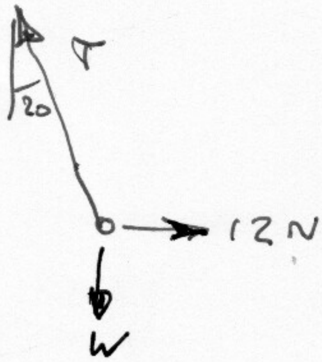
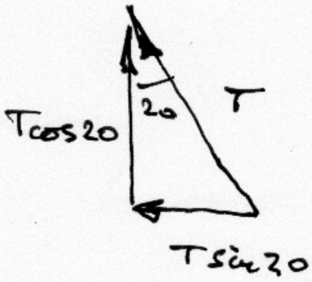
M1 June 2007

1.



Components of T:



Resolve vertically:

$T\cos 20 - W = 0$

Resolve horizontally

$T\sin 20 - 12 = 0$

$T = \dfrac{12}{\sin 20} = 35.09\text{N}$

$W = T\cos 20 = 32.97\text{N}$

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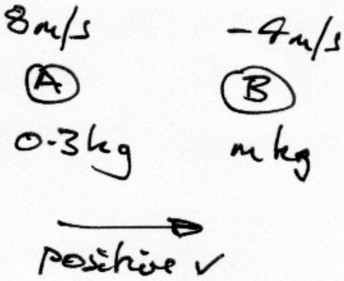
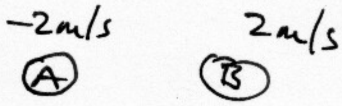
2. a)

Before



NB B at −4m/s since moving in opposite directions

After



Impulse = change of momentum of A (since we know its mass) $= m_a(v_a - u_a) = 0.3(-2-8) = -3\text{Ns}$ (on A) or $+3\text{Ns}$ on B. So magnitude (size, positive) $= 3\text{Ns}$

2 (b) For B, $I = m_b(v_b - u_b) = m(2-(-4))$
$= 6m$
and $I = 3$ Ns from before, so $m = 3/6 = \frac{1}{2}$ kg

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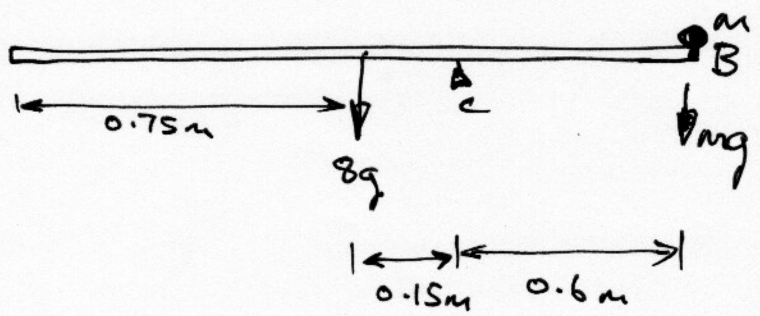
3. (a)



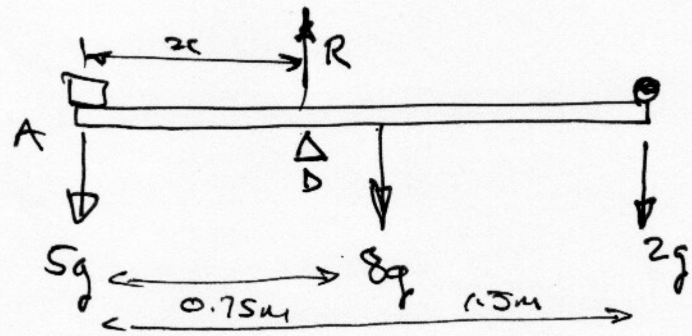
Moments about C:

$$0.6mg - 0.15(8g) = 0$$

$$mg = \frac{0.15 \times 8g}{0.6} = 2g.$$

$\therefore m = 2$ kg

(b) Draw it again:



(Clearly D is to the left of the centre if it balances)

Force balance:

$$5g + 8g + 2g - R = 0, \quad R = 15g$$

3(b+)

