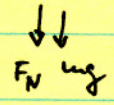
2006 PHYS 1036 FINAL EXAM

MC1. (D) Acceleration is g downwards if it has non-zero horiz. velocity.

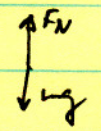
MC2. (C) $\sum \vec{F} = m\vec{a}$

MC3. (D) Top



$\vec{F}_T = -(F_N + mg)\hat{j} = -2mg\,\hat{j}$

Bottom



$\vec{F}_B = (F_N - mg)\hat{j} = -\vec{F}_T$

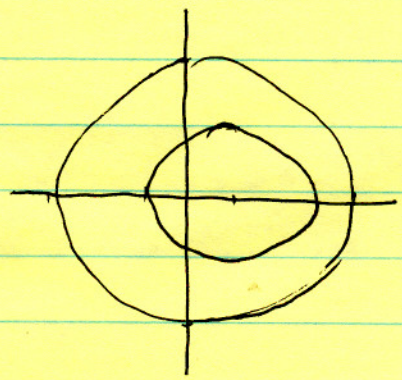
$F_{NB} = 3mg\,\hat{j}$

MC4. (D) $K' = \frac{1}{2}m(3v)^2 = 9K$

MC5 (B) Cons. momentum

$80\,kg \cdot v_i = (80\,kg + 110\,kg)\,v_f \qquad v_f = \frac{80}{190} v_i$

MC6 (A)



Solid sphere entirely inside spherical shell where $g = 0$.

MC 7 (D) $T = \frac{2\pi}{\omega} = 2\pi\sqrt{L/g}$

$$T_M = T_E \sqrt{g_E}/\sqrt{g_M} = T_E\sqrt{\frac{g_E}{g_M}} = 5\,s \cdot \sqrt{6} = 12.2\,s$$

MC 8. (D) $\omega_{1/2} = \omega_0\sqrt{1-\frac{1}{4Q_{1/2}^2}}$

$$\Delta\omega = \omega_1 - \omega_2 = \omega_0\left(\sqrt{1-\frac{1}{4Q_1^2}} - \sqrt{1-\frac{1}{4Q_2^2}}\right) = 0.0311\,\frac{rad}{s}$$

II

a) Maximum horiz. force on m_1 is $f_{s,max} = \mu_s m_1 g$

$$a_{max,1} = \mu_s g = \underline{5.89\,m/s^2}.$$

b) $T = (m_1 + m_2)a$

$m_3 g - T = m_3 a$

$$m_3 g - (m_1+m_2)a = m_3 a$$

$$m_3 = \frac{(m_1+m_2)a}{g-a}$$

Set $a = a_{max,1}$

$$m_3 = (m_1+m_2)\frac{\mu_s g}{g-\mu_s g} = \frac{\mu_s}{1-\mu_s}\cdot(m_1+m_2) = \underline{22.5\,kg}$$

II cont'd

c) Now m_1 slips!

$$\mu_k m_1 g = m_1 a_1 \qquad a_1 = \mu_k g = \underline{3.92\ m/s^2}$$

$$\left.\begin{aligned} T - \mu_k m_1 g &= m_2 a_2 \\ m_3 g - T &= m_3 a_2 \end{aligned}\right\} \quad m_3(g - a_2) - \mu_k m_1 g = m_2 a_2$$

$$a_2 = \frac{m_3 g - \mu_k m_1 g}{m_2 + m_3} = \underline{6.87\ m/s^2}$$

$$T = m_3(g - a_2) = \underline{88.3\ N}$$

III

a) $\frac{1}{2} k x^2 = \frac{1}{2} m v^2 \qquad v = x\sqrt{k/m} = \underline{3.16\ m/s}$

b) $\frac{1}{2} k x^2 = mg\ell \sin 45^\circ \qquad \ell = \frac{kx^2}{2mg \sin 45^\circ} = \underline{0.72\ m}$

c) $\frac{1}{2} k x^2 = mg\ell \sin 45^\circ + \mu_k mg \cos 45^\circ \ell = mg\ell(\sin 45^\circ + \mu_k \cos 45^\circ)$

$$\ell = \frac{kx^2}{2mg(\sin 45^\circ + \mu_k \cos 45^\circ)} = \underline{0.60\ m}$$

(IV)

a) $F_{th} = R v_{ex} = 200\ kg/s \cdot 1.8 \cdot 10^3\ m/s = \underline{3.6 \cdot 10^5\ N}$

b) $T = \frac{0.8 \cdot 30000\ kg}{200\ kg/s} = \underline{120\ s}$

c) $a_i = \frac{F_{th,i}}{m_i} - g = \frac{3.6 \cdot 10^5\ N}{30000\ kg} - 9.81\ m/s^2 = \underline{2.19\ m/s^2}$

d) $a_f = \frac{F_{th}}{m_f} - g = \frac{3.6 \cdot 10^5\ N}{0.2 \cdot 30000\ kg} - 9.81\ m/s^2 = \underline{50.2\ m/s^2}$

(V)

a+b) $mg - T = ma$ $\qquad \tau = I\alpha$

$TR = \frac{2}{5} MR^2 \frac{a}{R} \Rightarrow T = \frac{2}{5} Ma$

combine:

$ma + \frac{2}{5} Ma = mg$ $\qquad a = \frac{m}{m + \frac{2}{5}M} g.$

$T = \frac{2}{5} M \frac{m}{m + \frac{2}{5}M} g = \frac{2Mm}{5m + 2M} g$

VI

a) $|g| = G\frac{M_E}{R_1^2} = a_c = \frac{v_1^2}{R_1} \Rightarrow v_1 = \sqrt{G M_E / R_1} = 3074 \text{ m/s}$ (o)

b) $K_1 = \frac{1}{2}mv_1^2 = \frac{1}{2} G \frac{mM_E}{R_1} = 2.36 \text{ GJ}$

c) $U_1 = -G\frac{mM_E}{R_1} = -2K_1 = -4.73 \text{ GJ}$

d) $E = K + U = K - 2K = -K.$

$\Delta E = E_2 - E_1 = -K_2 - (-K_1) = K_1 - K_2$

$K_2 = \frac{1}{2} G \frac{mM_E}{2R_1} = \frac{1}{2} K_1$

$\Delta E = K_1 - \frac{1}{2}K_1 = \frac{1}{2}K_1 = 1.18 \text{ GJ}$

VII

a) At bottom: $\frac{1}{2}kh^2 = mgh$ $\quad h = \frac{2mg}{k} = 7.85 \text{ cm}$ (o)

b) At equilibrium: $kh = mg$ $\quad h = \frac{mg}{k} = 3.92 \text{ cm}$ (i)

c) $mgh = \frac{1}{2}kh^2 + \frac{1}{2}mv^2 \Rightarrow \frac{(mg)^2}{k} - \frac{1}{8}k\left(\frac{mg}{k}\right)^2 = \frac{1}{2}mv^2$

$v = \sqrt{\frac{mg^2}{4k}} = 0.62 \text{ m/s}$

d) $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}} = 0.397 \text{ s}$