HOOKE'S LAW

Poor Robert Hooke...you even get portraits of Newton when you google Hooke.

INTRODUCTION

Poor Robert Hooke. Anything he could do, Newton did better. Imagine being almost, but not quite, as much of a genius as Newton. And living at the same time as Newton did, so that every good idea (and Hooke had a lot of them) is met with an even better one from Newton. Now, neither man had a particularly endearing personality, but it's hard not to feel a little sympathy–if not for Newton, we would probably learn *Hooke's* Laws of Motion, and *Hooke's* Universal Gravitation. I suppose getting your name on the law that governs springs is something, but not much.

Elasticity is the tendency of a solid object to return to its original shape after being stretched or compressed. According to Hooke's Law, elastic deformation is proportional to the amount of force applied. A rubber band is pretty obviously elastic; the whole point of a rubber band is to snap back to its original shape after you stretch it (ouch!). Metals are also typically elastic, although this is much less obvious, since you can't usually snap a steel band like you can a rubber band (and you generally won't find stainless steel ponytail holders at the Target store). The elasticity of metals makes them useful for any number of applications (those big old-fashioned old-timey cars always have steel bumpers, don't they?), but we can most easily observe the elastic behavior using a metal spring.

Carefully zero the pointer before adding mass!

OBJECTIVES

- Observe the elastic deformation of a spring
- Measure the spring constant using Hooke's Law: $F = kx$
- Graphically show the relationship between deformation and force
- Practice constructing a best-fit line and calculating its slope

EQUIPMENT

- Hooke's Law apparatus with slotted weights

EXPERIMENTAL PROCEDURE

- Attach the sliding centimeter scale to the vertical support rod, then attach the spring with its connected hanger.
- Adjust the sliding centimeter scale to match the position of the pointer with zero cm.
- Add a 50g mass to the hanger. Measure the amount of spring stretch by recording the new position of the hanger.
- Continue to add mass and measure the spring stretch until you have five data pairs. Always measure the spring stretch from the original unstretched position.
- Watch your units! Record the mass in kilograms, and the stretch in meters. Remember that 1 kg = 1000g, and that 1 m = 100 cm. For example, a 5cm stretch should be recorded as 0.05m.

DATA & ANALYSIS

If you have not done so already, create a neat and logical table of applied force (calculated from the total amount of mass suspended from hanger) and spring stretch (in meters).

MASS (kg)	FORCE (N)	STRETCH (m)	MASS (kg)	FORCE (N)	STRETCH (m)
0.50			0.200		
0.100			0.250		
0.150					

1. Calculate the force applied to the spring by the hanging mass:

$$F = mg$$

   where m is the mass in kg, and g is the acceleration due to gravity ($g = 9.8\ m/s^2$).

2. Prepare a graph of force (y–axis) vs. stretch (x–axis). Use the entire page, and scale your axes carefully. Label your axes and include units. Plot your points accurately, then use a ruler to draw the best–fit line for your data. Do not connect the dots, or force the line to pass through any particular point.

3. Choose two points on the line and calculate its slope (k):

$$k = \frac{(F_2 - F_1)}{(x_2 - x_1)}$$

where points (x_1, F_1) and (x_2, F_2) do not have to be data points, but they do have to be on the line.

4. What are the units on the slope? What do they mean?
5. If you replaced the spring you used with a stiffer spring, what would happen to the slope of the graph? If you were shown a graph with a smaller (less steep) slope, what would you conclude about the stiffness of the spring (compared to the spring you tested)?
6. Does the line pass through (0, 0)? If not, what is the y–intercept? Think about this. What would you expect the intercept to be? If there is zero load, how much stretch should there be? Why doesn't your graph show this?
7. Use the graph to predict how much the spring would stretch if you added an extra 100g of mass to your maximum recorded load.
8. What happens to the spring when you remove the load? Have you permanently deformed the spring?
9. If you had stretched the spring beyond its elastic limit (please don't), how would you be able to tell from looking at the spring? How would you be able to tell from looking at the graph?
10. Explain how the bathroom scale works.

When you step on the scale, why does the needle move?