



07 May 2011  
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1) 1 JUNE 03 Model Solutions

①   $R_A = R_C = R$

a)  $R + R = 80g + 40g \Rightarrow 2R = 120g \Rightarrow R = 60gN$

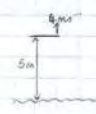
b)  $M(A): \begin{cases} R \times 3 = 80g \times x + 40g \times 2 \\ 180g = 80g + 80g \times x \\ \frac{100}{80} = x \Rightarrow x = 1.25m \end{cases}$

② 

a)  $I = mv - mu = 0.12 \times 3 - 0.12 \times 0 = 0.36 \text{ Ns}$

b)  $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$   
 $0.12 \times 3 + 0.08 \times 0 = 0.12 \times 1.2 + 0.08v$   
 $0.36 = 0.144 + 0.08v$   
 $\Rightarrow v = 2.7 \text{ ms}^{-1}$

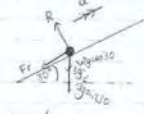
c) Take  $\rightarrow$  to be positive:  
 $I = mv - mu = 1.2 \times 0.12 - 3 \times 0.12 = -0.216 \text{ Ns}$  Impulse is  $0.216 \text{ Ns}$

③ 

a)  $u = -4$   
 $v = v$   
 $a = 9.8$   
 $s = +5$   
 $t = \dots \Rightarrow v = 10.7 \text{ ms}^{-1}$

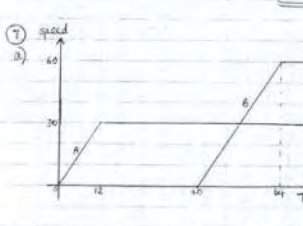
b)  $s = ut + \frac{1}{2}at^2 \Rightarrow 5 = -4t + \frac{1}{2} \times 9.8t^2$   
 $\Rightarrow 4.9t^2 - 4t - 5 = 0$   
 $\Rightarrow t = \frac{4 \pm \sqrt{16 + 4 \times 4.9 \times 5}}{2 \times 4.9} = \frac{4 + 11.4}{9.8} = 1.50 \text{ s}$

c) We have ignored air resistance, the size of the diver, the horizontal component of velocity, spinning in the air, hitting the board on the way down.

③ 

a)  $\mu = 0.4$   
 $F_r = 0.4R$   
 $R = 3g \cos 30^\circ \therefore F_r = 1.2g \cos 30^\circ = 10.2 \text{ N}$

b)  $u = 6$   
 $v = 0$   
 $a = a$   
 $s = 3$   
 $t = \dots$   
 $v^2 = u^2 + 2as \Rightarrow 0 = 36 + 2 \times -8.24 \times 3$   
 $\Rightarrow 16.6s = 36$   
 $\Rightarrow s = 2.17 \text{ m}$


④ 

a) At T, both travelled same distance,  $\therefore$  area under graphs is equal.

$(A) = \frac{1}{2} \times 30 \times (T + (T-12)) = 15(T+T-12) = 30T - 180$

$(B) = \frac{1}{2} \times 60 \times ((T-40) + (T-64)) = 30(2T-104) = 60T - 3120$

Since  $(A) = (B)$ ,  $30T - 180 = 60T - 3120$   
 $2940 = 30T$   
 $\Rightarrow T = 98 \text{ s}$

④ 


$x = \tan^{-1}(1/4) \Rightarrow \cos x = 4/5$   
 $\sin x = 3/5$   
 $F_r = \mu R$

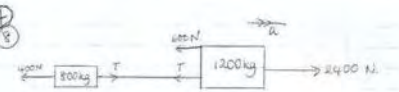
$R = 5g \cos x + 20 \sin x = 4g + 12$   
 $F_r = \mu R = \mu(4g + 12)$

$F_r + 20 \cos x = 5g \sin x$   
 $\mu(4g + 12) + 20 \cos x = 5g \sin x$   
 $\mu = \frac{5g \sin x - 20 \cos x}{4g + 12} = \frac{3g - 16}{4g + 12} = \frac{67}{256} \approx 0.262$

⑤ a)  $\vec{r} = 2\hat{i} - 3\hat{j}$   
 $\vec{u} = -2\hat{i} + 7\hat{j}$   
 $\vec{v} = \vec{u} + \vec{a}t$   
 $\vec{v} = -2\hat{i} - 3\hat{j} + (-2\hat{i} + 7\hat{j})t$   
 $\vec{v} = (-2 + 2t)\hat{i} + (7 - 3t)\hat{j}$   
 Parallel to  $\vec{u}$  means  $\hat{j}$  component = 0:  
 $7 - 3t = 0 \Rightarrow t = 7/3 \text{ s}$

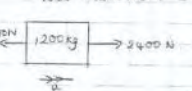
b)  $t = 3$ ,  $\vec{v} = (-2 + 2 \times 3)\hat{i} + (7 - 3 \times 3)\hat{j}$   
 $\text{Speed} = |\vec{v}| = \sqrt{4^2 + 2^2} = \sqrt{20} \approx 4.47 \text{ ms}^{-1}$

c)  $t = 3$ :   
 $\alpha = \tan^{-1}(1/4)$   
 $\text{Angle} = 40^\circ + \alpha = 116.6^\circ$

④ 

a)  $RF = ma$  Truck:  $2400 - 600 - T = 1200a$   
 $1800 - T = 1200a$   
 $\Rightarrow T = 1800 - 1200a$  ①  
 Car:  $T - 400 = 800a$  ②  
 Sub ① into ②:  $(1800 - 1200a) - 400 = 800a$   
 $1400 = 2000a$   
 $a = 0.7 \text{ ms}^{-2}$

b)  $T = 1800 - 1200a$   
 $= 1800 - 1200 \times 0.7 = 960 \text{ N}$

c)  New acceleration:  $RF = ma$   
 $2400 - 600 = 1200a$   
 $1800 = 1200a$   
 $\Rightarrow a = 1.5 \text{ ms}^{-2}$

To reach  $28 \text{ ms}^{-1}$ :  $u = 20$   
 $v = 28$   
 $a = 1.5$   
 $s = \dots$   
 $t = t$   
 $v = u + at \Rightarrow t = \frac{v-u}{a} = \frac{28-20}{1.5} = 5.33 \text{ s}$

If rope had not broken, then time taken to reach  $28 \text{ ms}^{-1}$ :  
 $u = 20$   
 $v = 28$   
 $a = 0.7$   
 $s = \dots$   
 $t = t$   
 $v = u + at \Rightarrow t = \frac{v-u}{a} = \frac{28-20}{0.7} = 11.43 \text{ s}$

Difference between times =  $11.43 - 5.33 = 6.1 \approx 6 \text{ s}$  QED