# PHY 221 LAB 04-1: Springs in series and springs in parallel

In this experiment, you will measure the effective stiffness of two springs in series and the effective stiffness of two springs in parallel.

## Qualitative Observations

You should do the following exercises on your own, even if you are in a lab group. It is important that you "feel" the stiffness of a spring or a certain combination of springs.

1. Using your hands stretch the red spring by itself and note whether the spring is easy to stretch or hard to stretch.

2. Connect two red springs end to end. In this orientation, we say that the springs are connected *in series*. Stretch the springs and note whether it is easier or harder to stretch the springs, compared to stretching one spring alone.

3. Now, hold the springs so that they are parallel to one another. In this orientation, we say that the springs are connected *in parallel*. Pull the ends of both springs simultaneously. If this is too difficult to do, you might want to connect the ends of the springs with paperclips. Again, note whether it is easier or harder to stretch than one spring alone.

4. Rank the springs in order of stiffness from low stiffness to high stiffness. In other words, rank them in order from "easier" to stretch to "harder" to stretch.

| **stiffness (from low stiffness to high stiffness)** | **spring description (number of springs, color, orientation, etc.)** |
|---|---|
| 1 | |
| 2 | |
| 3 | |

## Experiment

1. Set up an apparatus similar to what you used last week to measure the stiffness of springs. Measure the stiffness of the following springs. Do each measurement of stiffness three times and calculate the average.

| **spring** | **average stiffness, $k$ (N/m)** |
|---|---|
| red spring | |
| two red springs in series | |
| two red springs in parallel | |
| blue spring | |
| blue and red springs in series | |
| blue and red springs in parallel | |

## Application

1. Write an equation to calculate the effective spring stiffness for N identical springs that are connected in series. Your answer should be in terms of $k$, the stiffness of a single spring, and $N$ the total number of springs connected in series.

2. Write an equation to calculate the effective spring stiffness for N identical springs that are connected in parallel. Your answer should be in terms of $k$, the stiffness of a single spring, and $N$ the total number of springs connected in parallel.

3. Use Newton's second law to derive an equation for the effective stiffness of two springs in series in terms of the stiffness of each spring.

4. Use Newton's second law to derive an equation for the effective stiffness of two springs in parallel in terms of the stiffness of each spring.

5. Calculate the theoretical stiffness for the two red springs in series, the two red springs in parallel, the blue and red springs in series, and the blue and red springs in parallel.

6. Calculate the % difference between the measured and theoretical values for effective stiffness of the series and parallel pairs of springs using the equation below.

$$\% \text{ difference} = \frac{\text{measured value} - \text{theoretical value}}{\text{theoretical value}} \times 100\% \tag{1}$$

7. Suppose that you have 10 red springs in series. What is the effective stiffness of the springs?

8. Suppose that you have 10 red springs in parallel. What is the effective stiffness of the springs?