LAB 3 ENERGY IN SPRINGS

EXPERIMENTAL GOALS

Chapter C7 states that the potential energy $V(x)$ stored in an ideal spring is given by the formula

$$V(x) = \tfrac{1}{2}k_s x^2 \qquad (1)$$

where x is the distance that the spring is stretched beyond its relaxed length (we can call this the spring's "extension") and k_s is the spring's "spring constant." In class, we used techniques in chapter C8 to show that this potential energy formula mathematically implies that the magnitude of the force the spring exerts at a given extension x is

$$\text{mag}(\vec{F}_S) = k_s|x| \qquad (2)$$

Your goal in this experiment is to measure the value of k_s for a given spring two different ways: (1) using conservation of energy and and the first equation above, and (2) by hanging weights from the spring and using the second equation above. You should then compare these values: are your results consistent with each other within your uncertainties?

LABORATORY SKILLS you will be developing

In both cases you should obtain the value of k_s by calculating the *slope* of a graph of measured data so that you can practice linear regression (see Chapter 10 of the *Lab Reference Manual*): the technique of determining a value from a slope is very useful in physics.This lab will also give you the opportunity to practice the uncertainty analysis skills you developed in the previous two labs. This is also the first lab where you will examine whether two independently-measured values are consistent with each other given the uncertainties in the measurements: two measured values are considered consistent if their uncertainty ranges significantly overlap.

SOME PROCEDURAL SUGGESTIONS AND NOTES

Each team will have a specific spring. To measure the value of the spring's k_s using conservation of energy, we will use the spring to connect a glider on an air track to the end of the track. Arranged along the air track are four photogates that are connected to a computer. The computer measures the time that it takes the glider's flag to move through each photogate, and uses the known width of the flag to compute and display a close approximation to the glider's *squared* speed at the instant its center goes through the photogate. So if you pull the glider beyond the furthest photogate and release it, the computer will display the glider's squared speed at four different points as it is pulled by the spring. You can decide where to put the photogates, but DO NOT pull the glider more than 50 cm from its position when the spring is relaxed.

We have only one air track, so teams will take turns using it. You need do only a single run (for reasons that your helper can explain, the runs are not really repeatable). Before you do your run, though, you should figure out what kind of graph you can construct using the data you will get whose slope is related in a simple way to the value of k_s. Be sure that you explain your procedure to your *helper* before you do your run. (We are not doing formal procedure interviews this time.) You can use the digital scale to measure the glider's mass.

Each team will also have a a set of cylindrical masses, a wooden frame with a meter stick, and a bolt that you can use to attach the masses to the spring. By hanging weights from the spring, you can use the second equation to determine k_s. Again, figure out you can use your measured data to construct a graph whose slope is k_s, and check out your procedure with your *helper* before you spend a lot of time taking data. You can measure your weights using a pan balance.

At several points during the lab, you will have to calculate the uncertainty in a calculated quantity. We will later discuss a general approach this problem of "propagation of uncertainties", but for now you can use the computer program *PropUnc*. Your lab instructor or helper will demonstrate this program and describe how it works.

You will be graded on your work on the pre-lab exercises in the *Lab Reference Manual* and on your team's performance during the checkout interview at the end of lab.