5.2: Activities

Equipment

- spring
- paper clips
- clamped post
- 2-meter stick
- hanging weights

The General Idea

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 its original shape, the mechanical energy lost from this "inelastic collision" (a topic we will cover soon) is substantial. A simple model reveals that in fact the amount of mechanical energy that is lost during this process is $25\% \pm 4\%$ (i.e. between 21% and 29%). We now seek to test this model's prediction with an experiment.

Some Things to Think About

A significant amount of thought needs to go into the physics behind this experiment, and much of this is addressed in the Background Material. Here are some pointers about those issues:

- The spring is not ideal, so you cannot compute the potential energy stored within it using $\frac{1}{2}kx^2$. This means that the stored potential energy has to be computed using the work done on the spring to bring it to a given stretch, and this work can be computed graphically after taking some data (which should be tabulated, as usual) on what force is required to stretch the spring various amounts. Small changes in the best-fit line of this graph can possibly lead to some fairly significant differences in the final result, so you will want many data points for your graph, to narrow the range of best-fit lines that work. Spread out the data points as much as possible, from very small to large stretches. **But do not over-stretch the spring – you will not need to hang more than 300 grams.**
- It is challenging to measure the heights to which the fast-moving spring rises, so you should again consider recording video on a smart phone to slow things down and get a better view.
- The change in gravitational potential energy of the spring is determined by the distance that its *center of mass* rises. Some care must be taken to make sure you get this value correct, given that the spring is stretched at its lowest point and not stretched at its highest point.
- You will not need to estimate uncertainties for the measurements of this experiment, because these come out to be insignificant compared to the uncertainty range built into the theoretical model.
- As with any experiment that has values difficult to measure (like the height the spring attains), it is useful to do the same run more than once, to make sure you did not experience a "glitch" with a single trial (you are only required to do the full analysis for a single spring launch, however).
- Unlike previous labs in which we merely plotted data points, this time we actually need to *use* the best-fit line that these data produce. If you use the usual online graphing calculator to plot these data points, then you can add a second formula with the equation for a line, $y = mx + b$. Create sliders for m and b and adjust these values until the line fits the data points way you think it should (in future labs, we'll have the computer do this for you). You can then print this as usual for your lab report, but what is nice is that you *have the actual equation* for your best fit line, and you can work with that for your final calculations, rather than refer back to the graph.

Lab Report

Craft a lab report for these activities and analysis, making sure to include every contributing group member's name on the front page. You are ***strongly encouraged*** to refer back to the Read Me as you do this, to make sure that you are not leaving out anything important. You should also feel free to get feedback from your lab TA whenever you find that your group requires clarification or is at an impasse.

Every member of the group must upload a separate digital copy of the report to their lab assignment in Canvas *prior to leaving the lab classroom*. These reports are not to be written outside the lab setting.