

Conor Hunt  
Lab Practicum - Hooke's Law

**Brief Overview of the Chosen Lab:**

This lab is designed to help students investigate Hooke's Law. According to the lab, there are three major objectives: investigate Hooke's Law, determine the spring constant of a spring algebraically and graphically, and use Hooke's Law to determine unknown masses on a spring.

The experimental set up includes a spring suspended from a ceiling and a number of free masses, not yet attached to the spring

The simulation used, titled "[Masses and Springs](#)," allows users to directly measure a number of different physical quantities:

- Extension Length (with a ruler)
- Time (with a stopwatch)

In addition to directly measuring these quantities,, the simulation allows for other quantities/system characteristics to be set or adjusted:

- The Mass of the suspended spring
- The Acceleration Due to Gravity (i.e. the planet the measurements are being taken on)
- The Damping

Other information that users can obtain from the settings provided include:

- Energy Graphs (to the left hand side)
- Velocity and Acceleration Vectors for if/when the mass is oscillating

**Includes series of photographs/screenshots or video that document that you completed the activity in full and/or had your students complete the activity:**

Conor Hunt

Laboratory Experiments in  
Physics 1  
**Hooke's Law and The Spring Constant**  
using

([https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs\\_en.html](https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_en.html))

**Objectives:**

1. To investigate Hooke's law
2. To determine the spring constant of a spring graphically and analytically
3. To use Hooke's law to determine unknown masses hung on a spring

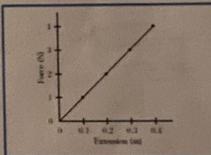
**Apparatus:**

PhET Simulation: Masses and Springs

**Theory:**

Hooke's law is a significant and widely-used law in physics and engineering, and its applications go far beyond springs. Mainly, Hooke's law states that the extension of a spring, whether it is a compression or an expansion, is directly proportional to the applied force.

If a spring obeys Hooke's law, then a graph of the applied force against extension will be a straight line whose slope is  $k$ : the spring constant. Therefore, to graphically determine the spring constant of a spring, the slope of the force versus extension graph must be calculated.



Hooke's law is represented by the straight-line equation:  $F = kx$  where:

$F$  = the applied force (N)

$k$  = the spring constant (N/m)

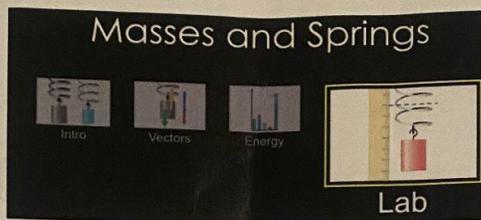
$x$  = the extension of the spring (m)

To analytically determine the spring constant of a spring, Hooke's law must be solved for  $k$ .

The equation yields  $k = \frac{F}{x}$ .

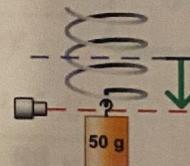
**Procedure:**

Open the following link and click the lab option: [https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs\\_en.html](https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_en.html)



**Part 1: Investigating Hooke's Law and Determining the Spring Constant**

1. Check the 'Displacement' and 'Movable Line' options in the box to the right.
2. Slide the 'Damping' option to 'Lots'; this will help in stopping the spring from springing back to its relaxed position.
3. Slide the 'Mass' option to 50g and place the mass onto the spring.
4. Once the spring stops oscillating, place the dotted red line just below the tip of the green arrow.
5. Use the ruler tool to measure the extension of the spring from the blue line to the red line.
6. The ruler gives measurements in (cm); convert the extension to (m) and record it in table 1.
7. Convert the mass to (kg) and calculate its weight by multiplying it by  $9.8 \text{ m/s}^2$ . Record the weight in table 1.
8. Repeat the experiment for the 100g and 250g masses and record your findings in table 1.

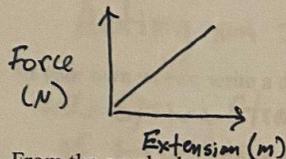


**Table 1**

Mass (g)	Mass (kg)	Weight (N)	Extension (m)
50	0.05	0.49	<del>0.09</del> 0.17
100	0.10	0.98	0.42
250	0.25	2.45	

- a) Using Microsoft Excel, plot a graph of force (weight) versus extension and insert it below. Note: Force (N) is plotted on the y-axis, and extension (m) is plotted on the x-axis.

Sketch



- b) From the graph, determine the value of the spring constant (in N/m).

$$\text{Line of Best Fit} \rightarrow F(x) = (5.93 \text{ N/m})x + 0.03$$

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{\text{Force}}{\text{Extension}} = \frac{2.45 - 0.98}{0.42 - 0.17} = \boxed{5.88 \text{ N/m}}$$

- c) Calculate the value of the spring constant (in N/m) for the 3 trials using Hooke's Law.

