5.2: Activities

Things You Will Need

Nothing! All the data has been meticulously collected for you.

A Jumping Spring

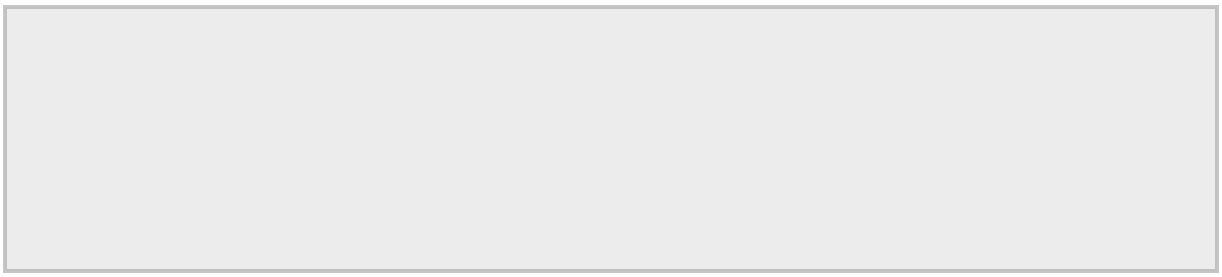
The physical system we will be examining is that of a spring that is threaded over a vertical post. The spring is closed at the top, so that the top is prevented from going lower than the top of the post. The bottom of the spring is then pulled downward, stretching it, and is released, after which the spring leaps upward. Our goal is to test energy conservation by measuring the energy stored in the spring before it is released, and compare it to the gravitational potential energy the spring gains at its peak height (at both of these stages, the kinetic energy is zero).

When confronted with the details of this experiment, a theorist works on the problem, and declares that because the coils collide when the spring returns to it original shape, the mechanical energy lost from this "inelastic collision" (a topic we will cover in this class soon) is substantial. A simple model reveals that in fact *one quarter* of the mechanical energy is lost during this process. We now seek to test this hypothesis with an experiment.

The Data

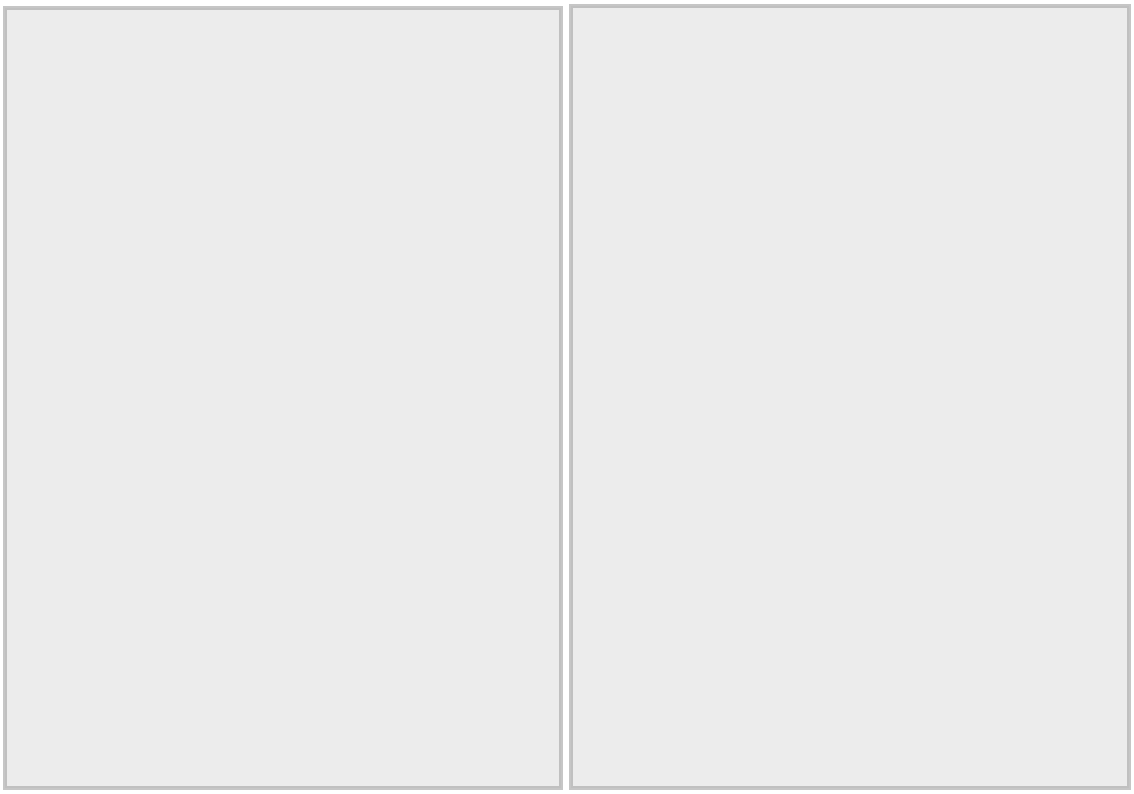
The first collection of data collected relates to the spring. The photos below show the position of the bottom of the spring with weights in 20 gram increments hanging from it (the top of the spring is at the same location in every case).

Figure 5.2.1 – Spring Data



The second collection of data comes from the launch of the spring. The photo below shows the stretch of the spring before launching, and the gif shows the result of the launch. The mass of the spring is measured to be 9.8 grams.

Figure 5.2.2 – Launch Data



Data Analysis and Additional Discussion

1. Compute the elastic potential energy stored in the spring before launch:
    a. Make a table and plot the data for the applied force vs. spring stretch (you do not need to include error bars).
    b. Use the plot to create a best-fit line for the data, and write the equation for this line.
    c. From the equation for the line, derive a formula for the work done in stretching this spring by an amount x.
    d. Apply the work formula to determine the elastic potential energy stored in the spring just before the launch.
2. Compute the gravitational potential energy change by the spring at the peak of its flight:
    a. Measure the vertical distance traveled by the bottom of the spring. [*Naturally it is better to do several launches and take an average, but we will treat the launch shown as being representative of a typical launch.*]
    b. Adjust the vertical displacement to account for the height to which the *center of mass* rises. [*Hint: When the spring is stretched, the center of mass moves down half as far as the amount of stretch.*]
    c. Use the vertical displacement of the center of mass of the spring to compute its change in gravitational potential energy.
3. Compute the mechanical energy loss.
    a. Express the energy loss as a percentage.
    b. Compare the percentage loss measured by the experiment with the predicted loss.
4. Check uncertainties to see if the experiment "comes close enough" to confirm the prediction:
    a. Which part of the launch data do you think is susceptible to the greatest absolute error? Which provides the greatest percent error? [*For this, you will first be making estimates of absolute uncertainties based on what you can see – not by doing statistics. And to get the percent uncertainties, you need to keep in mind what is being measured in each case.*] Explain your reasoning.
    b. Calculating the correct percent uncertainty for the spring potential energy before the launch is a tricky matter, so we will just use the percent uncertainty of the stretch of the spring prior to the launch. Is the hypothesis confirmed within this percent uncertainty?

Lab Report

Download, print, and complete this document, then upload your lab report to Canvas. [*If you don't have a printer, then two other options are to edit the pdf directly on a computer, or create a facsimile of the lab report format by hand.*]
