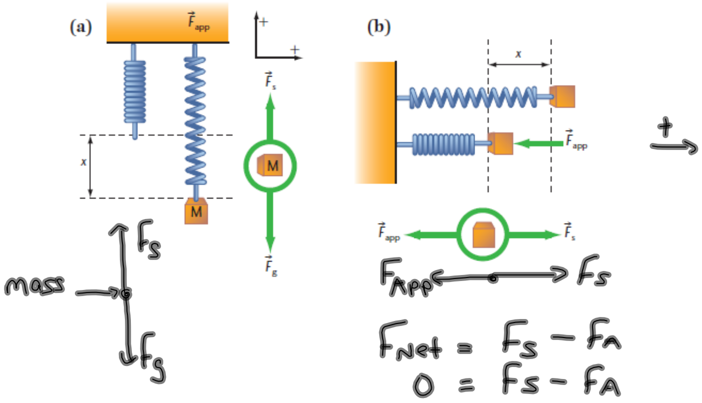
Section 2.6 Hooke's Law

When you stretch or compress a spring, the effect is always the same – the spring tries to restore itself to its original length.



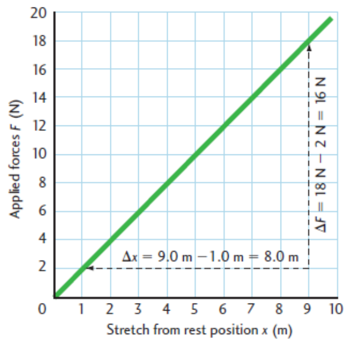
$F_{net} = F_s - F_A$
$0 = F_s - F_A$
$F_A = F_s$

$F_{net} = F_s – F_g$
$0 = F_s - F_g$
$F_g = F_s$

Providing you do not stretch a spring to the point where you turn it into a wire, a graph of the force needed to stretch the spring versus the stretch of the spring from its rest position produces a straight line.

The slope of the the *F*-*x* graph shown at the right has the units N/m and is an indicator of how stiff the spring is. This indicator is called the **spring constant** and has the symbol *k*.

MS (scale in cm) →



Hooke's law: The restoring force of a spring is $F = kx$, where *k* is the spring constant in N/m.

F is the restoring force in Newtons and *x* is the amount of stretch or compression in meters. The amount of deformation of an elastic object is directly proportional to the force applied to deform it. (ie $F \propto \Delta x$).

MC. → $F \propto \Delta x$

ie if I double the force, I will double the amt of stretch.

$\frac{F}{k} = \frac{kx}{k}$ $\qquad$ $\frac{F}{x} = \frac{kx}{x}$

$\frac{F}{k} = x$ $\qquad$ $\frac{F}{x} = k$

Examples

1. A force of 2500 N will compress a car's suspension by 10.0 cm. Calculate the value of k for the spring.

$F = 2500 N$
$\Delta x = 10 cm = 0.10 m$
$k = ?$

$\frac{F}{x} = \frac{kx}{x}$

$\frac{2500 N}{0.10 m} = k$

$25000 N/m = k$

2. The spring in a BB gun has a spring constant of 800.0 N/m.
   A) What force is required to compress it by 10.0 cm from its original length?

$k = 800 N/m$
$F = ?$
$x = 10 cm = 0.10 m$

$F = kx$
$= (800 N/m)(0.10 m)$
$= 80.0 N$

   B) By how much would a force of 50.0 N compress it?

$k = 800.0 N/m$
$F = 50.0 N$
$x = ?$

$\frac{F}{k} = \frac{kx}{k}$

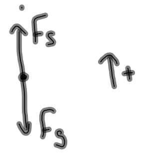
$\frac{50.0 N}{800.0 N/m} = x$

$0.0625 m = x$

or $6.25 cm = x$

3. A spring with k = 1200 N/m is hung vertically from a stand and a mass of 50.0 kg is suspended from it. By how much will the spring stretch?

$k = 1200 N/m$
$m = 50.0 kg$
$x = ?$



* $F_{net} = F_s - F_g$
$0 = F_s - F_g$
$F_g = F_s$
$mg = kx$
$(50 kg)(9.8 m/s^2) = (1200 \frac{N}{m})x$
$\frac{490 N}{1200 \frac{N}{m}} = \frac{(1200 \frac{N}{m})x}{(1200 \frac{N}{m})}$
$0.408 m = x$

$mg = kx$
$\frac{mg}{k} = x$
$\frac{(50 kg)(9.8 m/s^2)}{1200 N/m} = x$

or
$F_g = mg = (50 kg)(9.8 m/s^2) = 490 N$
$F_s = F_g = 490 N$
$\frac{F}{k} = \frac{kx}{k}$
$\frac{490 N}{1200 N/m} = x$

4. A spring is initially 13.0 0 cm long. When a force of 10.00 N is applied to one end, the spring stretches until its full length is 17.20 cm. Calculate the value of its spring constant.

$\Delta x = 17.20\text{ cm} - 13.00 = 4.20\text{ cm} = 0.0420\text{ m}$

$F = 10.00\text{N}$

$k = ?$

$$\frac{F}{x} = \frac{kx}{x}$$

$$\frac{10.00\text{N}}{0.0420\text{m}} = k$$

$$238.1\ \text{N/m} = k$$

5. A spring is initially 16.00 cm long and has a spring constant of 250.0 N/m. What will be its new length if it is stretched by a force of 20.00 N?

$L_1 = 16\text{cm}$

$k = 250\text{N/m}$

$L_2 = ?$ $L_1 + \Delta x$

$F = 20.00\text{N}$

$\Delta x = ?$ ← stretch

$$\frac{F}{k} = \frac{kx}{k}$$

$$\frac{20.0\text{N}}{250\text{N/m}} = x$$

$0.08\text{m} = x$

$8\text{ cm} = x$ ← stretch

New Length = 16 + 8 = 24cm

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