Hooke's Law and the spring constant

OBJECTIVE:

1. To measure the spring constant, *k*, of a spiral spring from Hooke's Law.
2. To determine the mass of the spring.

APPARATUS:

Stand with a clamp, a set of slotted masses, ruler, and geometry box.

THEORY:

Hooke's Law

A spring with a varying amounts of force applied is proportional to its displacement. This proportionality constant is called the spring constant, *k*, and the entire relation is referred to as Hooke's Law:

$$F = -kX. \tag{1}$$

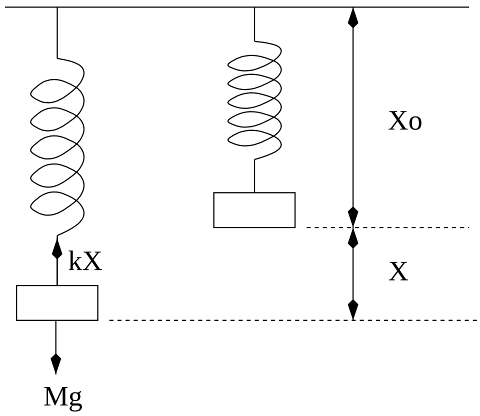

Figure 1: Hooke's Law Setup.

The minus sign is only used to describe the "restoring" force. This force opposes the applied force on the spring and tries to return the spring to equilibrium. In figure 1, X_o is the length of the spring with the mass holder hanging at rest at the equilibrium point. The displacement, *X*, is measured relative to the equilibrium point.

Hooke's Law becomes invalid only when the elastic limit of the spring is surpassed.

In this experiment, mass is added to the holder and the elongation (or stretch) is measured to determine the spring constant *k*. This value is obtained from the slope of the graph of Force Applied vs. Total Elongation.

PROCEDURE:

Hooke's Law

1. Hang the spring vertically from the clamp, and record the lowest point of the spring with meterstick. Let's call this position X_0 and record it in Table-1.

2. Add masses, one at a time, beginning with 150 grams. Increment the mass by 50 grams and record the lowest point of the spring, X, in each case and write theses in the third column in Table-1.
3. Compute the total elongation of the spring, $L = |X - X_0|$ for each added mass. Record the data in the fourth column in Table 1.
4. Determine the Force Applied in Newtons for each mass added and record it in the second column in Table-1.
5. Plot the Force Applied (F) vs. Total Elongation (L), and determine the slope of of the line. Write this below Table-1.
6. Using the slope of the graph determine the value of the spring constant, k. Record this value under Table 1.

Spring mass

1. Do the following and record in Table-2.
2. Lay the spring horizontally on a flat table. Measure the length of the spring, L_h and record in Table-2..
3. Hang the spring vertically from the clamp without any external or added mass. Measure the length of the spring, L_v, and record it in Table-2.
4. Compute the change in the spring length between the horizontal and vertical lengths in the previous two steps. This change in length is due to the effective spring mass. Record this value of extension of the spring as $\Delta L = |L_v - L_h|$ in Table-2.
5. Use $mg = k\Delta L$ and the spring constant k from the graph calculated in Table-1 to find the effective mass m. Note that this effective spring mass is responsible for elongation when the spring is vertical.
6. Measure the actual spring mass M by using the digital balance.
7. Compute the ratio m/M and fill-up Table-2.

Lab Report

Name of the Experiment	:
Your Name	:
Your ID #	:
Name of the lab Partner	:
Date	:

Instructor's comments:

Table 1. Static Determination of the Spring Constant, k

Position of the lowest point of the spring, X_0 = ____________ (m).

Mass Added to the spring (kg)	Force, F (N)	Spring position, X (lowest point) (m)	Elongation, $L = \lvert X - X_0 \rvert$ (m)
0.150			
0.200			
0.250			
0.300			
0.350			
0.400			

Spring constant: ____________ N/m

Table 2. Spring mass determination

Length of the spring (Horizontal), L_h (cm)	
Length of the spring (vertical), L_v (cm)	
Extension of spring length, $\Delta L = \lvert L_h - L_v \rvert$ (cm)	
Effective mass of the spring, m (kg)	
Actual mass of the spring, M (kg)	
Ratio of the masses, m/M	

QUESTIONS:

1. To what extent does your graph agree with Hooke's Law?

2. How does your calculated and measured values of the spring mass compare?

3. Did the graph passes through the origin? If not, interpret the meaning of the y-intercept.

4. From your understanding of the Hook's law and the graph you plotted, explain why the position of the equilibrium does not effect the graph.

Prelab:

1. A force of 5 N to is required to compress an industrial spring by 0.0001 meters, how much force is required to compress this spring by 0.0003 meters?

2. You have a certain set-up of a vertical spring, and when hung freely the equilibrium position reading is 30cm on earth. If you take the same set-up on the moon surface, would the equilibrium position be more than, less than or equal to 30cm? Explain.