<u>Moments about A:</u>

$$1.5 \times 2g + 0.75 \times 8g - x(15g) = 0$$

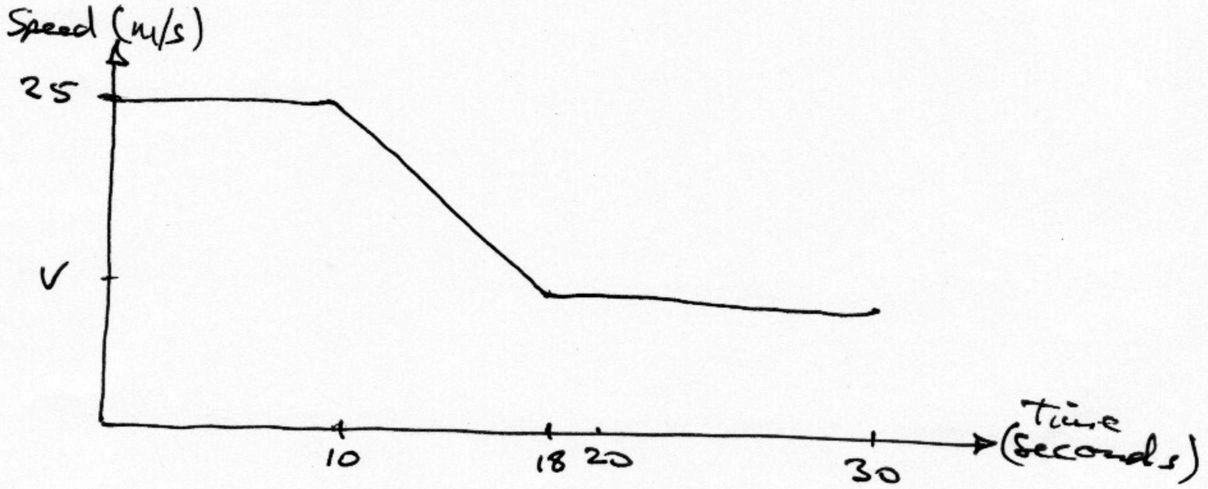
$$x = \frac{3+6}{15} = \frac{9}{15} = \frac{3}{5}\text{ m} = \text{distance } AD$$

Alternatively, could take moments about D:

$$-5gx + 8g(0.75-x) + 2g(1.5-x) = 0$$

& solve for x.

4. (a)



(b) Distance travelled $= 25 \times 10 + \left(\frac{25+V}{2}\right) \times 8 + V \times 12$

$$= 250 + 100 + 4V + 12V$$

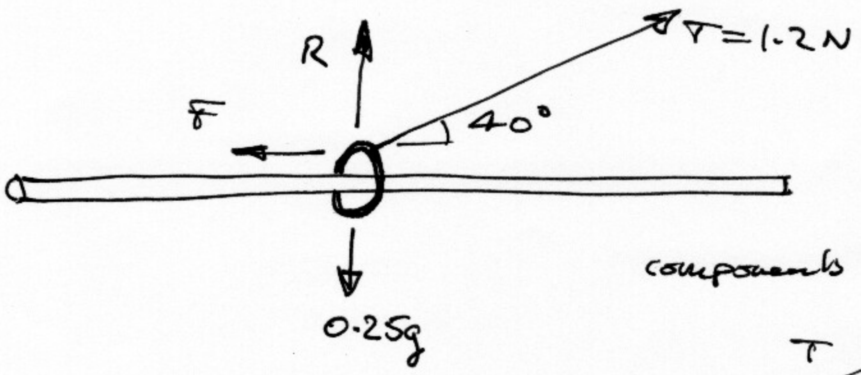
$$= 350 + 16V = 526\text{ m}$$

$$\therefore V = \frac{526-350}{16} = 11\text{ m/s}$$

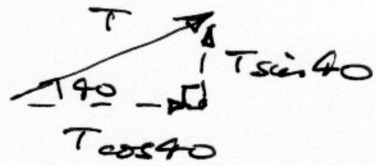
(c) Acceleration $= \frac{v-u}{t} = \frac{11-25}{8} = -1\frac{3}{4}\text{ m/s}^2$, so

<u>deceleration</u> $= 1\frac{3}{4}\text{ m/s}^2$

5(a)



components of T:



<u>Resolve vertically:</u>

$$R + T\sin 40 - 0.25g = 0$$

$$R = 0.25g - 1.2\sin 40 = 1.679\,N$$

(b) <u>Resolve horizontally:</u>

$$F - T\cos 40 = 0$$

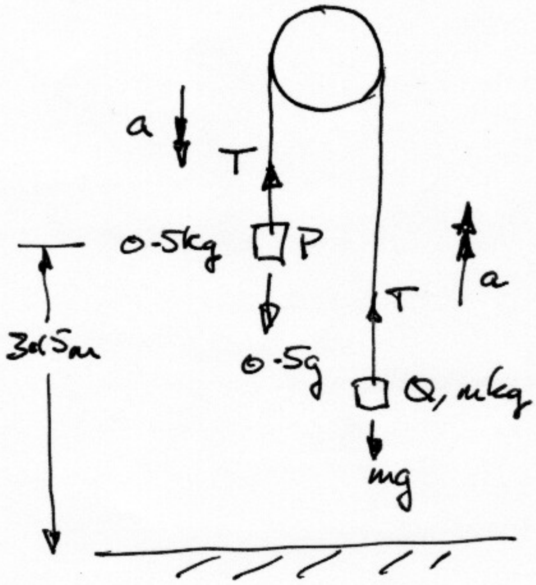
ma, since no acceleration

$$F = T\cos 40 = 1.2\cos 40 = 0.9193\,N$$

Then $\mu = F/R$ since in limiting equilibrium

$$= \frac{0.9193}{1.679} = 0.5476$$

6.



