Exam III PHYS 10310 April 2007

MC1. A: no its an inelastic collision

B: no it decreases

C: no impulse is $I = \int F\,dt$ but if interval $\Delta t = 0$ then $I = 0$.

D: no its inelastic

E true

MC2. Impulse $I = \int F\,dt = 2 \cdot \frac{1}{2} \cdot 4\,kN \cdot 3\,ms = 12\,Ns$. $v_{final} = \frac{p_{final}}{m} = \frac{12\,Ns}{4\,kg} = 3\,m/s$.

A

MC3. A large moment of inertia is obtained by placing the largest possible fraction of mass as far from rotational axis as possible

A

MC4. $\tau = (7\,kg \cdot 5\,m \cdot \cos 37° - 4\,kg \cdot 3\,m)g = 156\,Nm$

B

MC5. $\bar{L}_{total} = \bar{L}_{spin} + \bar{L}_{rot}$ $\bar{L}_i = \bar{L}_0$ since $L_{rot,i} = 0$.

cons. $\bar{L}$ => $\bar{L}_f = \bar{L}_{spin,f} + \bar{L}_{rot,f} = \bar{L}_0$ & $\bar{L}_{spin,f} = -\bar{L}_0$

⇓

$\bar{L}_{rot,f} = \bar{L}_0 - \bar{L}_{spin,f} = 2\bar{L}_0$

D

II a) conservation of momentum:

$$m_p v_i = (m_p + m_c) v_f \qquad v_f = v_i \frac{m_p}{m_p + m_c} = 4\,m/s \cdot \frac{60\,kg}{(60+120)\,kg} = \underline{\underline{1.33\,m/s}}$$

b) $$\Delta \bar{p}_p = m_p(\bar{v}_f - \bar{v}_i) = 60\,kg\,(1.33-4)\,m/s\,\hat{\imath} = \underline{\underline{-160\,kg\,m/s}}\,\hat{\imath}$$

$$\Delta \bar{p}_c = m_c(\bar{v}_f - 0) = \underline{\underline{160\,kg}}\,m/s\,\hat{\imath} = -\Delta \bar{p}_p$$

c) Friction force:

$$f_k = \mu_k F_N = \mu_k m_p g = 0.4 \cdot 60\,kg \cdot 9.81\,m/s^2 = \underline{\underline{235.44\,N}}\ (0)$$

d) Change in momentum of person given by:

$$|\Delta p_p| = f_k \cdot \Delta t \qquad \text{since } f_k = \text{const.}$$

$$\Delta t = \frac{160\,kg\,m/s}{235.44\,N} = 0.68\,s\ (1)$$

e) $$\Delta E_{th} = -K_f + K_i = -\frac{1}{2}(m_p + m_c) v_f^2 + \frac{1}{2} m_p v_i^2 = -\frac{1}{2} \cdot 180\,kg \cdot (1.33\,m/s)^2 + \frac{1}{2} \cdot 60\,kg\,(4\,m/s)^2$$

$$= \underline{\underline{320\,J}}$$

III. a) NII for blocks & pulley:

$$T_1 = m_1 a \qquad (m_2 g - T_2) = m_2 a \qquad (T_2 - T_1) R = I \alpha$$

$\Downarrow$

$$m_2(g-a) - m_1 a = I\alpha/R$$

non-slip condition: $a = \alpha R$

$\Downarrow$

$$(m_1 + m_2 + I/R^2)\, a = m_2 g \qquad a = \frac{m_2 g}{m_1 + m_2 + I/R^2} = \frac{1}{3} g = \underline{\underline{3.27\ \mathrm{m/s^2}}}$$

$$\alpha = a/R = \frac{3.27\ \mathrm{m/s^2}}{0.1\ \mathrm{m}} = \underline{\underline{32.7}}\ \mathrm{rad/s^2}$$

b) $T_1 = m_1 a = 1\ \mathrm{kg} \cdot 3.27\ \mathrm{m/s^2} = \underline{\underline{3.27\ N}}$

$T_2 = m_2(g-a) = \frac{2}{3} m_2 g = \underline{\underline{6.54\ N}}$

IV. a) cons. energy:

$$mg\,L/2 = \frac{1}{2} I\omega^2 \qquad I = \frac{1}{3} mL^2$$

$\Downarrow$

$$\omega = \sqrt{\frac{2\,mg\,L/2}{I}} = \sqrt{\frac{mgL}{\frac{1}{3}mL^2}} = \sqrt{3g/L} = \sqrt{3 \cdot 9.81\,m/s^2/1m} = \underline{\underline{5.42\ rad/s}}\ (0)$$

b) N II:

$$\tau = I\alpha \qquad \tau = mg\,L/2$$

$$\alpha = \frac{mg\,L/2}{\frac{1}{3}mL^2} = \frac{3}{2}\,g/L = \frac{3}{2} \cdot 9.81\,m/s^2/1m = 14.72\ rad/s^2\ (1)$$

c) vertical:

$$a_y = -a_t = -\alpha\,L/2 = -\frac{3}{2}\,g/L \cdot L/2 = -\frac{3}{4}g = -7.36\ m/s^2\ (2)$$

Horizontal:

$$a_x = -a_c = -\frac{v_t^2}{L/2} = -\frac{(\omega L/2)^2}{L/2} = -\frac{1}{2}\omega^2 L = -\frac{1}{2} \cdot 3g/L \cdot L = -\frac{3}{2}g = -14.72\ m/s^2\ (3)$$

d) $F_x = ma_x = -\frac{3}{2}g \cdot 1kg = \underline{\underline{-14.72\ N}}$

$F_y - mg = ma_y \Rightarrow F_y = m(g + a_y) = m(g - \frac{3}{4}g) = \frac{1}{4}mg = \underline{\underline{2.45\ N}}$

V a) Cons. angular momentum:

$$I_i \omega_i = I_f \omega_f \Rightarrow \omega_f = \omega_i \, I_i / I_f$$

$$I_{i/f} = I_{st} + 2 m R_{i/f}^2 \qquad I_i = 3\ kg\ m^2 + 2 \cdot 3\ kg\ (1\ m)^2 = 9\ kg\,m^2$$

$$I_f = 3\ kg\ m^2 + 2 \cdot 3\ kg \cdot (0.3\ m)^2 = 3.54\ kg\,m^2 \ (\cdot)$$

$$\omega_f = 0.75\ rad/s \cdot \frac{9}{3.54} = \underline{\underline{1.91\ rad/s}} . \ (1)$$

b) Kinetic energy: $K = \frac{1}{2} I \omega^2$

$$K_i = \frac{1}{2}\, 9\ kg\,m^2 \,(0.75\ rad/s)^2 = \underline{\underline{2.53\ J}} \ (2)$$

$$K_f = \frac{1}{2} \cdot 3.54\ kg\,m^2\,(1.91\ rad/s)^2 = \underline{\underline{6.44\ J}} \ (3)$$

c) Student does work against centripetal force

$$W = \Delta K = (6.44 - 2.53)\ J = \underline{3.90\ J}$$

we can show this result explicitly w/a little work }