07 May 2011
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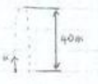
M1 November 03 Model Solutions

1 a)



$\downarrow a = 9.8$

$u = u$
$v = 0$
$a = -9.8$
$s = 40$
$t = \text{—}$

$v^2 = u^2 + 2as$
$0 = u^2 + 2 \times -9.8 \times 40$
$\Rightarrow u^2 = 784$
$u = \underline{28\ ms^{-1}}$

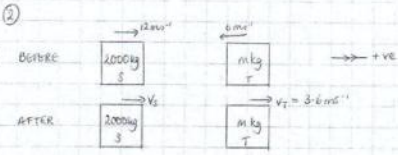
b) From start to finish:

$u = 28$
$v = \text{—}$
$a = -9.8$
$s = 0$
$t = t$

$s = ut + \frac{1}{2}at^2$
$0 = 28t - 4.9t^2$
$t(4.9t - 28) = 0$
$t = 0$ (at start) or $t = \frac{28}{4.9} = \underline{5.71\ s}$ (at finish)

2

a)



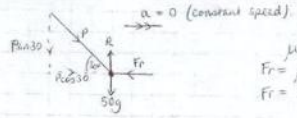
Impulse of T on S is in negative direction:
$I = 2000v_S - 2000 \times 12 = -28{,}800$
$2000v_S - 24{,}000 = -28{,}800$
$2000v_S = -4800$
$v_S = -2.4\ ms^{-1}$

Speed of $S = \underline{2.4\ ms^{-1}}$.

b) Direction of S is <u>WEST</u>.

c) Conservation of momentum: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
$\Rightarrow 2000 \times 12 - 6m = -2.4 \times 2000 + 3.6m$
$\Rightarrow 24000 - 6m = 3.6m - 4800$
$\Rightarrow 28800 = 9.6m$
$\Rightarrow \underline{m = 3000\ kg}$

3



$\mu = \frac{3}{5}$
$Fr = \mu R$
$Fr = \frac{3}{5}R$

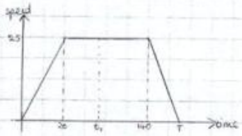
Vertically: $R = P\sin 30 + 50g$

$Fr = \frac{3}{5}R = \frac{3}{5}(P\sin 30 + 50g)$
$\therefore Fr = \frac{3P}{10} + 30g$ — ①

Horizontally: $RF = ma$
$P\cos 30 - Fr = 50 \times 0$
$\Rightarrow P\cos 30 = Fr$ — ②

Let ① = ②: $P\cos 30 = \frac{3P}{10} + 30g$
$(\times 10)$ $10P\cos 30 = 3P + 300g$
$P(10\cos 30 - 3) = 300g$
$P = \frac{300g}{10\cos 30 - 3} = 519.4 \approx \underline{519\ N}$

4 a)



b) Distance = area under graph $= 4$ km.

$\frac{1}{2} \times 25 \times (T + 120) = 4000$
$T + 120 = 320$
$\underline{T = 200\ s}$

c) When the car has travelled 1.5 km (point t_1 on the graph):
$\frac{1}{2}(25)(t_1 + (t_1 - 20)) = \frac{1}{2} \times 25 \times (2t_1 - 20) = 1500$
$\Rightarrow 2t_1 - 20 = 120$
$t_1 = 70s$.

The motorbike set of 10s later so has been travelling $70 - 10 = \underline{60s}$

d)
$u = 0$
$v = v$
$a = \text{—}$
$s = 1500$
$t = 60$

$s = \left(\frac{u+v}{2}\right)t$
$1500 = \left(\frac{0+v}{2}\right) \times 60$
$25 = \frac{v}{2} \Rightarrow v = \underline{50\ ms^{-1}}$

5

a)
$\underset{\sim}{u} = 3\underset{\sim}{i} - 5\underset{\sim}{j}$
$\underset{\sim}{v} = -5\underset{\sim}{i} + 11\underset{\sim}{j}$
$\underset{\sim}{a} = \underset{\sim}{a}$
$\underset{\sim}{s} = \text{—}$
$t = 4$

