$\Sigma F = ma$ & SUVAT

Connected particles
String breaking / becoming slack } Situation changes

M1 June 2005 Q7 ✓
M1 June 2006 Q6 ✓
M1 Jan 2007 Q7 ✓
M1 June 2007 Q6 ✓
M1 Jan 2008 Q7 ✓

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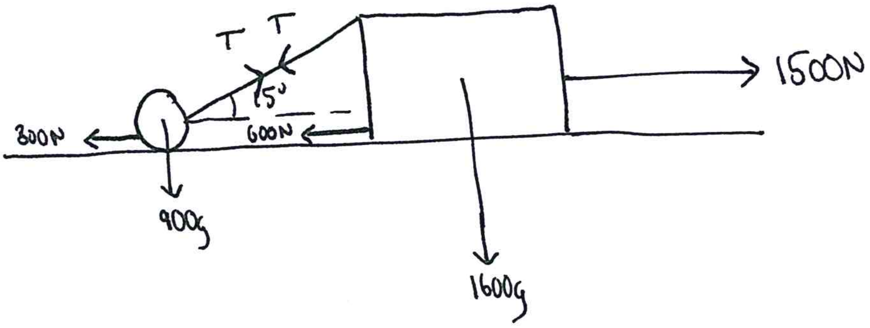
Extra questions you can have a go at.

M1 Jan 2010 Q6
M1 June 2010 Q8
M1 Jan 2011 Q7
M1 June 2011 Q6
M1 Jan 2012 Q8
M1 Jan 2013 Q7
M1 June 2017 Q8
M1 June 2014 Q7 *
M1 June 2015 Q8 IAL
M1 June 2014 Q7 IAL
M1 June 2014 Q5 (R)
M1 Jan 2017 Q7 IAL
M1 Jan 2016 Q7 IAL
M1 Jan 2015 Q8 IAL

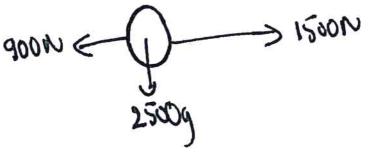
M1 June 2005 Q1



a) Acceleration of lorry & car re of system ∴ consider whole system.

In considering the entire system 'T' becomes an internal force and in $\Sigma F = ma$ we consider <u>external forces</u>.

Consider system



$\Sigma F_{\rightarrow} = ma \Rightarrow 1500 - 900 = 2500a$

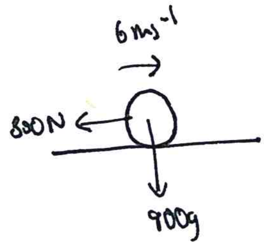
$a = \frac{600}{2500} = 0.24\ ms^{-2}$

b) Consider car (less forces to deal with): $\Sigma F_{\rightarrow} = ma \Rightarrow T\cos 15 - 300 = 900(0.24)$

$T = \frac{516}{\cos 15} = 534.2$

$\approx 534N$ (3sf)

c) New system → new diagram:



$\Sigma F_{\rightarrow} = ma \therefore -300 = 900a$

$a = -\frac{1}{3}\ ms^{-2}$

d) $\left.\begin{array}{l} s \\ u = 6 \\ v = 0 \\ a = -\frac{1}{3} \\ t \end{array}\right\}$ $\frac{v^2 - u^2}{2a} = s \therefore \frac{(0)^2 - (6)^2}{2 \times -\frac{1}{3}} = 54m$

e) Normal reaction will increase as vertical component of tension is gone.

Before : (↑) $R + T\sin 15 = 900g \Rightarrow R = 900g - T\sin 15$

After : (↑) $R = 900g \Rightarrow R = 900g$

$\Big\}$ $900g > 900g - T\sin 15$ since $T > 0$

M1 June 2006 Q6

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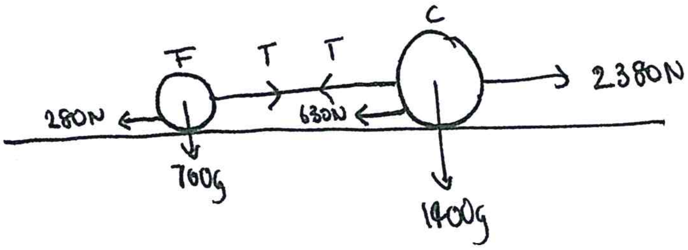
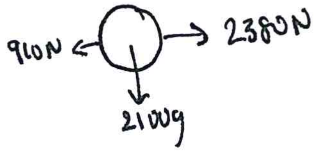
(Pulling' ∴ tension in wire (not a push → thrust).



