

# Hooke's Law of Elasticity

Mechanics: Hooke's law, spring constant, elasticity	GLX setup file: <b>spring constant</b>
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Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Force Sensor	PS-2104
1	Large Base and Support Rod	ME-9355
1	Rod, 45 cm	ME-8736
1	Double Rod Clamp	ME-9873
1	Equal Length Spring Set (red spring)	ME-8970
1	Hooked Mass Set	SE-8759
1	Meter Stick	SE-8695

## Purpose

The purpose of this activity is to determine the relationship of the force applied to a spring and the distance that the spring is stretched.

## Background

A spring that is hanging vertically from a support with no mass at the end of the spring has a length  $L$  (called its rest length). When a mass is added to the spring, its length increases by  $\Delta L$ . The equilibrium position of the mass is now a distance  $L + \Delta L$  from the spring's support. What happens when the mass is pulled down a small distance from the equilibrium position? The spring exerts a restoring force,  $F = -kx$ , where  $x$  is the distance the spring is displaced from equilibrium and  $k$  is the spring constant of the spring ( $k = \frac{F}{x}$ ). The

negative sign indicates that the force is directed opposite to the direction of the displacement of the mass.

## Preview

Use a Force Sensor to measure the force exerted on a spring as it is stretched. Use the Xplorer GLX to record the force. Enter the stretch (displacement) of the spring into the Xplorer GLX.

## Safety Precaution

- Follow all directions for using the equipment.

## Procedure

### GLX Setup

- Turn on the GLX (☺) and open the GLX setup file labeled **spring constant** (check the Appendix at the end of this activity.) The file has a Graph and a Table of Force, pull positive (N) versus stretch (m). The file is set up for you to enter the 'stretch' of the spring.

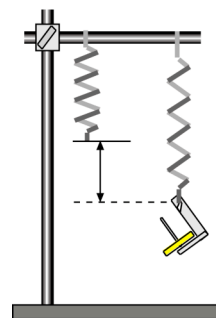


Fig. 1: Stretched spring

No Data	
Force, pull positive (N)	stretch (m)
1	
2	
3	
4	
5	
6	
7	
8	

Fig. 2: GLX table

2. Press  $\text{Home}$  to go to the Home Screen. Press  $F2$  ( $F2$ ) to open the Table screen.
3. Connect the Force Sensor to one of the sensor ports on the top end of the GLX.

### Equipment Setup

1. Attach the hook that's included with the Force Sensor to the end of the sensor.
2. Mount the Force Sensor vertically so its hook end is down.
3. Hang the spring from the sensor's hook.
4. Use a meter stick to measure the position of the bottom end of the spring (without any mass added to the spring). For your reference, record this measurement as the *spring's equilibrium position* in the Data Table in the Lab Report section.

### Record Data

- NOTE: The procedure is easier if one person handles the equipment and a second person handles the Xplorer GLX.
1. Press the tare button on the Force Sensor to zero the sensor.
  2. Press Start ( $\text{Start}$ ) on the GLX. The GLX measures the signal from the Force Sensor, but will not record the data until you press the Flag key.
  3. Press the Flag key ( $\text{Flag}$ ) to record the first force measurement.
- The Table screen will prompt you to enter the 'stretch (m)' at the bottom of the screen.
4. Use the keypad to enter "0.00" and then press  $F1$  ( $F1$ ) to select OK.
  5. Hang a 100 g mass on the spring.
  6. Press  $\text{Flag}$  to record the new force measurement.
  7. Use the meter stick to carefully measure the new position of the bottom of the spring.

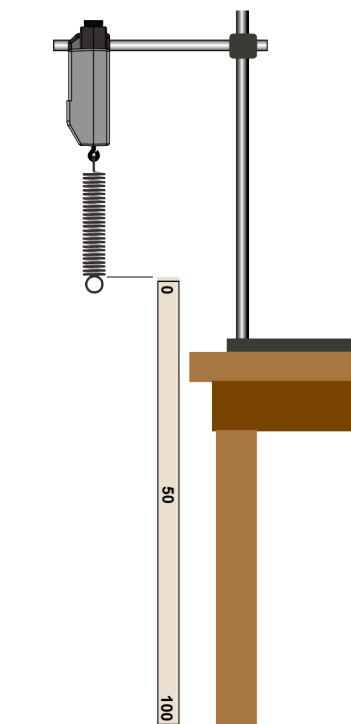


Fig. 3: Equipment setup

Run #1	
Force, pull positive (N)	stretch (m)
1	
2	
3	
4	
5	

stretch (m)

