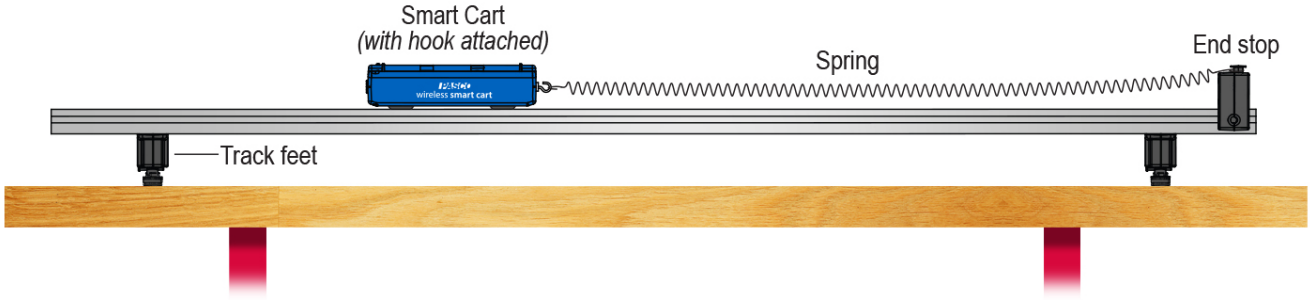
Investigation 5B: Hooke's law

Essential question: How are force and displacement related when stretching a spring?

In this investigation you will measure force from the spring, and spring deformation (*spring deflection*) using the force and position sensors on the Smart Cart.

Part 1: Extension and spring force

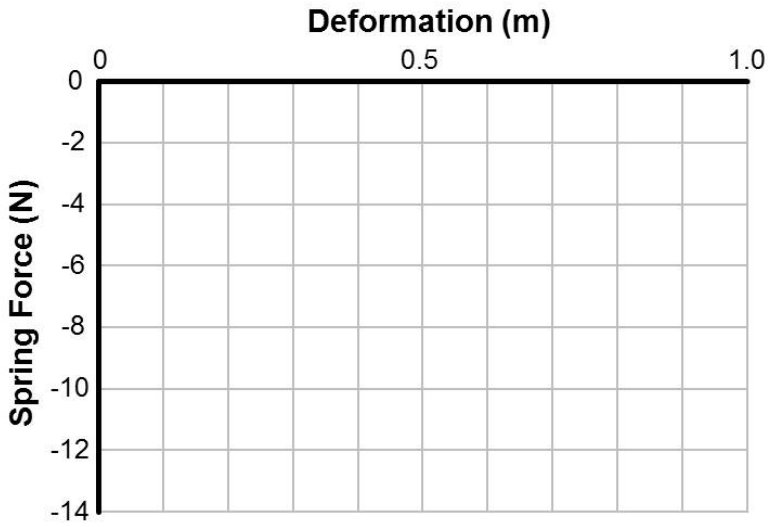
1. Set up the equipment like the picture using the loosest of the three springs.



2. Open the **05B_HookesLaw** experiment file in your software, and then connect your smart cart using Bluetooth.
3. In your software, zero the Smart Cart force sensor while nothing is touching the hook.
4. Begin recording data, and then pull the cart backward (extending the spring) about 10 cm and hold it in place. Use the check mark in the software to record your first data point.
5. Keep pulling the cart backward and record four more data points at four different deformation lengths (any lengths will work as long as they are in order from shortest to longest).
6. Stop recording data, and then copy your data into Table 1. Sketch a copy of your graph.

Table 1: Loose spring deformation data

Deformation (m)	Spring Force (N)



Part 2: Stiff and loose springs

1. Repeat the experiment using the medium and stiff springs.
2. Copy your data in the tables below, and then sketch the graphs for each spring.