$\underset{\sim}{v} = \underset{\sim}{u} + \underset{\sim}{a}t$
$\Rightarrow \underset{\sim}{a} = \frac{\underset{\sim}{v} - \underset{\sim}{u}}{t}$
$= \frac{(-5\underset{\sim}{i} + 11\underset{\sim}{j}) - (3\underset{\sim}{i} - 5\underset{\sim}{j})}{4}$
$= \frac{-8\underset{\sim}{i} + 16\underset{\sim}{j}}{4} = \underline{-2\underset{\sim}{i} + 4\underset{\sim}{j}\ ms^{-2}}$

b) $\underset{\sim}{F} = m\underset{\sim}{a}$
$= 3 \times (-2\underset{\sim}{i} + 4\underset{\sim}{j}) = \underline{-6\underset{\sim}{i} + 12\underset{\sim}{j}\ N}$

$|\underset{\sim}{F}| = \sqrt{6^2 + 12^2} = \sqrt{180} = \underline{13.4\ N}$

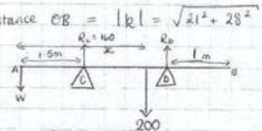
c) When $t = 6$, what is $\underset{\sim}{v}$?
$\underset{\sim}{v} = (3\underset{\sim}{i} - 5\underset{\sim}{j}) + (-2\underset{\sim}{i} + 4\underset{\sim}{j}) \times 6$
$= -9\underset{\sim}{i} + 19\underset{\sim}{j}$

3s after F is removed: displacement = velocity × time
$= (-9\underset{\sim}{i} + 19\underset{\sim}{j}) \times 3$
$= -27\underset{\sim}{i} + 57\underset{\sim}{j}$

Position vector of P at this point $= (6\underset{\sim}{i} - 29\underset{\sim}{j}) + (-27\underset{\sim}{i} + 57\underset{\sim}{j})$
$\underset{\sim}{b} = -21\underset{\sim}{i} + 28\underset{\sim}{j}$

Distance $OB = |\underset{\sim}{b}| = \sqrt{21^2 + 28^2} = \underline{35\ m}$

6

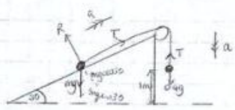


a) $M(D)$: $200(4 - x) + W \times 4 = 160 \times 2.5$
$800 - 200x + 4W = 400$
$200x - 4W = 400$
$\underline{50x - W = 100}$ QED

b) W moved to B: $(R_C = 50)$ $M(D)$: $200(4 - x) = 50 \times 2.5 + W \times 1$
$800 - 200x = 125 + W$
$\underline{200x + W = 675}$

c) $50x - W = 100 \Rightarrow W = 50x - 100$
$200x + W = 675 \Rightarrow 200x + 50x - 100 = 675$
$\Rightarrow x = \frac{775}{250} = \underline{3.1m}$
$W = 50x - 100 = \underline{55N}$

7



a) $a = \frac{1}{5}g$ $\quad RF = ma \Rightarrow 0.4g - T = 0.4a$
$\Rightarrow 0.4g - T = 0.4 \times \frac{1}{5}g$
$\Rightarrow \underline{0.4g - T = 0.08g}$

b) $T = 0.4g - 0.08g = 0.32g = \underline{3.136\ N}$

c) Ⓐ: $T - mg\sin 30 = m \times \frac{1}{5}g = \frac{mg}{5}$
$3.136 - mg\sin 30 = \frac{mg}{5}$
$\Rightarrow 3.136 = m(g\sin 30 + \frac{g}{5})$
$\Rightarrow m = \frac{3.136}{g\sin 30 + \frac{g}{5}} = \underline{\frac{16}{35}}$ QED

d) No friction on the pulley.
Tension is equal throughout the string.

e)
$u = 0$
$v = v$
$a = \frac{1}{5}g$
$s = 1$
$t = \text{—}$

$v^2 = u^2 + 2as$
$= 0^2 + 2 \times \frac{1}{5}g \times 1$
$= \frac{2}{5}g$
$\Rightarrow v = \underline{1.98\ ms^{-1}}$

f) Tension is removed after 1m of movement.
To calculate the new acceleration: $-mg\sin 30 = ma$ $(m = \frac{16}{35})$
$a = -\frac{1}{2}g$

How far until particle A comes to rest?
$u = 1.98$
$v = 0$
$a = -\frac{1}{2}g$
$s = s$
$t = \text{—}$

$v^2 = u^2 + 2as$
$0 = 1.98^2 + 2 \times -\frac{1}{2}g\,s$
$\Rightarrow gs = 1.98^2$
$\Rightarrow s = \frac{1.98^2}{g} = \frac{2}{5} = 0.4\ m.$

So after a further 0.4m A comes to rest. This is at the pulley, 1.4m from the starting position.