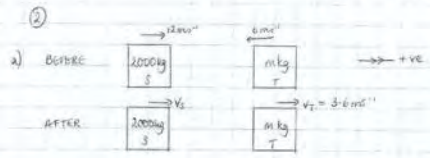


07 May 2011
22:33

11 November 03 Model Solutions

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

b) From start to finish:
 $u = 28$
 $v = 0$
 $a = -9.8$
 $s = 0$
 $t = t$
 $s = ut + \frac{1}{2}at^2$
 $0 = 28t - 4.9t^2$
 $t(28 - 4.9t) = 0$
 $t = 0$ or $t = \frac{28}{4.9} = 5.71 \text{ s}$
 at start at finish



Impulse of T on S is in negative direction:
 $I = 2000v_2 - 2000 \times 20 = -28800$
 $2000v_2 - 24000 = -28800$
 $2000v_2 = -4800$
 $v_2 = -2.4 \text{ ms}^{-1}$

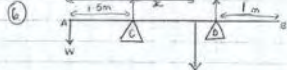
Speed of S is 2.4 ms^{-1}
 Direction of S is WEST.
 Conservation of momentum: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
 $\Rightarrow 2000 \times 20 - 6m = -24 \times 2000 + 3.6m$
 $\Rightarrow 24000 - 6m = 3.6m - 48000$
 $\Rightarrow 28800 = 9.6m$
 $\Rightarrow m = 3000 \text{ kg}$

5) a) $u = 3i - 5j$
 $v = -5i - 11j$
 $a = 0$
 $t = t$
 $x = ut + \frac{1}{2}at^2$
 $y = ut + \frac{1}{2}at^2$
 $\Rightarrow R = \frac{x - y}{t}$
 $= \frac{(-5t + 11t) - (3t - 5t)}{t}$
 $= \frac{-8t + 16t}{t} = -2i + 4j \text{ ms}^{-2}$

b) $F = ma$
 $= 3 \times (-2i + 4j) = -6i + 12j \text{ N}$
 $|F| = \sqrt{6^2 + 12^2} = \sqrt{180} = 13.4 \text{ N}$

c) When $t = 6$, what is x ?
 $x = (3i - 5j) + (-2i + 4j) \times 6$
 $= -9i + 19j$
 3s after F is removed: displacement = velocity \times time
 $= (-9i + 19j) \times 3$
 $= -27i + 57j$
 Position vector of P at this point = $(6i - 29j) + (-27i + 57j)$
 $k = -21i + 28j$

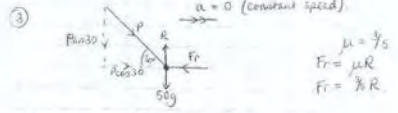
Distance OB = $|k| = \sqrt{21^2 + 28^2} = 35 \text{ m}$



a) M(A): $\hookrightarrow 200(4-x) + W \times 4 = 160 \times 2.5$
 $800 - 200x + 4W = 400$
 $200x - 4W = 400$
 $50x - W = 100$ QED

b) W moved to B: M(A) $\hookrightarrow 200(4-x) = 50 \times 2.5 + W \times 1$
 $800 - 200x = 125 + W$
 $200x + W = 675$

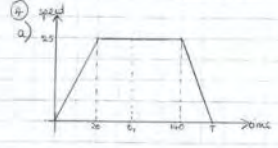
c) $50x - W = 100 \Rightarrow W = 50x - 100$
 $200x + W = 675 \Rightarrow 200x + 50x - 100 = 675$
 $\Rightarrow x = \frac{775}{250} = 3.1 \text{ m}$
 $W = 50 \times 3.1 - 100 = 55 \text{ N}$



Vertically: $R = P \sin 30 + 50g$
 $Fr = \frac{1}{2}R = \frac{1}{2}(P \sin 30 + 50g)$
 $\therefore Fr = \frac{3P}{4} + 30g$ — (1)

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

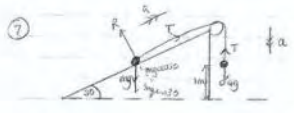
Let (1) = (2) $P \cos 30 = \frac{3P}{4} + 30g$
 $(\times 4) \quad 10P \cos 30 = 3P + 300g$
 $P(10 \cos 30 - 3) = 300g$
 $P = \frac{300g}{10 \cos 30 - 3} = 519.4 \approx 519 \text{ N}$



b) Distance = area under graph = 4 km.
 $\frac{1}{2} \times 25 \times (t + 120) = 4000$
 $t + 120 = 320$
 $t = 200 \text{ s}$

c) When the car has travelled 1.5 km (point t₁ on the graph):
 $\frac{1}{2} \times 25 \times (t_1 + (t_1 - 20)) = 1500$
 $\Rightarrow 2t_1 - 20 = 120$
 $t_1 = 70 \text{ s}$
 The motorbike set of 10s later so has been travelling $70 - 10 = 60 \text{ s}$

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



a) $a = \frac{1}{2}g$ $RF = ma \Rightarrow 0.4g - T = 0.4a$
 $0.4g - T = 0.4 \times \frac{1}{2}g$
 $\Rightarrow 0.4g - T = 0.2g$

b) $T = 0.4g - 0.2g = 0.2g = 3.136 \text{ N}$

c) (A): $T - mg \sin 30 = m \times \frac{1}{2}g$
 $3.136 - mg \sin 30 = \frac{m}{2}g$
 $\Rightarrow 3.136 = m(g \sin 30 + \frac{1}{2}g)$
 $\Rightarrow m = \frac{3.136}{g \sin 30 + \frac{1}{2}g} = \frac{3.136}{\frac{3}{4}g} = 4.18 \text{ kg}$ QED

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

e) $u = 0$ $v^2 = u^2 + 2as$
 $v = v$ $= 0^2 + 2 \times \frac{1}{2}g \times 1$
 $a = \frac{1}{2}g$ $= \frac{1}{2}g$
 $s = 1 \Rightarrow v = 1.98 \text{ ms}^{-1}$
 $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1}{\frac{1}{2}g}} = 0.4 \text{ s}$

f) Tension is removed after 1m of movement. To calculate the new acceleration: $-mg \sin 30 = ma$
 $(m = \frac{1}{2}g)$ $a = -\frac{1}{2}g$
 How far until particle A comes to rest?
 $u = 1.98$
 $v = 0$ $v^2 = u^2 + 2as$
 $a = -\frac{1}{2}g$ $0 = 1.98^2 + 2 \times -\frac{1}{2}g \times s$
 $s = s$ $\Rightarrow 9s = 1.98^2$
 $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times \frac{1.98^2}{g}}{-\frac{1}{2}g}} = \frac{1.98}{g} = \frac{1}{2} = 0.4 \text{ s}$

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