a) Consider whole system : $\sum F_{\rightarrow} = ma$.



$$2380 - 910 = 2100a$$

$$a = \frac{2380-910}{2100} = 0.7\,ms^{-2}$$

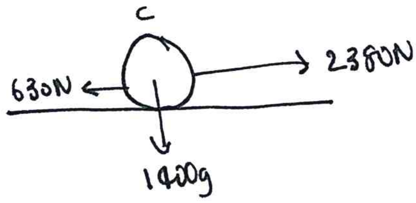
b) Consider trailer (F) because less forces to consider!

$$\sum F_{\rightarrow} = ma$$

$$T - 280 = 700(0.7)$$

$$T = 770N$$

c) New system → New diagram



$$\sum F_{\rightarrow} = ma$$

$$2380 - 630 = 1400a$$

$$a = \frac{2380-630}{1400}$$

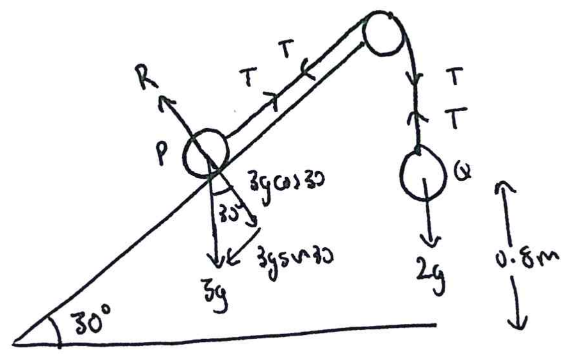
$$= 1.25\,ms^{-2}$$

$s =$
$u = 12$
$v =$
$a = 1.25$
$t = 4$

$\Big\}$ $s = ut + \frac{1}{2}at^2$ ∴ $s = (12 \times 4) + (\frac{1}{2} \times 1.25 \times 16)$

$= 58m.$

d) Magnitude of acceleration same for trailer as car.



a) Eq of motion for P: $\Sigma F_{\nearrow} = ma$ $\therefore$ $T - 3g\sin 30 = 3a$ ①

Q: $\Sigma F_{\downarrow} = ma$ $\therefore$ $2g - T = 2a$ ②

b) ① + ② $\Rightarrow$ $3g\sin 30 + 2g = 5a$ $\Rightarrow$ $a = \dfrac{3g\sin 30 + 2g}{5}$ $\quad \sin 30 = \frac{1}{2}$

$= 0.98\ \text{ms}^{-2}$

c) Hence $T = 2g - 2a$ from ①

$= (2\times 9.8) - 2(0.98)$

$= 18\text{N}$ (2sf)

d) The magnitudes of the accelerations of P & Q are equal. ie $|a_P| = |a_Q|$

e) $\left.\begin{array}{l} s = 0.8 \\ u = 0 \\ v = \\ a = 0.98 \\ t \end{array}\right\}$ $v^2 = u^2 + 2as$ $\Rightarrow$ $v = \sqrt{0 + 2\times 0.98\times 0.8} = 1.3\text{ms}^{-1}$ (2sf)

f) New situation (system) for P as string no longer taut!

$\Sigma F_{\nearrow} = ma$ $\Rightarrow$ $-\cancel{3}g\sin 30 = \cancel{3}a$

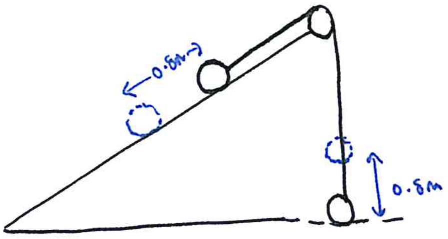
$a = -\dfrac{g}{2}$

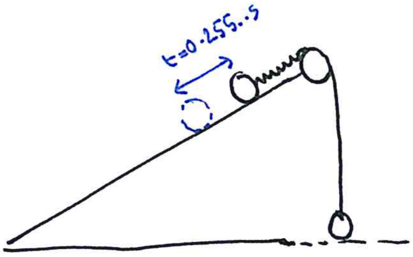
Distance travelled before P reaches 0 velocity!

