 = 0$

$t = \underline{0.5663}$ or -0.423 (formula)

<u>OR</u> $v^2 = u^2 + 2as = 0.7^2 + 2 \times 9.8 \times 1.175 = 23.52$,

$v = 4.85\,m/s$

$$t = \frac{v-u}{a} = \frac{4.85 - (-0.7)}{9.8} = 0.566 \text{ sec.}$$