Table 2: Medium spring deformation data

Deformation (m)	Spring Force (N)

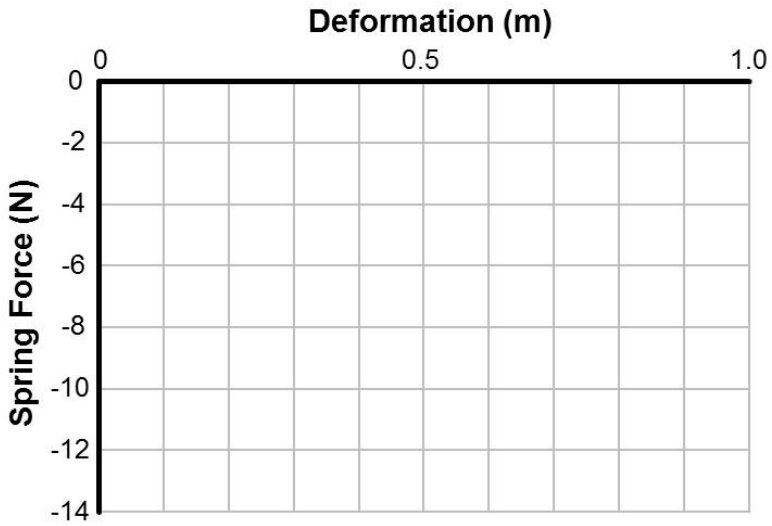
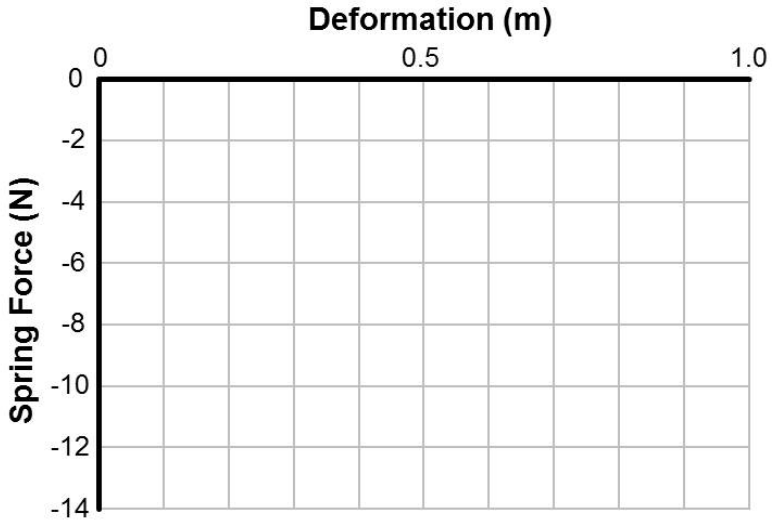


Table 3: Stiff spring deformation data

Deformation (m)	Spring Force (N)



Questions

a. When you stretch the stiffest spring by hand, how does it feel or respond that is different from the loosest spring? In supporting your answer, use data from your investigation.

b. How does the extension of the stiffest spring compare to that of the loose one for the same applied force?

c. What are the slope values of the three graphs? (Include units in your answer.)

d. What physical quantity do the slopes of your graphs represent? Why?

e. What is the spring constant of each of the springs? (Include units in your answer.)

f. Use your data to determine the force each spring would exert at these other deformations.

Deformation *x* (m)	**Loose Spring Force *F* (N)**	**Medium Spring Force *F* (N)**	**Stiff Spring Force *F* (N)**
0.47			
1.31			
2.22			

Applying new knowledge

1. Translate the equation $F = -kx$ into an English sentence with the same meaning.

2. Which of these has a higher spring constant, a Slinky® spring or the spring in a car suspension?

3. If the deflection of a spring is doubled, then how much does the force change?
   A. The force is halved.
   B. The force is doubled.
   C. The force increases by a factor of four.
   D. The force decreases by a factor of four.

4. A certain spring has k = 2,000 N/m. How much does the spring deflect under a force of 50 N?

5. Claus pulled on a spring with 15 newtons of force and it extended by 12 cm. What is the value of its spring constant?

6. What is the required spring constant for a vertical spring to support a mass of 10 kg while stretching only 1.0 cm?

7. A car with a mass of 1,500 kg sits on a suspension system that has four identical springs. When the mass of the car was originally placed on the springs, they compressed by 10 cm. What is the spring constant for each spring?

8. Is Hooke's law an exact law of physics or an approximation? Why?

9. Write a multiple-choice question that requires the reader to understand the difference between the free length of a spring, its stretched length, and its deflection x as used in Hooke's law.