Hooke's Law Investigation

Objectives

1. Investigate the relationship between Force, displacement, and energy.
2. Measure force and displacement of springs.
3. Find k (spring constant) from a graph.
4. Validate Hooke's Law.
5. Apply Hooke's law to solve problems.
6. Utilize Hooke's Law to determine unknown masses and an unknown g value.

Background Information

In 1678 English Physicist Robert Hooke published that "As the extension, so the force". He established that most solids behave (at times) with elastic properties; even very "inelastic" materials like steel will behave elastically under large loads.

In this lab you will determine the spring constant for a given spring. Operating within their elastic limits, most springs exhibit a linear relationship between the loads placed on them and the length that they are stretched. You will use several different weights in this lab to determine the spring constant of a spring based on the length it stretches.

Hooke's Law states that: force is directly proportional to the extension of spring and can be written as:

$$F = -k \cdot x$$

Where:
F = stretching force applied to the spring
k = spring constant
x = extension (or stretch displacement) of the spring

The negative sign indicates that the force always acts to bring the object back towards its equilibrium position. This is commonly called a restoring force.

Hooke's law states that extension of a spring is proportional to applied force. If a spring obeys Hooke's law, then a graph of applied force against extension will be a straight line, whose gradient (slope) is k.

Hooke's Law is an equation for a straight line where k is the slope of force versus extension graph.
Also, the work done by F (Elastic potential energy) is equal to U = $\frac{1}{2}kx^2$.

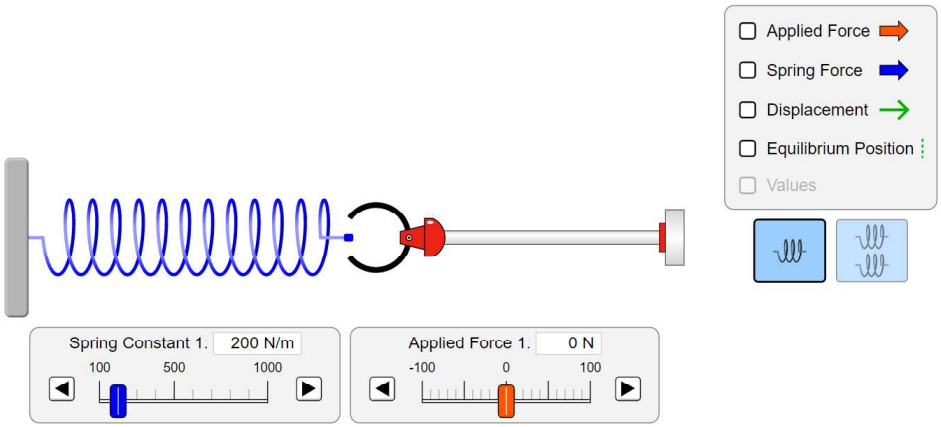
Where:
U= elastic energy
k= spring constant
x= extension of the spring

Lab Equipment

- pHet Website - https://phet.colorado.edu/en/simulation/hookes-law
- pHet Website - https://phet.colorado.edu/en/simulation/masses-and-springs
- Hooke's Law apparatus (clamps and ring stand)
- Weight hook
- notched weights (see picture)
- Springs (table set of 6 springs)
- Meter stick

Experimental Procedures (if virtual only) – Record all data measurements in your lab notebook.

1. Open the first pHet link above on Hooke's Law and click on "Intro". You will see the following screen.



Exploration - Intro

2. Click on Applied Force, Spring Force, Displacement, Equilibrium Position and Values. Which point is taken as reference to measure spring displacement? (the free end or the fixed end)?

3. Stretch and compress the spring. What is the relationship between Applied force and Spring force, (in terms of direction and magnitude)?

4. When the spring is stretched or compressed, what is the relationship between the direction of Spring Force and the displacement?

5. For a spring constant of 200 N/m, when you apply 100 N force on the spring, what will be its displacement? Verify it using formula: $F = -k\,x$. Keep the force 100 N. Increase value of the spring constant. How does the displacement change?

6. If a horizontal spring has a spring constant of 80.0 N/m. What force must be applied to the spring to compress it by 4.0 cm? (use the formula above)

7. If a horizontal spring is stretched 0.50 m and the force was 30,000 N, what is the spring constant? (use the formula above)