Hooke's Law

Experiment ~ Investigating Hooke's Law

Purpose of Experiment

Everybody knows that when you apply a force to a spring or a rubber band, it stretches. A scientist would ask, "How is the force that you apply related to the amount of stretch?" This question was answered by Robert Hooke, a contemporary of Newton, and the answer has come to be called Hooke's Law.

When matter is deformed (compressed, twisted, stretched, et cetera) and the deforming forces are sufficiently small, the material will return to its original shape when the deforming forces are removed. In such cases, the deformation is said to take place within the *elastic limit* of the material, i.e., there is no permanent deformation. The slight stretching of a rubber band is an example of an elastic deformation. Steel wires, concrete columns, metal beams and rods and other material objects can also undergo elastic deformations. For many materials, it is approximately true that when the material is stretched or compressed, the resisting or restoring force that tends to return the material to its original shape is proportional to the amount of the deformation but points in a direction opposite to the stretch or compression. This idealized behavior of matter is called **Hooke's Law.**

You can investigate Hooke's Law by measuring how much known forces stretch a spring. A convenient way to apply a precisely-known force is to let the weight of a known mass be the force used to stretch the spring. The force can be calculated from $W = mg$. The stretch of the spring can be measured by noting the position of the end of the spring before and during the application of the force.

Activity 1 ~ Varying the mass M and measuring the stretch in the spring

General Procedure

1. Choose the increments of mass to be used in the experiment. Keep the spring constant in mind when making this choice. The different springs in the set have spring constants of approximately 4 N/m, 8 N/m, and 96 N/m.

2. Connect the mass hanger to the bottom of the stretch indicator and place the first mass increment on the hanger. Record the stretch of the spring and the weight of the hanging mass. Don't forget to include the mass of the hanger.

3. Add five more increments of mass, each time recording the stretch of the spring and the weight of the hanging mass.

4. Repeat steps 2-3 for a different spring.

Increment	Spring 1		Spring 2		Spring 3	
	Force	**Stretch**	**Force**	**Stretch**	**Force**	**Stretch**
	weight of the hanging mass	stretch of the spring	weight of the hanging mass	stretch of the spring	weight of the hanging mass	stretch of the spring
1						
2						
5						
4						
5						
6						

5. In Excel, create a graph with “Force” on the vertical axis and “Stretch” on the horizontal axis.

6. Using the trendline feature in Excel, Place the equation for each of the lines on the graph.

Make sure to include appropriate variable, numbers, and units in the equation and on the axis.

7. The slope of the Force vs. Stretch graph is known as the spring constant or rate. The vertical intercept represents the amount of force needed to begin stretching the spring and is also known as the initial tension.

Hooke's Law says that the stretch of a spring is directly proportional to the applied force. (Engineers say "Stress is proportional to strain".) In symbols, F = kx, where F is the force, x is the stretch, and k is a constant of proportionality. If Hooke's Law is correct, then, the graph of force versus stretch will be a straight line.

Do your results confirm or contradict Hooke's Law? Please elaborate.

Look at how much the points scatter around your "best fit" line. The more they scatter, the poorer the precision. Does the graph form some other shape besides a straight line, such as a parabola? (This could mean that Hooke's Law is not valid for this spring.) What is your estimate of the error in *k* and how did you estimate this error? What are the sources of error for your data points and what is the relevance of these errors in your determination of *k*?