

PHYS 1405 – Conceptual Physics I
Laboratory # 2
Hooke's Law

Investigation: How does the force felt by a spring vary as we stretch it, and how can we determine the “stiffness” of a spring?

What to measure: Distance a spring is stretched, force felt by the spring

Measuring devices: A meter stick, a force sensor, two unknown springs

Calculations: The spring constant

INTRODUCTION

In the first part of this unit, we will be discussing and getting familiar with forces. Simply put, a force is a push or a pull. Some forces involve things touching (contact forces), while others do not require contact (force at a distance). In this experiment, we will investigate the forces exerted on and by a spring. These forces were first investigated by the British physicist Robert Hooke, and the equation he used to describe the so-called “elastic force” has been dubbed Hooke's Law:

$$\mathbf{F}_{\text{Spring}} = -k\mathbf{x}$$

In this equation, F is the force exerted by something stretching or compressing the spring, and x is the distance that the spring is stretched or compressed from its “rest” position. The letter k represents the “spring constant,” a number which essentially tells us how “stiff” a spring is. If you have a large value of k , that means more force is required to stretch it a certain length than you would need to stretch a less stiff spring the same length. Once you have determined the spring constant of a spring, you can use that k value for all future calculations, unless the spring is damaged in some way.

The negative sign is in the equation because force is a vector quantity. The negative sign tells us that the **direction** of the elastic force is always opposite to the direction of the stretching motion. In other words, if you stretch a spring downward, you feel the spring pull upward. If you want to stretch the spring out and hold it in place, you must apply the same amount

of force the spring is, but in the *opposite* direction. That is, to stretch a spring with spring constant k a distance x and hold it there in equilibrium, you must apply a constant force with a size given by

$$F_{\text{Applied}} = +kx$$

This force that you are applying exactly balances the opposite force exerted by the spring, to achieve an equilibrium situation. In this experiment, we will exploit this fact to find out the values of the spring constants of two springs.

PART 1: General Properties

Note that you have two springs for this lab, color-coded yellow and blue. The yellow spring should already be hanging next to the meter stick. The spring is hanging from a device called a force sensor, which is hooked to the computer. The sensor will tell the computer exactly how much force (measured in newtons) the spring is feeling.

We will not use the sensor for this part of the lab. Just pull a little on each spring (do not pull either to its limits!). Pull each spring out 10 centimeters from its “rest” position.

Question 1: Which spring is more difficult to stretch? Which spring do you think will have the higher spring constant?

Question 2: When you pull the spring out and hold it, you should feel a force being exerted on you by the spring. How does that force compare to the force you are applying? What makes you say that?

Question 3: If you let go of the spring, what will happen to it? Explain why, in terms of forces.

PART 2: Yellow Spring

The first thing we must do is calibrate the force sensor, so that it will only read the force that we are exerting on the spring, and no other forces. Hang the yellow spring from the force sensor next to the meter stick. Do not stretch the spring yet. Hit the “Collect” button on the computer screen and

let the sensor record data for a brief time. Select five data points and average them.

Question 4: What is the size of the force felt by the unstretched spring? Where does this force come from?

It is important to find out what this unstretched force is, because in this lab we are only concerned with the force that you exert on the spring. If you were to pull on the spring now, the force sensor would register *both* the force you were exerting and the force the unstretched spring feels. We can get rid of the “extra” force by “zeroing” the force sensor with the spring on it. With the spring hanging from the force sensor, click the “Zero” button that is next to the “Collect” button. When you hit the “Collect” button again, the sensor should read close to 0.000.

Once you have zeroed out the force sensor, click on the “Collect” button and gradually stretch the spring. The force felt by the spring will be displayed on the graph, and as a stream of numbers on the right of the screen.

Question 5: How does the force change with distance stretched? Explain this behavior in terms of Hooke’s Law.

Now stretch the spring to 10 centimeters past its “rest length.” Click on the collect button and gather a few seconds worth of data. It’s very important to keep the end of the spring steady at all times. Values for the force should appear in the data table at the right of the screen. Average five values and determine the force that you exerted on the spring. Dividing that force by the distance stretched (10 cm) should give the large spring’s spring constant, in units of newtons per centimeter (N/cm).

Repeat your observations for 20, 30, 40, and 50 centimeters. Calculate a value for the spring constant each time. Average all six spring constant values. Construct a data table with the following information for each trial: distance stretched (x in cm), average force (F in N), spring constant (in N/cm).

Distance (cm)	Force (N)	k (N / cm)
10		
20		

30		
40		
50		
		Average =

PART 3: Blue Spring

Remove the yellow spring from the force sensor and replace it with the blue spring. Zero out the sensor with the blue spring hanging from it. Take force measurements for stretches of 10, 20, 30, 40 and 50 centimeters. Determine a spring constant value for all trials, then an average spring constant. Create a data table as you did in Part 2 for this spring.

Question 6: Which spring was stiffer? Which spring really had the higher spring constant?

PART 4: Graphs

Create two graphs to finish the lab report, one for each spring. On each graph, the x-axis will be distance stretched, and the y-axis will be the force felt by the spring. Plot as many data points as you have on each graph. Draw the best line you can through all the data points. Calculate the slope (rise/run) for each line.

Question 7: What number is the slope of the graph roughly equal to?

Materials List

Two springs, labeled yellow and blue
Force sensor
Meter stick