

## CH03-3 Springs

Hooke's Law for an ideal spring

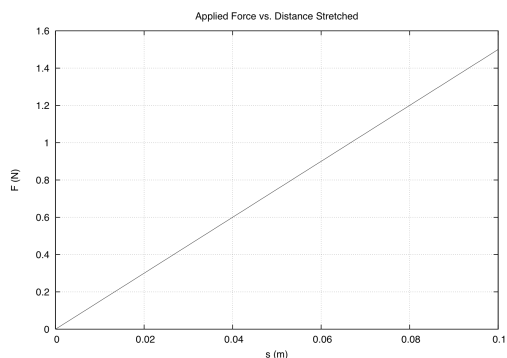
## Experiment

Measure the force  $F$  required to stretch a spring a distance  $s$  from its unstretched length. Plot  $F$  vs.  $s$  and fit a curve to the linear portion of the graph.

Repeat your experiment for various springs.

What does the slope of the  $F$  vs.  $s$  graph tell you?

## Force vs. Distance Stretched



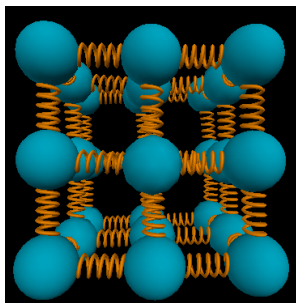
## Hooke's Law

$$|\vec{F}_{spring}| = ks \quad \text{where } s = |L - L_0|$$

The force by a spring on an object attached to the spring is always along its axis and is toward its unstretched length. Thus, a compressed spring pushes outward along its axis and a stretched spring pulls inward along its axis.

## Why are springs important?

If you stretch a spring, it exerts an "inward" force back toward equilibrium. If you compress a spring, it exerts an "outward" force back toward equilibrium. This behavior can be seen in many physical systems. Thus, a spring is the most simple way to model some physical systems.



## Example

A 0.5-kg object hangs from a spring of stiffness 10 N/m. Sketch the forces on both the object and the spring. Note that for a "massless" spring to stretch or compress, it is pulled with equal magnitude forces on both sides of the spring.

### Example

A 0.5-kg object hangs in equilibrium from a spring of stiffness 10 N/m and length 10 cm. Apply the Momentum Principle to the object. How far is the spring stretched and how long is the spring?

### Example

A bathroom spring scale is used to measure a person's weight. Suppose that it is made up of four identical springs in parallel beneath a flat platform. A person of known mass 80 kg steps on the scale. If each spring compresses 0.015 m, what is the stiffness of each spring?

### Example

If you take the scale in the previous question to Moon, which has a gravitational field at its surface that is approximately  $(1/6)g_{\text{Earth}}$ , how far will each spring compress and what weight will the scale read if the same mass person stands on the scale?

### Poll

A spring of stiffness 10 N/m is attached to a stationary bracket. You pull the other end so that you stretch the spring in the +x direction 0.1 m from its unstretched length and you maintain this force. What is the force by your hand on the spring?

1.  $\langle 100, 0, 0 \rangle$  N
2.  $\langle -100, 0, 0 \rangle$  N
3.  $\langle 1.0, 0, 0 \rangle$  N
4.  $\langle -1.0, 0, 0 \rangle$  N
5. zero

### Poll

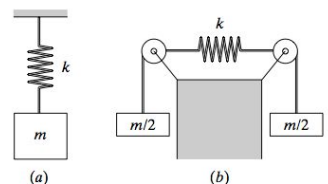
What is the force by the bracket on the spring?

1.  $\langle 100, 0, 0 \rangle$  N
2.  $\langle -100, 0, 0 \rangle$  N
3.  $\langle 1.0, 0, 0 \rangle$  N
4.  $\langle -1.0, 0, 0 \rangle$  N
5. zero

### Poll

The spring in configuration (a) is stretched 0.10 m. How much will the same spring be stretched in configuration (b)?

1. 0.1 m
2. 0.2 m
3. 0.05 m
4. 0.4 m
5. 0.025 m



## Poll

You stand on a spring scale in an elevator. If the elevator is moving upward at a constant speed, the magnitude of the force by the scale on you is

1. Equal to your weight.
2. Greater than your weight.
3. Less than your weight.

## Poll

You stand on a spring scale in an elevator. If the elevator is moving upward and speeding up, the magnitude of the force by the scale on you is

1. Equal to your weight.
2. Greater than your weight.
3. Less than your weight.

## Poll

You stand on a spring scale in an elevator. If the elevator is moving downward and slowing down, the magnitude of the force by the scale on you is

1. Equal to your weight.
2. Greater than your weight.
3. Less than your weight.

## Modeling motion

The force by an expanding or compressing spring on an object is NOT constant as the spring expands or compresses. If you use a compressed spring to launch a dart, for example, the force by the by the spring on the dart changes as the spring decompresses. Constant force equations do not apply. Use a numerical approach to determine the position and velocity of an object attached to a spring.

## VPython

Write a VPython program to calculate the speed of a cart as it leaves a compressed spring when the spring is used to "launch" the cart.