a) P descends 3.15m in 1.5 seconds from rest

$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}a(1.5^2) = 3.15m$

$\therefore \; a = 2.8 \, m/s^2$

b) Equation of motion for P ($F = ma$):

$0.5g - T = 0.5 \times 2.8$

$T = 3.5N$

c) Equation of motion ($F = ma$) for Q:

$T - mg = ma, \qquad T = m(g+a),$

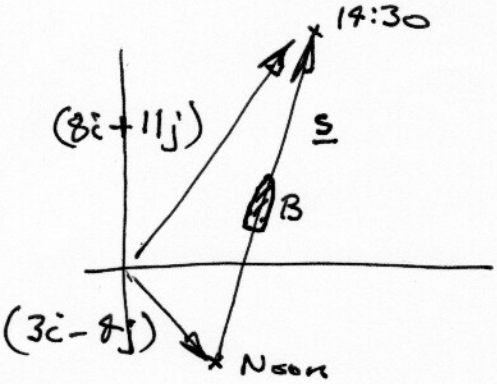
$m = \frac{T}{g+a} = \frac{5}{18} \, kg$

d) In part (c), the acceleration of Q is taken to be the same as the acceleration of P because the string is inextensible

e) After falling for 1.5s at $2.8 \, m/s^2$, P has speed $1.5 \times 2.8 = 4.2 \, m/s$. Q is then accelerating under gravity, from 4.2m/s upwards to 4.2m/s downwards

$t = \frac{2 \times 4.2}{9.8} = \frac{6}{7}$ second.

7. (a)



$(3i - 4j) + \underline{s} = (8i + 11j)$

$\therefore \underline{s} = (8-3)i + (11-(-4))\underline{j} = 5\underline{i} + 15\underline{j}$ km

= motion of B over $2\frac{1}{2}$ hours

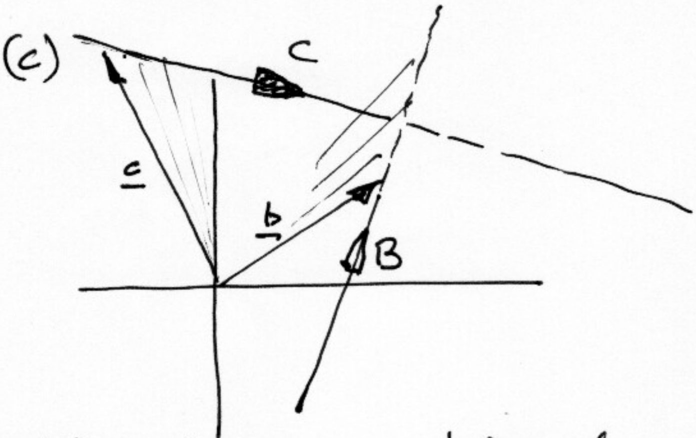
$\therefore$ Velocity of B $= \dfrac{s}{2\frac{1}{2}} = 0.4s = (2\underline{i} + 6\underline{j})$ km/hour

(b) $\underline{b}$ = (initial position) + (velocity × time)

$= ((3\underline{i} - 4\underline{j}) + (2\underline{i} + 6\underline{j})t)$ km

or $= ((3+2t)\underline{i} + (-4+6t)\underline{j})$ km

(c)



When $\underline{b} = \underline{c}$, $\underline{b}$ & $\underline{c}$ have same i components:

$3 + 2t = -9 + 6t \Rightarrow 12 = 4t$, $t = 3$ hours

and same j-components: $-4 + 6t = 20 + \lambda t$,

$-4 + 18 = 20 + 3\lambda$, $-6 = 3\lambda$, $\lambda = -2$

(d) $\left.\begin{array}{l} \text{Speed of B} = \sqrt{2^2 + 6^2} = \sqrt{40} \text{ km/hour} \\ \text{Speed of C} = \sqrt{6^2 + (-2)^2} = \sqrt{40} \text{ km/hour} \end{array}\right\}$ same.