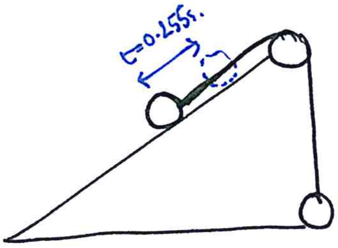
$\left.\begin{array}{l} s \\ u = 1.3 \\ v = 0 \\ a = -g/2 \\ t \end{array}\right\}$ $v = u + at$ $\Rightarrow$ $\dfrac{0 - 1.3\ldots}{-\frac{g}{2}} = t$

$= 0.255\ldots\text{ s}$

$\therefore$ time for string to become taut again $T = 0.255 \times 2 = 0.51\text{s}$ (2sf) vertical motion marksphysicshelp







By symmetry the time taken from the moment the string is no longer taut (ie when Q hits the ground) to the moment the ~~~~ particle comes to rest is the same the amount of time for the particle to turn around and move back to ~~the~~ position where the string lost its 'tautness'

This is because the magnitude of its acceleration up the plane is equal to the magnitude of its acceleration down the plane (once the string has lost its tautness and the particle moves freely under gravity).

↳ It is just like a projectiles question:

If a ball is thrown vertically in the air and hits the ~~floor~~ ground again after 5s, how long does it take the ball to reach its maximum height (assuming the ball is thrown from the ground)?

It is 2.5s of course

Alternatively, I could ask what is the total time of flight if time taken to reach max height is 2.5s? 5s obviously.

2.5s to go up. 2.5s to go down.

M1 June 2007 Q6

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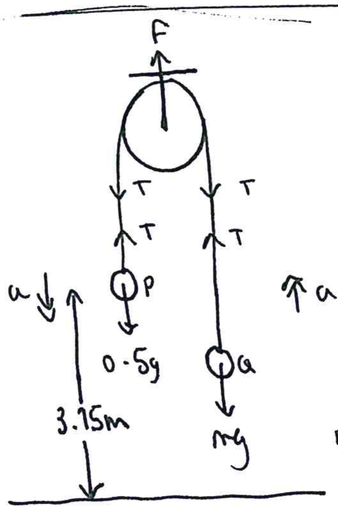


P takes 1.5s to hit ground.

$m < 0.5$

Motion of P: $\Sigma F_{\downarrow} = ma$

$0.5g - T = 0.5a$ ①

Q: $\Sigma F_{\uparrow} = ma$

$T - mg = ma$ ②

acceleration of P: $s = 3.15$, $u = 0$, $v =$, $a = a$, $t = 1.5s$ $\Big\}$ $s = ut + \frac{1}{2}at^2 \Rightarrow 3.15 = 0 + \frac{1}{2}a(1.5^2)$

$\frac{2 \times 3.15}{(1.5)^2} = a = 2.8 \, ms^{-2}$

) from ①

$T = 0.5g - 0.5a$

$= 0.5(9.8 - 2.8)$

$= 3.5N$

) from ②

$\frac{T}{g + a} = m \Rightarrow \frac{3.5}{9.8 + 2.8} = \frac{5}{18}$ as required.

) Magnitudes of accelerations of P and Q the same.

) final velocity of P = final velocity of Q: $s =$, $u = 0$, $v =$, $a = 2.8$, $t = 1.5$ $\Big\}$ $v = u + at$

$v = 0 + 2.8 \times 1.5 = 4.2 \, ms^{-1}$

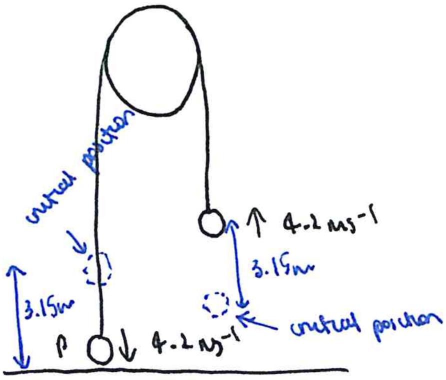
ow Q acts as a free particle after string becomes slack:

$u = 4.2$, $v = 0$, $a = a$, $t =$ $\Rightarrow$ Find a: $\Sigma F_{\uparrow} = ma$. $-\cancel{m}g = \cancel{m}a \Rightarrow a = -g$

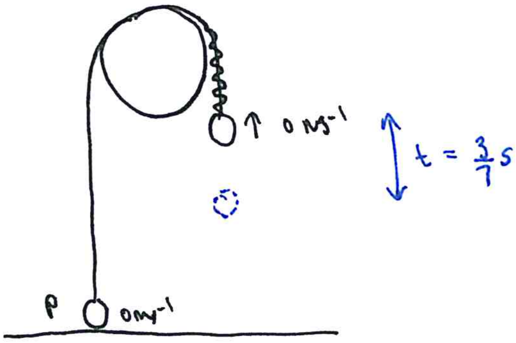
$v = u + at \Rightarrow 0 = 4.2 - gt \Rightarrow t = \frac{3}{7} = t_{\frac{1}{2}}$

total time $t_{total} = \left(\frac{3}{7} \times 2\right) = \frac{6}{7}s = 0.86s$ (2sf)

