Hooke's Law

Greg C. Jacobs
Woodberry Forest School
Woodberry Forest, VA 22989

Abstract

Today, you will investigate the relationship between the force applied to a spring and the distance the spring stretches -- this relationship is called Hooke's law. This week in class you will discuss springs in some detail. Next week in the laboratory you will determine whether a rubber band obeys Hooke's law.

DAY ONE

Prelab Exercise

Describe a method to measure the force applied by a spring when the spring is stretched. You may use any commonly available equipment for this method.

Objectives

After completing today's experiment, you will be able to:

- Describe in words from your experiences how the force applied by a spring relates to the spring's extension
- Relate your experiment to a future class discussion of Hooke's law
- Discuss relative merits of several methods of measuring force

Materials/Procedure:

You are to make a graph that elucidates the relationship between the force applied by a spring, F, and the distance the spring is stretched, x.

You may use any equipment available in the laboratory.

Safety and Disposal

Assuming common-sense lab protocols (i.e., no shooting rubber bands in each others' eyes!), the only safety issue comes when the springs or rubber bands are stretched near their structural limit. At that point safety goggles are useful.

Lab Tips:

The force *F* applied to the spring can be measured in a variety of ways, using a number of different materials. Be creative. You may use your answer to the prelab exercise; you may solicit suggestions from other groups.

For each applied force, measure the distance *x* the spring stretched *from its original, unstretched position*. A ruler or meter stick will be the most efficient tool with which to measure this distance.

Data/Observations

Though you should not break the spring, be sure you have tested a wide range of displacements.

For some springs, the graph may not be linear for small displacements. This is sometimes because the coils stick together. If this happens, it is acceptable to apply just enough force to spread out the coils, then redefine the equilibrium position to the point where the coils are barely separated.

It will be to your benefit to kibitz other groups' experiments. Note what other possible force-measuring methods you see. Also, observe similarities and differences between your spring and other groups' springs.

Analysis

You are likely to find a linear relationship between force and displacement. Determine and state the slope of your graph (with appropriate units, of course!).

The slope of the *F* versus *x* graph is called the **spring constant**, and is indicated by the variable *k*.

Before answering the discussion questions, share data with at least two other groups. In your notebook, record the spring constants determined by these two other groups. Be careful about units -- in order to make a valid comparison, all the spring constants must be put into the same units. It will also be useful to write a brief description of the other groups' springs, paying attention to how their springs differ from yours.

Questions to Answer:

1. Describe in words what the spring constant tells you about a spring. Include specific reference to other groups' springs (and their spring constants) in your discussion.

2. In an automobile's (or a train's) suspension, the wheel assembly is connected to the passenger compartment using several springs. You may even have seen these springs before. Comment on how the spring constant of an auto spring compares to the spring constant you measured today.

DAY TWO

Prelab Exercise

Describe a method with which to determine whether a rubber band obeys Hooke's law. You may use any commonly available lab equipment.

Objectives

After today's experiment, you will be able to:

- Apply your understanding of Hooke's law to noncanonical situations
- Interpret a graph that does not represent a simple mathematical function
- Explain the limits of the validity of Hooke's law

Materials/Procedure:

You are to determine whether the rubber band you are given obeys Hooke's law. You may use any equipment available in the laboratory.

Lab Tips:

Be sure to test a wide range of displacements.

Data/Observations

Record whatever data and graphs you consider necessary in order to determine whether the rubber band obeys Hooke's law.

At a minimum, you should be able to either:

- Justify the nonexistence of a spring constant, with reference to last week's lab

or

- Justify the rubber band's obedience to Hooke's law, based on a graph

Note that the answer will likely be more complicated than a simple "yes" or "no."

Analysis

You will write a very brief account of this week's experiment. Your account will consist of two paragraphs:

> Paragraph 1: Experiment
> Describe what you measured and how you measured it. This should take no more than three to four sentences. It will be useful to include a diagram, but a diagram is not a substitute for a verbal description.
>
> Paragraph 2: Analysis
> State whether or not the rubber band obeys Hooke's law, and justify your answer with reference to your data. Remember, the answer will likely be more complicated than a simple "yes" or "no."

This account should be very short -- it may not take up more than a handwritten page. So, include *only* substantive information that contributed to your conclusion. Eliminate filler material, such as lists of equipment or irrelevant information about the data recording process.