Hooke's Law Lab
AP Physics 1

Objective: I can explain the direction and relations associated with the spring force by collecting empirical data and describing the cause for the overall spring force.

In this simulation, you will be learning more about the spring (aka restoring) force, which is the type of force that occurs when springs are stretched and compressed. We did not talk about the spring force in detail during the forces unit, but it will be important now.

When we work with springs, we assume the springs themselves to be massless, and we typically hang some mass from it. A common example is a spring attached to a block with mass m on one end. The spring force then follows a law – Hooke's Law – in regards to describing the motion of the mass. The spring constant, *k*, is a property of the spring that essentially represents how "stiff" a spring is: a higher value means stiffer spring.

Part 1: Forces
Note: Table 7 does not have a force sensor. For those at Table 7, skip steps 1-4 and you will instead be hanging masses from a spring that is vertical. You will use $k = \frac{mg}{\Delta y}$ and the applied force will be mg for the hanging mass instead. Other tables: if you wish to follow this procedure and NOT use force sensors too, you can do so. Otherwise, proceed below.

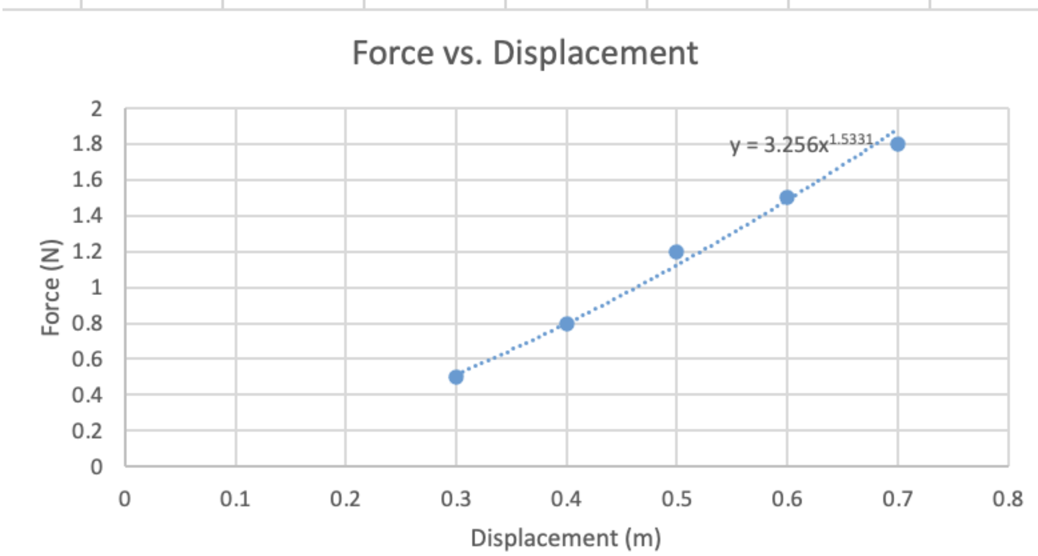
1. For your group, have one person connect the PASCO interface to their laptop via USB or Bluetooth.
2. Open PASCO Capstone and choose any display which has a "1.23" indicated on its picture.
3. On the left side of the screen under "Hardware Setup", make sure "Force Sensor" is present. If so, close Hardware Setup by clicking on the menu name again.
4. Press "Zero" on the force sensor with the spring attached horizontally.
5. Hang the spring from the force sensor hook. Record data and pull the spring with a constant force. Solve for the spring constant using the spring's displacement and the following equation:
$$k = \frac{F}{\Delta x}.$$
6. If your spring is hanging from the blue force sensor, press "Zero" on the force sensor.
7. Click "Record" and pull the spring with a constant force.
8. Record values for displacement of the spring (NOT the length of the spring) and force. ***<u>Keep in mind that displacement has direction! Take down to be positive.</u>*** Also, enter your data into the excel document on Schoology.
9. Change the pulling force and repeat Step 8.

Table 1. Data showing the displacement of the spring from equilibrium and the force applied to the mass.

Spring Constant = ________2.6__________ N/m (from Step 4)

Displacement (m)	Applied Force (N)
0.3meters	0.5N
0.4meters	0.8N
0.5meters	1.2N
0.6meters	1.5N
0.7meters	1.8N

10. Create a graph for applied force vs. displacement using the Excel file on Schoology. Add a power trendline (or, instead, a linear trendline if the power trendline has a power close to 1). Then screenshot it and include it below



11. Determine the slope of your trendline (do a power fit first! If the power is close to 1, choose a linear fit instead). What does it physically represent in terms of values you have listed in Table 1? The slope of our trendline following a linear fit is 3.3, this means that for every 0.1 meters that the spring stretches there is an increase of 3.3 Newtons.

