Physics 10154 - Exam #3d

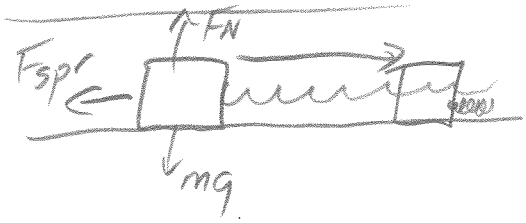
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (35 pts) A 55 gram mass A slides across a horizontal, frictionless table to have a collision with 1.2 kg mass B, initially at rest connected to a horizontal spring in equilibrium (k = 2300 N/m). After the collision, mass A bounces back with a speed of ~~8~~ 5 m/s, and mass B compresses the spring by a maximum amount of ~~42~~ 9.4 cm. What was the initial velocity of mass A?

Collision $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

$(.055) v_{1i} + 1.2(0) = (.055)(-15) + (1.2) v_{2f}$

Spring



$\Sigma W_{nc} = W_{spr} = \Delta K$

$+\frac{1}{2} k x^2 = 0 + \frac{1}{2} m v_0^2$

$(2300)(.094)^2 = (1.2) v_0^2$

$v_0 = 4.115 \text{ m/s}$

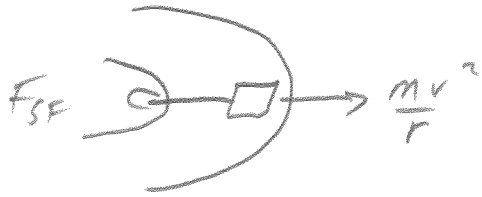
$.055 v_{1i} = (.055)(-15) + (1.2)(4.115)$

$v_{1i} = \dfrac{-0.825 + 4.938}{.055}$

$= 75 \text{ m/s}$

2. (35 pts) A small mass sits on a turntable, 85 cm from the center, with everything initially at rest. The turntable begins to turn with a constant acceleration from rest at a rate of 0.15 m/s^2, and after a total of 5.0 revolutions, the mass begins to slide off. What is the coefficient of static friction between the mass and the turntable?

When mass slides off: threshold problem, so max value



$$\Sigma F_{rad} = \frac{mv^2}{r} - F_{SF} = 0$$

$$\frac{mv^2}{r} - \mu_s F_N = 0$$

$$\frac{mv^2}{r} = \mu_s mg$$

$$\mu_s = \frac{v^2}{rg}$$

Angular motion

$\Delta\theta = 5.0 \text{ rev} = 31.4 \text{ rad}$

$\omega_0 = 0$

$\omega = ?$

$\alpha = \frac{a_{tan}}{r} = \frac{0.15}{0.85} = 0.176 \text{ rad/s}^2$

$t = ?$

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\omega^2 = 0^2 + 2(.176)(31.4)$

$\omega = 3.33 \text{ rad/s}$

$v = r\omega = 2.83 \text{ m/s}$

$$\mu_s = \frac{(2.83)^2}{(.85)(9.8)}$$

$$= \boxed{0.96}$$

3. (30 pts) A satellite in geosynchronous orbit will appear to hover over a particular spot on Earth. This happens if the period of the satellite is 23 hours and 56 minutes.

a) How far away is the satellite from the center of the Earth?
b) What is the orbital velocity of the satellite?

a) $T = 23h\ 56m = 86160_s$

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(86160)^2}{4\pi^2}$$

$$= \frac{2.96\times10^{24}}{4\pi^2} = 7.50\times10^{22}$$

$$r = 4.22\times10^7\ m = 6.6\,R_E$$

b) $$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.67\times10^{-11})(5.98\times10^{24})}{4.22\times10^7}}$$

$$= \sqrt{9.45\times10^6}$$

$$= 3100\ m/s$$