Concepts of Physics
Lab 2: Springs

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Springs

The force F exerted by an ideal spring is proportional to the amount you stretch it; or $F \propto x$, where x is the amount the spring is stretched by.

One way to see this is to hang a mass m from it. Since the weight of the mass is proportional to m, and it's the only force stretching the string, we should have $x \propto m$. Thus if you graph x versus m, and the data approximate a straight line, that is evidence that the spring fits the ideal model well.

Activity 1: Graph x vs. m

Make a graph of x vs. m, and see if you get a straight line. Use 10 different masses, but don't add more than 500 g total, as more than that may permanently deform the spring.

Note that x should be on the vertical axis, and m should be on the horizontal axis.

To hand in for activity 1

- Values of m and x for each trial,
- Graph of x versus m,
- Your calculation for s_1, the slope of the line you graphed. (What are the units for the slope?)

Oscillations

We can also see how a spring behaves when we stretch it further with a mass on the end, and let it go. You will see that the larger the mass, the longer it takes for the spring to bounce up and down. It turns out that for an idealized spring, the *square* of the period of its oscillations (P) are proportional to the mass hanging on it; $P^2 \propto m$. Therefore, if you put a bunch of different masses on a spring and measure the period for each mass, and then graph P^2 versus m, you should get a straight line.

The most precise way to measure the period is to measure, say, 50 periods, and then divide by 50. (You can make this number larger or smaller depending on how long each measurement takes.) That way, any imprecision in your measuring process is spread out over a much greater time, and will have a much smaller overall effect. If n is the number of periods you time, and t_n is the time for all those periods, then $P = t_n/n$.

You will have to face an extra complication in this part of the lab. I want you to figure out a way of measuring time *without* using any watches, clocks, or other device that is designed to tell time. This is, in fact, a problem the first experimental physicists faced, before devices to measure short periods of time became available.

Activity 2: How period depends on mass

Think of a method of measuring time intervals. Note that as long as your time intervals are short (comparable to the period of the oscillations) and fairly constant, you will do fine. Just to check whether $P^2 \propto m$ does not require that time be measured in any particular units, so don't worry if you can't tell exactly how many seconds your basic time interval happens to be.

Now, using your method of timing, find P for ten different values of hanging mass ranging from 300 g down to about 50 g. Then make a graph of P^2 versus amount of hanging mass, again with m on the horizontal axis. With an ideal spring, you should get a straight line. Do you?

In fact, if all went according to expectations, the slope of the line in this graph, s_2, should be related to the slope you found before by

$$s_2 = \frac{4\pi^2}{g} s_1 \tag{1}$$

where $g = 9.8$ m/s^2, the acceleration due to gravity. Using this relationship, find out how many seconds your basic time interval was.

To hand in for activity 2

- A description of your method of timing.
- Values of m, t_n, n, P and P^2 for each trial,
- Graph of P^2 versus m, and the slope.
- The length of your basic time interval, according to equation (1) above.