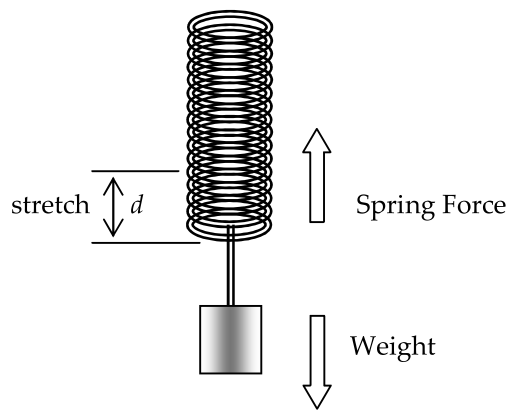
Simple Springs

Introduction:

The strength of any spring is characterized by its *spring constant*, k, measured in newtons per meter. When k is large, the force required to stretch or compress the spring must also be large. For example, garage door springs typically have an enormous spring constant because they are required to raise and lower the weight of garage doors. In this experiment, we will be measuring the spring constant using two different methods and comparing our results.

<u>Method #1</u> involves hanging various objects from a vertical spring and measuring the distance that the spring stretches. Since the system is at rest, the forces must balance: the weight of the hanging object (mg) must equal the force exerted by the spring. The spring force depends on the distance d that the spring is stretched and its spring constant k according to *Hooke's Law* (Spring Force = kd). Putting this all together, we have



Weight = Spring Force

$$mg = kd$$

$$m = \left(\frac{k}{g}\right)d$$

As you can see, the spring constant may be determined solely from the mass of the hanging object and the distance that the spring is stretched ($g = 9.8 \text{ m/s}^2$). If you plot different masses along the y axis and their stretch distances along the x axis, the data points should lie along a straight line of slope = k/g.

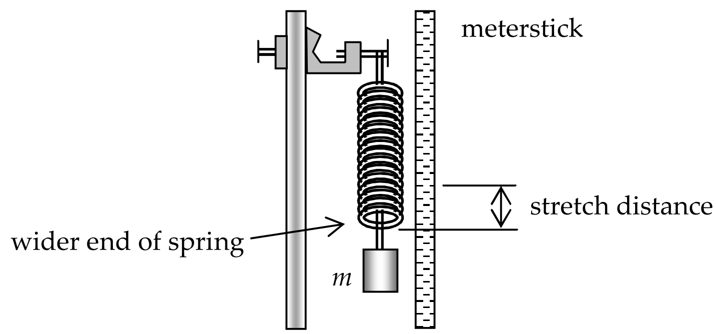
<u>Method #2</u> involves observing the same set of hanging objects in *Simple Harmonic Motion*. By pulling the object downward slightly and releasing, the object will oscillate up and down. According to the mathematical theory of SHM, there is a relationship between the mass m and the square of the period of oscillation T (i.e. the time for one complete up and down motion):

$$m = \left(\frac{k}{4\pi^2}\right)T^2$$

In this method, the spring constant may be determined solely from the mass and the period. If you plot different masses along the y axis and their corresponding periods along the x axis, the data points follow a quadratic curve of leading coefficient equal to $k/4\pi^2$.

Make sure that your group has a vertical stand (upright pole held in place by a triangular base), a two-axis clamp, a meterstick, a set of hooked masses, and a stopwatch. You will also be using Microsoft Excel in order to plot your data and to fit it to a curve (trendline).

Procedure and Data Collection:



1) Attach the two-axis clamp close to the top of the vertical stand.
2) Hang the spring from the protruding screw so that wider end of the spring is at the bottom. Note the location of the bottom on your meterstick.
3) Hook a 50-gram mass (0.050 kg) at the bottom of the spring and measure the distance that the spring stretches. Record that distance *in meters* in the data table below.
4) Now slightly pull down the 50-gram mass and release in order to set it into Simple Harmonic Motion.
5) Use your stopwatch to time ten complete oscillations. One complete oscillation consists of one up-down motion. Divide your time by ten to obtain the period and record it in your data table.
6) Repeat Steps 3 through 5 for the remaining masses listed in the data table. Note that you may need to combine masses by hooking them together.

Mass	**Stretch Distance [meter]**	**Period of Oscillation [sec]**
0.050 kg		
0.100 kg		
0.150 kg		
0.200 kg		
0.250 kg		
0.300 kg		
0.350 kg		
0.400 kg		
0.450 kg		
0.500 kg		

Plotting the Data:

1) Open Excel.
2) Fill column A with your values for the stretch distance and fill column B with your masses.
3) Highlight Columns A and B. Pull down the Insert menu and pick Chart.
4) Select chart type XY (Scatter) then click Next > twice.
5) Fill in the chart title as "Method #1 Data". The X axis value is "Stretch Distance [meter]" and the Y axis value is "Mass [kilogram]".
6) Click the Gridlines tab and remove the check mark.
7) Click the Legends tab and remove the check mark, then click Next > and Finish. Your graph has been inserted into your spreadsheet.
8) Select your graph. Little black boxes will appear in the corners.
9) Pull down the Chart menu and pick Add Trendline. Select chart type Linear.
10) Click the Options tab and place a check next to *Display equation on chart*. Click OK. Be sure that your graph resembles the sample shown below before you print it out.
11) Now replace the data in column A with your values for the period of oscillation.
12) Repeat Steps 3 through 8.
13) Pull down the Chart menu and pick Add Trendline. Select chart type Polynomial, Order 2.
14) Click the Options tab and place a check next to *Display equation on chart*. Click OK. Be sure that your graph resembles the sample shown below before you print it out.

Data Analysis:

To determine the value for the spring constant in Method #1, record the slope of your trendline below (see the sample graph):

Slope = ______________________________

Spring constant k = Slope × g = ________________________________

To determine the value for the spring constant in Method #2, record the coefficient of the x^2 term in your trendline equation (see the sample graph):

Coefficient = ________________________________

Spring constant k = Coefficient × 4 × π^2 = ________________________________

Now calculate the percent discrepancy between the spring constants from two methods:

$$\text{Percent discrepancy} = \frac{100 \cdot |\text{Method 1} - \text{Method 2}|}{\text{Method 1}} = \underline{\hspace{5cm}}\ \%$$

Note that the formula has an *absolute value* so your answer should be positive!

Before you leave the lab, turn in this lab sheet with your two graphs stapled to it. Don't forget to write your names at the top of the sheet!

Sample Graphs: