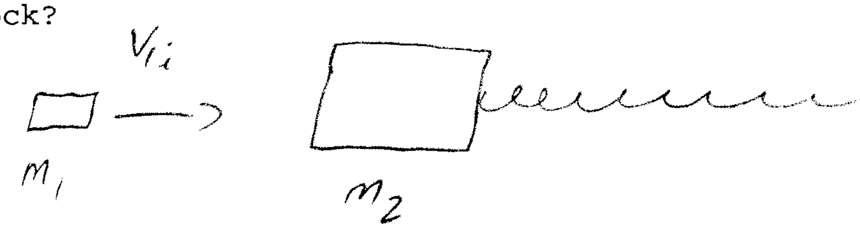
Physics 10154 - Exam #3d

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.

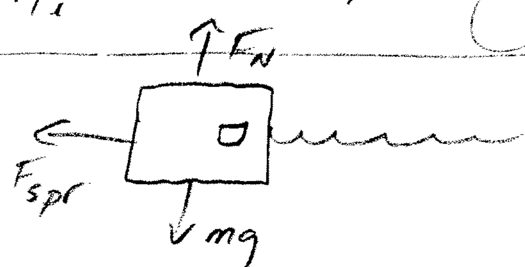
1. (40 pts) An 11 gram bullet is fired with some unknown initial velocity. It embeds itself in a 220 gram wooden block attached to a spring with k = 650 N/m. The bullet remains embedded in the block after the collision, and the bullet-block mass causes the spring to compress to a maximum value of 22 centimeters. What was the initial velocity of the bullet prior to the collision with the block?



Collision: $m_1 V_{1i} + m_2 V_{2i} = (m_1 + m_2) V_f$

$.011 V_{1i} + 0 = .231 V_f$

Work-Energy



$\Sigma W_F = W_N + W_g + W_{spr} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$

$0 + 0 - \frac{1}{2}kx^2 = 0 - \frac{1}{2}mv_0^2$

$V_0^2 = \frac{k}{m}x^2 = \frac{650}{.231}(.22)^2$

$V_0 = 11.67$ m/s

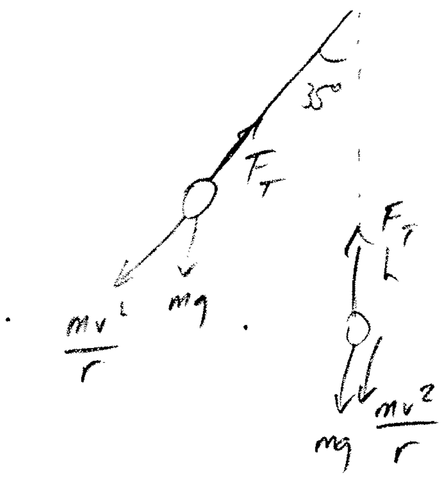
$V_{1i} = \frac{.231}{.011}(11.67) = \boxed{250 \text{ m/s}}$

assumed vertical in solution

2. (30 pts) A 1.5 meters long pendulum with mass attached of 2.2 kg drops from rest with an initial 35° angle with the horizontal.

a) What is the force of tension when the pendulum reaches its lowest point?

b) What is the force of tension when the pendulum reaches its maximum height on the far side of where it was released?



$h = L - L\cos\theta$

$= 1.5 - 1.5\cos 35^\circ = 0.27\,m$

$\Sigma W_F = W_T + W_c + W_g = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$

$0 + 0 + mgh = \frac{1}{2}mv^2 - 0$

$v = \sqrt{2gh} = 2.3\,m/s$ (3.5)

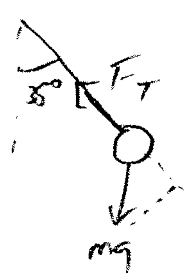
$\Sigma F_{rad} = mg + \frac{mv^2}{r} - F_T = 0$

$F_T = mg + \frac{mv^2}{r}$

$= (2.2)(9.8) + \frac{(2.2)(2.3)^2}{1.5}$

$= 21.56 + 7.76$ (+ 17.97)

$= \boxed{29\,N}$ 40 N



$\frac{mv^2}{r} = 0$ at max height

$\Sigma F_{rad} = mg\cos\theta - F_T = 0$

$F_T = (2.2)(9.8)\cos 35^\circ = \boxed{18\,N}$

(55°) = 12 N

3. (30 pts) A satellite has an orbital period of 3.2 hours.

a) What is the altitude of this ^100 kg satellite above Earth's surface?

b) How much work was needed by the rocket engines in order for the satellite to reach this altitude (you may assume that the initial and final kinetic energies are the same for simplicity)?

$$T = 3.2\ hr = 11520\ s$$

$$r^3 = \frac{GMT^2}{4\pi^2} = \frac{(6.676\times10^{-11})(5.98\times10^{24})(11520)^2}{4\pi^2}$$

$$= 1.34\times10^{21}$$

$$r = 1.103\times10^{7}\ m$$

$$h = r - R_E = 1.103\times10^{7} - 6.38\times10^{6}$$

$$= \boxed{4.7\times10^{6}\ m} \text{ or } 2900\ mi$$

$$W_{App} + W_{grav} = \Delta K = 0$$

$$\text{so } W_{App} = -W_{grav} = \Delta U_{grav}$$

$$U_f = -\frac{GMm}{r} = -\frac{(6.676\times10^{-11})(5.98\times10^{24})(100)}{1.103\times10^{7}}$$

$$= -3.619\times10^{9}$$

$$U_i = -\frac{GMm}{R_E} = -6.257\times10^{9}$$

$$W_{App} = -3.619\times10^{-9} - (-6.257\times10^{9}) = \boxed{2.6\times10^{9}\ J}$$