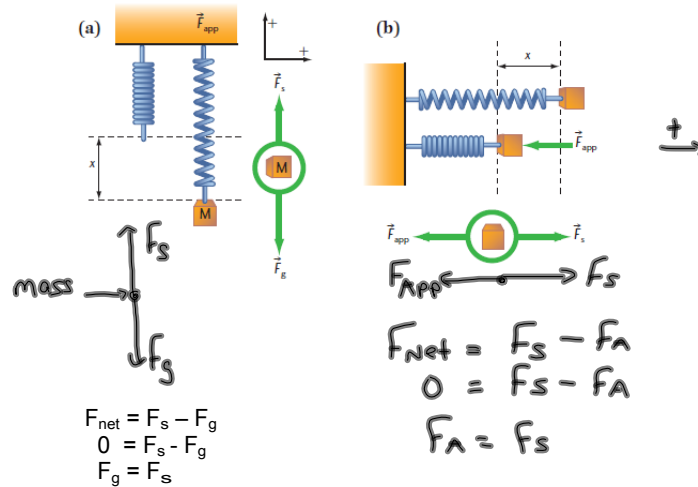


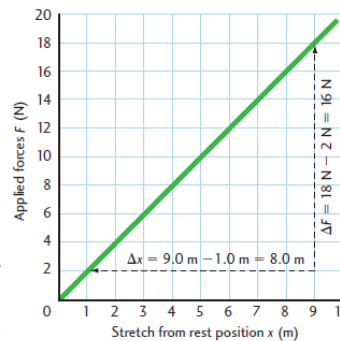
Section 2.6 Hooke's Law

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



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. $\rightarrow F \propto \Delta x$
 ie if I double the force, I will double the amt of stretch.

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

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.

$$\begin{aligned}
 F &= 2500 \text{ N} \\
 \Delta x &= 10 \text{ cm} \\
 &= 0.10 \text{ m} \\
 k &= ?
 \end{aligned}
 \qquad
 \begin{aligned}
 \frac{F}{x} &= \frac{kx}{x} \\
 \frac{2500 \text{ N}}{0.10 \text{ m}} &= k \\
 25000 \text{ N/m} &= k
 \end{aligned}$$

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?

$$\begin{aligned}
 k &= 800 \text{ N/m} \\
 F &= ? \\
 x &= 10 \text{ cm} \\
 &= 0.10 \text{ m}
 \end{aligned}
 \qquad
 \begin{aligned}
 F &= kx \\
 &= (800 \text{ N/m})(0.10 \text{ m}) \\
 &= 80.0 \text{ N}
 \end{aligned}$$

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

$$\begin{aligned}
 k &= 800.0 \text{ N/m} \\
 F &= 50.0 \text{ N} \\
 x &= ?
 \end{aligned}
 \qquad
 \begin{aligned}
 \frac{F}{k} &= \frac{kx}{k} \\
 \frac{50.0 \text{ N}}{800.0 \text{ N/m}} &= x \\
 0.0625 \text{ m} &= x \\
 \underline{\text{or}} \quad 6.25 \text{ cm} &= x
 \end{aligned}$$

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

$$\begin{aligned}
 k &= 1200 \text{ N/m} \\
 m &= 50.0 \text{ kg} \\
 x &= ?
 \end{aligned}
 \qquad
 \begin{aligned}
 * F_{\text{net}} &= F_s - F_g \\
 0 &= F_s - F_g \\
 F_g &= F_s \\
 mg &= kx \\
 (50 \text{ kg})(9.8 \text{ m/s}^2) &= (1200 \frac{\text{N}}{\text{m}})x \\
 \frac{490 \text{ N}}{1200 \frac{\text{N}}{\text{m}}} &= \frac{(1200 \frac{\text{N}}{\text{m}})x}{(1200 \frac{\text{N}}{\text{m}})} \\
 \boxed{0.408 \text{ m} = x}
 \end{aligned}$$

Free body diagram: A vertical line with an upward arrow labeled F_s and a downward arrow labeled F_g . A red arrow points from the $mg = kx$ equation to the F_g arrow.

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

$$\begin{aligned}
 \underline{\text{or}} \quad F_g &= mg = (50 \text{ kg})(9.8 \text{ m/s}^2) = 490 \text{ N} \\
 F_s &= F_g = 490 \text{ N} \\
 \frac{F}{k} &= \frac{kx}{k} \\
 \frac{490 \text{ N}}{1200 \text{ N/m}} &= x
 \end{aligned}$$

4. A spring is initially 13.00 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?

$$L_1 = 16 \text{ cm}$$

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

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

$$F = 20.00 \text{ N}$$

$$\Delta x = ?$$

Stretch

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

$$\frac{20.00 \text{ N}}{250 \text{ N/m}} = x$$

$$0.08 \text{ m} = x$$

$$8 \text{ cm} = x$$

stretch

$$\text{New Length} = 16 + 8 = \underline{24 \text{ cm}}$$

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