

Hooke's Law: Spring's and Elastic Potential Energy

Required Lab for the Physics Regents Exam

Introduction: Springs are interesting devices. They are able to absorb energy and then return it to a system. For example, a toy dart gun may have a spring in it such that when you press the dart into the gun, you compress the spring. When you pull the trigger, you release the dart and the spring ejects the dart from the gun. The work you did by pressing the dart into the gun against the spring is returned in the form of the kinetic energy of the dart as it exits the toy.

Another aspect of springs is the one that Robert Hooke (a contemporary and rival of Isaac Newton) discovered with regard to springs. He noted that the amount of force needed to stretch or compress a spring is directly proportional to the distance the spring is stretched or compressed (he termed the stretching and compression: deformation.). This has since been codified into Hooke's Law: The amount of deformation of a spring is directly proportional to the force causing the deformation as long as the force does not exceed the spring's elastic limit.

In this lab we will investigate the elastic properties of a spring and determine the work done stretching it, and thus the potential energy stored in the spring.

Materials: Lab Stand, hooked mass set, two springs of differing stiffness, meter stick.

Procedures:

1. Set up the lab stand with the pendulum clamp so that the clamp is at least 50 cm above the top of the table.
2. Attach one of the spring onto the pendulum clamp by removing one of the knobs, putting its threaded end through the loop on the spring and reattaching the knob to the clamp.
3. Measure the distance from the tabletop to the bottom loop of the spring. Measure to the "flat" loops, not the bottom of the loop that you can hang things from. This distance is called the **Rest Position**. Record it as such on the Data page.
4. If place a 10 gram hooked mass on the end of the spring. If this mass moves the spring a significant amount (about 1 centimeter), then measure the distance from the tabletop to the bottom loop you measured the *Rest Position* to. Record this as your first distance in the **Distance from the table to the Bottom of the Spring** column in the data table. If the spring **does not** stretch a significant amount (less than 0.5 cm) use 100 grams instead.
5. Continue adding hooked masses in 10-gram increments to the spring until you have a total of 100 grams on the spring. Measure the distance that each new amount of mass stretches the spring. If you are starting with the 100 gram mass, then make your increment in 100 gram amounts and add mass until you reach 1000 grams.
6. When you have finished with 10 distances and masses for one spring, take it off the clamp and attach a new spring on the clamp and repeat steps 3 – 5.
7. After you have finished the second spring, return your materials to the side benches.

Observations:

1. Determine the **Weight of the hanging mass** using: $F_g = m \cdot g$
Where: F_g = the weight of the hanging mass in Newtons.
 m = mass in **kilograms**. Remember, you were thinking of the mass in terms of grams...**SO**, divide the mass by 1000 to get the mass in kilograms (move the decimal three to the left!)
 $g = 9.80 \text{ m/s}^2$ – the local acceleration due to gravity
2. Determine the **elongation** of the spring by subtracting the *Distance from the table to the Spring* from the *Rest Position* of the spring.

3. Determine the spring constant using: $k = \frac{F}{x}$

Where: k = the spring constant in N/m.

F = the force stretching the spring in Newtons. This is the **weight** of the hanging mass.

x = the elongation of the spring in meters found in step 2.

4. Determine the potential energy stored in the spring using: $PE_s = \frac{1}{2}kx^2$

Where: PE_s = the elastic potential energy in Joules stored in the stretched spring.

k = the spring's spring constant in Newtons/meter found in Step 3 above.

x = the elongation of the spring in meters found in step 2.

5. Determine the average spring constant for each of your springs.

Conclusions:

- Construct a graph of the Force required to stretch a spring versus the elongation of the spring in the following manner: Label and plot Force Stretching the spring on the y axis (vertical axis), and label and plot the elongation of the spring on the x axis (horizontal axis). Yes, I realize that according to the manner with which we collected our data, the Force was the Independent variable, but please indulge me for the moment.
 - Plot two graphs for each of your springs.
 - Determine the slope of each of the graphs.
 - Compare the slope of each of the graphs to the corresponding average spring constant for that spring by using a percent error calculation.
- Choose the elongation of the fifth trial or fifth mass for each of the springs. Draw a vertical line from the line on your graph to the x axis at that elongation, and shade the triangular area below the graph and above the x axis.
 - Determine the area of this triangle mathematically. What have you found by calculating this area?
 - Compare this area to the value of the potential energy you found for this elongation by using a simple comparison. Do these value equal each other? Should they? Explain any significant discrepancy you have between the area and the potential energy.
- Using the elongation of the first amount of mass, find the nearest elongation on that spring that is triple that first elongation. Compare the potential energy of the first elongation to the tripled elongation by making a ratio of the tripled elongation to the first elongation. What is this ratio? What it should have been?
- Using the data of the stiffer of the two springs, determine the following: If you were designing a catapult to use this spring to shoot a cart along a horizontal track (essentially frictionless), how far would you need to stretch this spring in order to have it propel the cart with a velocity of 5.00 m/s, if the cart had a mass of 0.500 kg?

Data Page

Spring 1:

		Rest Position =				
Trial	Total Hanging Mass in Kg	Weight of Hanging Mass in Newtons	Distance from Table to bottom of spring in Meters	Elongation in Meters	Spring Constant in N/m	Elastic Potential Energy in Joules
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
			Average Spring Constant =			

Spring 2:

		Rest Position =				
Trial	Total Hanging Mass in Kg	Weight of Hanging Mass in Newtons	Distance from Table to bottom of spring in Meters	Elongation in Meters	Spring Constant in N/m	Elastic Potential Energy in Joules
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
			Average Spring Constant =			