Ballistic Pendulum– Prelab Quiz

Answer these questions after reading the "Ballistic Pendulum" assignment. Be sure to show all of your work so that partial credit can be given.

1. **[3 points]** Write an expression for the uncertainty in the moment of inertia δI using Equation 3.10 from the assignment. Note: The `SymPy` package can make this job easier in Python. Look under the "Python Help" link on Blackboard for `SymPy` examples.

   Simplify your expression for δI so that it looks like Equation 2.4 in the "Error Propagation Reference".

   Assume for a moment that the fractional errors: $\delta R_{cm}/R_{cm}$, $\delta M/M$, and $\delta T/T$ are all identical. Which term contributes most to the overall error in the moment of inertia δI?

2. **[1 points]** Considering your answer from Exercise 1, where should the most care be taken to reduce the impact of the dominant term in the uncertainty expression for δI? What can be done to reduce the fractional error when measuring a given quantity?

3. **[3 points]** When the muzzle velocity of a projectile is found, the spring constant k of the projectile launcher can be determined using the conservation of energy. The energy stored in a spring is given by:

   $$\mathbb{U}_{\text{spring}} = \frac{1}{2}kx^2 \tag{0.1}$$

   where x is the compression of the spring.

   When the projectile launcher fires, the energy stored in the spring is transferred to the kinetic energy of the ball. That is:

   $$\mathbb{U}_{\text{spring}} = \mathbb{K}_{\text{ball}} \tag{0.2}$$

   $$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \tag{0.3}$$

   because of the conservation of energy.

   Data are collected for several spring compression lengths x_i and the resulting projectile velocity v_i is measured. Using Equation 0.3, what can be plotted to obtain a straight-line relationship from which the value of k can be obtained? Support your answer by explicitly showing how k relates to the resulting parameters of the line fit.

4. **[3 points]** Consider your answer to Exercise 3. Describe how the uncertainty on each of the plotted variables will be estimated. Specifically, describe how will you compute the horizontal and vertical axis error bars.