Calculate the average value of k.

$$k_1 = \frac{\text{Force}_1}{x_1}$$

$$k_1 = \frac{0.49 \text{ N}}{0.09 \text{ m}}$$

$$\boxed{k_1 = 5.44 \text{ N/m}}$$

$$k_2 = \frac{\text{Force}_2}{x_2}$$

$$k_2 = \frac{0.98 \text{ N}}{0.18 \text{ m}}$$

$$\boxed{k_2 = 5.76 \text{ N/m}}$$

$$k_3 = \frac{\text{Force}_3}{x_3}$$

$$k_3 = \frac{2.45 \text{ N}}{0.42 \text{ m}}$$

$$\boxed{k_3 = 5.98 \text{ N/m}}$$

$$\boxed{k_{\text{avg}} = 5.72 \text{ N/m}}$$

- d) What is the relationship between force and extension?

~~Force~~ 5.72 Newtons of

Force is Needed to Move the Spring 1 meter

- e) What evidence from the graph proves your answer to part c?

Replace w/ "Supports"

The Calculations in Part c Correspond to the Slope (k) of the F vs. x Graph!

- f) Does the value of the spring constant for one spring vary with the magnitude of the force acting on it?

In theory, the Extension length should be Directly Proportional to the Downward Force Acting on it. As a result, the k value should be

- g) In your own words, write a definition for the spring constant (k).

The Spring Strength! The Amount of Force Needed to Move a Spring a Distance of 1 meter.

The Same for Each Pair of F & x Values. These k values are slightly different due to measurement imprecisions.

### Part 2: Determining Unknown Masses Hung on a Spring

Using the average value for the spring constant you calculated using Hooke's Law, work backwards to find the masses of the red and blue hangers in the simulation and record them in table 2 ( $g = 9.8 \text{ m/s}^2$ ).

$$K_{\text{AVG}} = 5.72 \text{ N/m}$$

Table 2

Mass Color	Spring Constant (N/m)	Extension (m)	Weight (N)	Mass (kg)
red	5.72	0.61	3.48	0.36
blue	5.72	0.38	2.17	0.22

### Questions:

1. A spring extends by 20 cm when a force of 2 N is applied. What is the value of the spring constant in N/m?

$$k = \frac{F}{x} = \frac{2 \text{ N}}{0.20 \text{ m}} = 10 \text{ N/m}$$

2. A spring extends by 5 cm when a force of 20 N is applied to it. What force would be needed to extend the spring by 10 cm?

$$k = \frac{F}{x} = \frac{20 \text{ N}}{0.05 \text{ m}} = 400 \text{ N/m}$$

$$F = kx$$

$$F = (400 \text{ N/m})(0.10 \text{ m})$$

$$F = 40 \text{ N}$$

**Describes how the activity connects to physics learning outcomes:**

In terms of its state learning objectives, this lab does provide students with an opportunity to determine the spring constant both graphically and analytically. It guides students to measure the extension length of the spring for 3 different suspended masses. From this data, they create a Force (N) vs. extension length (m) graph and determine the value of the slope (in part b). This connection between spring constant and slope is initially spelled out in the Theory section of the lab. The following question (part c) asks students to calculate the value of the spring constant using Hooke's Law. While not spelled out in the objectives, it seemed as though an additional objective of this section of the lab was to build students' conceptual understanding of the spring constant and what it represents. Questions d, f, and g all ask the student to interpret what the slope means and to spell out the explicit relationship between Force and extension length. This goes beyond just determining/calculating the spring constant.

Furthermore, Part 2 of the lab has students working backward to determine unknown masses. Similar to part 1, students still have to measure extension length, and use Hooke's Law to algebraically determine the unknown masses

**Reflects on the pros/cons and age/development appropriateness of the activity to your own students:**

There are a number of things this lab does well. For one, it gets students to make direct measurements of extension lengths and to use excel to construct a graph of Force (N) vs. extension length (m). Furthermore, Part 1 of this lab gives students practice with calculating the slope of this Force (N) vs. extension length (m), as well as practice using Hooke's Law to calculate spring constant. The questions at the end provide more of this practice as well.

On the other hand, this lab is a cookbook style lab where the objectives and procedures are explicitly laid out for students to follow. As a result, the level of inquiry is extremely low. For example, in Part 1, students are told to calculate weight by multiplying their mass values by  $9.8 \text{ m/s}^2$ . It is likely that students will just follow this step with no consideration as to why this calculation is necessary. Similarly, the unit conversions are just stated as directions to be followed, without any real discussion or consideration as to why they need to be done. Furthermore, students are told exactly what to measure and where to record the measurements, with no considerations for how the physical set up allows for certain quantities to be measured. In my class, I like to ask students, "what things can we measure?" whenever we look at a new experimental set up. There's no attention brought to this in this lab. It's simply a series of steps to follow and plug and chug calculations to complete. This lab provides students a chance to practice rote Hooke's law calculations, but does not do a good job to get students in the act of doing inquiry based science.

**Note: I am going to modify this assignment for Levels of Inquiry (Elective #5)!**