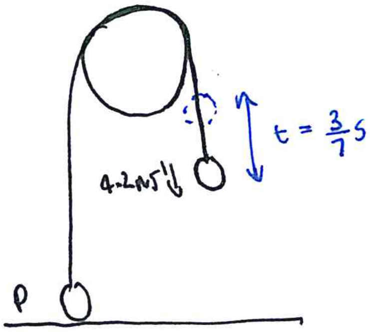
$(t_{\frac{1}{2}} \times 2)$



instant P hits ground



~~ost~~ as Q comes to rest



M1 Jan 2008 Q7

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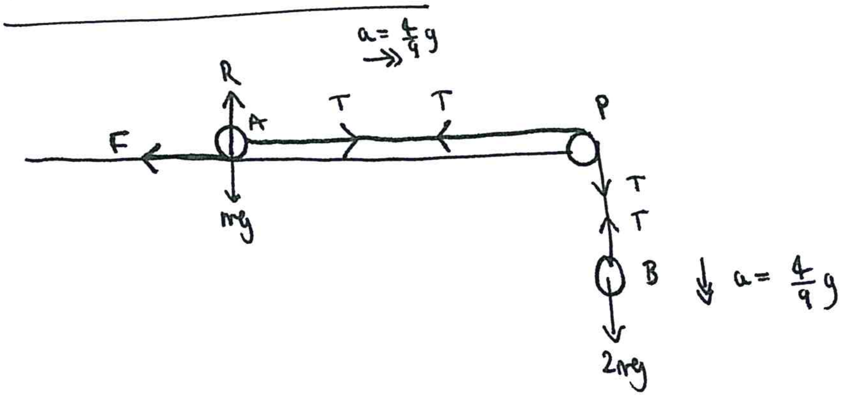


Consider motion of A: $\Sigma F_{\rightarrow} = ma$ $\therefore$ $T - F = ma$ ①

vector sum of the forces in the direction of motion

B: $\Sigma F_{\downarrow} = ma$ $\therefore$ $2mg - T = 2ma$ ②

$T = 2mg - 2m\left(\frac{4}{9}g\right)$

$= \frac{10}{9}mg.$

a) from ① : $T - F = ma$ $F = F_{max}$ in motion so $F = \mu R$; $R = mg$

$F = \mu mg$

$\frac{10}{9}\cancel{m}\cancel{g} - \mu\cancel{m}\cancel{g} = \cancel{m}\frac{4}{9}\cancel{g}$

$\frac{10}{9} - \mu = \frac{4}{9}$

$\mu = \frac{6}{9} = \frac{2}{3}$ as required.

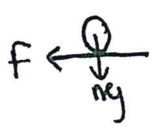
) Speed after a distance 'h'.

$s = h$
$u = 0$
$v =$
$a = \frac{4}{9}g$
t

$v^2 = u^2 + 2as \Rightarrow v^2 = 0 + 2\left(\frac{4}{9}g\right)h = \frac{8}{9}gh$ $\left(v = \sqrt{\frac{8}{9}gh} = \frac{\sqrt{8}}{3}gh\right)$

Speed as it hits 'P' (a distance $\frac{1}{3}h$ away)

$s = \frac{1}{3}h$
$u = \sqrt{\frac{8}{9}gh}$
$v =$
$a = a$ $\Rightarrow$
$t =$



$\Sigma F_{\rightarrow} = ma \Rightarrow -F = ma \Rightarrow -\mu\cancel{m}g = \cancel{m}a$

$-\frac{2}{3}g = a$

$v^2 = u^2 + 2as \Rightarrow v^2 = \frac{8}{9}gh + 2\left(-\frac{2}{3}g\right)\left(\frac{1}{3}h\right) = \frac{8}{9}gh - \frac{4}{9}gh = \frac{4}{9}gh$

$v = \frac{2}{3}\sqrt{gh}$

d) Magnitude of tension at/on A = magnitude of tension at/on B.

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M1 June 2017 Q8

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M1 June 2014 Q7 *

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M1 June 2015 Q8 IAL

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M1 June 2014 Q1 IAL   markphysicshelp

M1 June 2014 Q5 (R) markphysicshelp

M1 Jan 2017 Q7 IAL

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