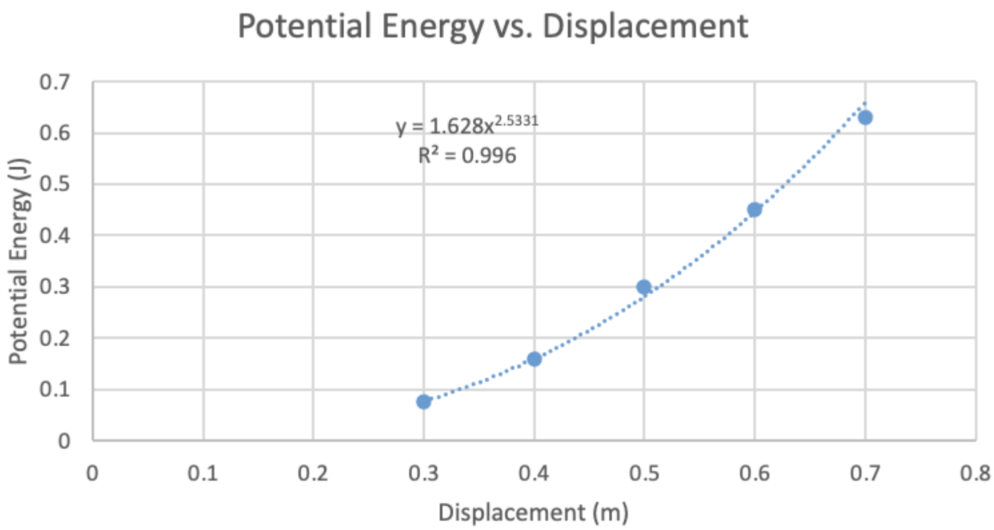
12. <u>Question:</u> What does the spring force do?
    a. Formulate a statement about how the spring force relates to the applied force: "The restoring force is equal (compare magnitude) and opposite (compare direction) to the applied force."

13. Complete the equation: F_{spring} = -kx

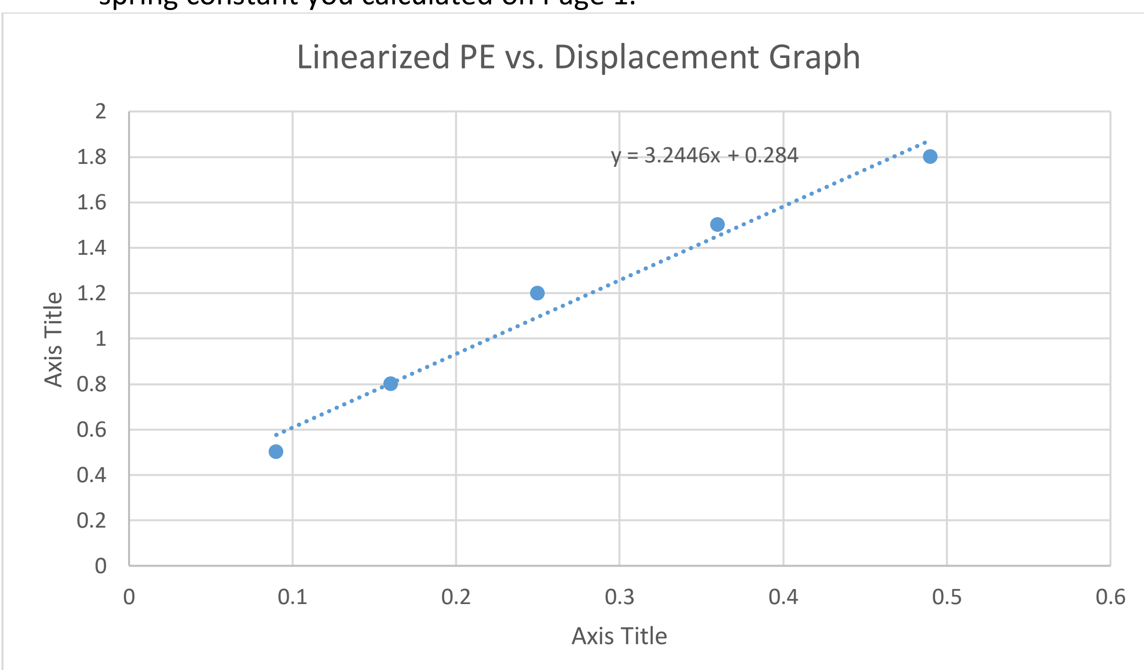
Part 2: Spring Potential Energy

Spring potential energy refers to the energy stored inside the system (spring + mass) that can be converted to "useful" energy – such as kinetic energy.

1. In the Excel file, Potential Energy should be calculated automatically. Add a power trendline and screenshot it, along with the data table from Excel, to add below.



2. Create a linearized PE vs. displacement graph below and compare the slope to the spring constant you calculated on Page 1.



3. Analyze the slope of the linearized graph in which the trendline is linear. What is it equal to? What might it represent physically? The slope of the trendline is 3.2446, this slope is approximately equal to the slope of the Force vs Displacement graph. Physically what it represents is a measure of what the spring is and what the spring constant is.

Before you attempt the quiz, you should be able to (rhetorical questions for you to consider)…

1. Determine how the spring force relates to the applied force
2. Relate the direction and magnitude of the spring force to the direction and magnitude of the displacement from equilibrium of the spring
3. Analyze a force vs. displacement graph and determine what the slope represents
4. Analyze a potential energy vs. displacement graph and determine what the slope of the linearized version of the graph represents
5. Determine the causes of the spring force (hint: think about what causes a normal force) and the applied force (how would you move the mass in real life?)
6. Relate potential energy to the force vs. displacement graph