20 Hooke's Law

It's Spring Time!

Purpose

To verify Hooke's law and determine the spring constants for a spring and a rubber band.

Required Equipment and Supplies

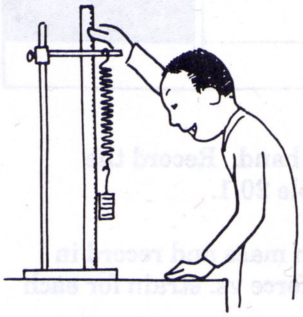
ring stand or other support with rod and clamp
several springs
paper clips
masking tape
meterstick
slotted weights
large rubber bands
graph paper
Data Plotter graphing program (optional)

Discussion

When a force is applied to an object, it may be stretched, compressed, bent, or twisted. The electrical forces between atoms in the object resist these changes. These forces become greater as the atoms are moved farther from their original positions. When the applied force is removed, these forces return the object to its original shape. These forces comprise the *restoring force*. Too large an applied force may partially overcome the restoring force and cause the object to deform permanently. The maximum amount of force with no permanent distortion is called the *elastic limit*.

Hooke's law applies to changes below the elastic limit. It states that the amount of stretch or compression (the strain) is directly proportional to the applied force (the stress). The proportionality constant is called the *spring constant* (or force constant) k. Hooke's law is written $F = -kx$. A stiff spring has a high spring constant and a weak spring has a smaller spring constant.

Procedure



Step 1. Hang a spring from a support. Attach a paper clip to the free end of the spring with masking tape. Clamp a meterstick in a vertical position next to the spring. Note the position of the bottom of the paper clip relative to the meterstick. Place a piece of masking tape on the meterstick with its lower edge at this position.

Step 2. Attach different masses to the end of the spring. With your eye level with the bottom of the paper clip, note its position each time. The strain in each case is the difference between the positions of the paper clip when a load is on the spring and when no load is on the spring. Be careful not to exceed the elastic limit of the spring. Record the mass and strain of each trial in the first section of Data Table 20.1.

Step 3. Repeat Steps 1 and 2 for two more springs. Record the masses and strains in the next two sections of Data Table 20.1.

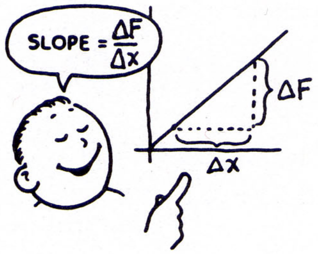
Data Table 20.1

	MASS	FORCE	STRAIN	SPRING CONSTANT
SPRING 1				
SPRING 2				
SPRING 3				
RUBBER BAND				
SPRINGS IN SERIES				

Step 4. Repeat Steps 1 and 2 using a large rubber band. Record the masses and strains in the fourth section of Data Table 20.1.

Step 5. Calculate the corresponding weight of each mass and record in Data Table 20.1. On graph paper, make a graph of force vs. strain for each spring and the rubber band.

Analysis



For each graph that is an upward sloping straight line, draw a horizontal line through one of the lowest points on the graph. Then draw a vertical line through one of the highest points on the graph. Now you have a triangle. The slope of the graph equals the vertical side of the triangle (ΔF) divided by the horizontal side (Δx). The slope of a force vs. strain graph is equal to the spring constant, k. By finding the slope of each of your graphs, determine the spring constant, k, for each spring. If *Data Plotter* is available, you might want to verify the slope of your graph using the computer.

1. How is the value of k related to the stiffness of the springs?

2. Are all your graphs straight lines? If they are not, can you think of a reason why?

Going Further

Springs in Series

Step 6. Repeat Steps 1 and 2 for two springs connected in series (end to end). Record the masses and strains in the last section of Data Table 20.1.

Step 7. Repeat Steps 5 and 6 to determine the spring constant for the combination.