0.00

OK Cancel Num Lock

Fig. 4: Enter 0.00

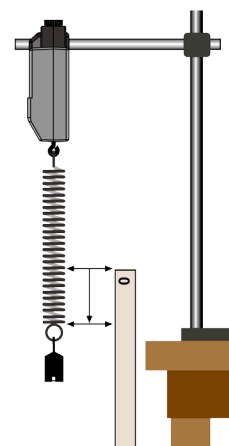


Fig. 5: Hang 100 g

8. Use the keypad to enter the amount of stretch of the spring and then press  $F1$  ( $F1$ ) to select OK.
  9. Hang a total of 200 g on the spring.
  10. Press  $F2$  to record the third force measurement. Use the meter stick to carefully measure the new position of the bottom of the spring. Use the keypad to enter the stretch of the spring and then press  $F1$  to select OK.
  11. Repeat the process. Increase the mass on the spring by 100 g each time until the mass on the end of the spring is 800 g. Press Stop ( $\blacktriangleright$ ) to end data recording.
- The table will display the values of force and the corresponding values of stretch.

### Analysis

1. Press  $F1$  to go to the Home Screen. Press  $F1$  ( $F1$ ) to open the Graph screen of the force and stretch data.
  2. Press  $F3$  ( $F3$ ) to open the Tools menu. Select Linear Fit.
- The *Slope* of the linear fit is the spring constant of your spring.
3. Record the value of the slope in the Lab Report.

### Extension

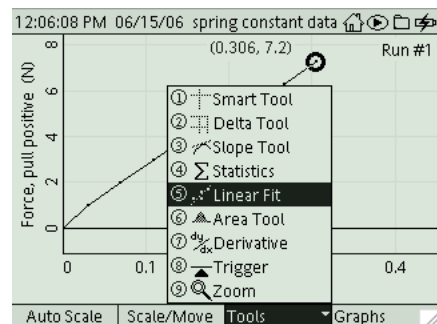
Repeat with a different spring. Try other items that are elastic like a spring, such as a rubber band.

Run #1	Force, pull positive (N)	stretch (m)
1	0.0	0.000
2		
3		
4		
5		

**Fig. 6: Enter the amount of 'stretch'**

Run #1	Force, pull positive (N)	stretch (m)
1	0.0	0.000
2	1.0	0.031
3	2.0	0.070
4	2.9	0.110
5	3.9	0.149
6	4.9	0.189
7	5.2	0.229
8	6.2	0.267




**Fig. 7: Data table**



**Fig. 8: Linear Fit**

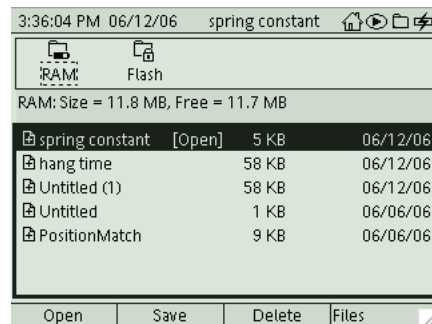
## Appendix

### Opening a GLX File

To open a specific GLX file, go to the Home Screen (press ). In the Home Screen, select Data Files and press the Activate () button. In the Data Files screen, use the cursor keys to navigate to the file you want. Press *F1* () to open the file. Press the Home button to return to the Home Screen. Press *F1* to open the Graph.



Data Files Icon

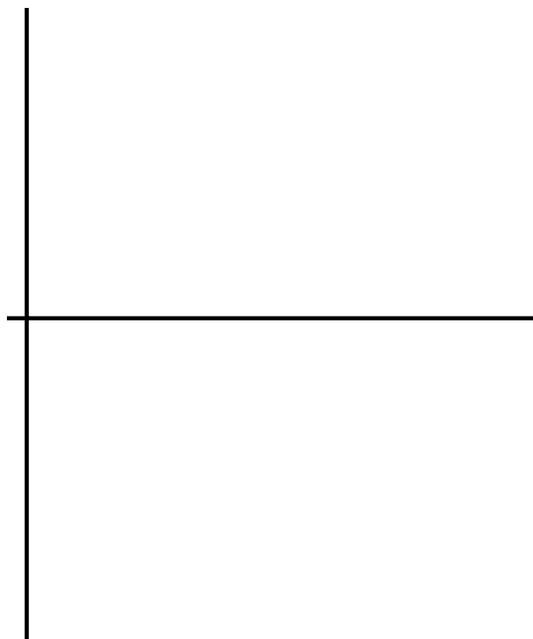


**Lab Report - Activity 11: Hooke's Law of Elasticity**

Name \_\_\_\_\_ Date \_\_\_\_\_

**Data**

1. Make a sketch of your *force versus time* graph including labels for the y- and x-axes.



2. Record your value for the spring constant,  $k$ , of your spring.

Item	Value
Equilibrium Position	m
Spring Constant, $k$ (slope)	N/m

**Question**

1. How well did your measured value for the spring constant compare to the accepted value?

**Problem**

1. If a spring has a spring constant of 3 newtons per meter (3 N/m), how much force is needed to stretch the spring 0.15 m?