https://youtu.be/**3JXFeatTbTo**

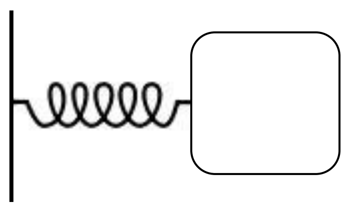
Hooke's Law

Hooke's law relates the amount of stretch or compression to the amount of force applied to the spring. Conversely the force a spring exerts when it is compressed or stretched is also a definition of Hooke's law.

Hooke's law for an Ideal Spring states that the amount of stretch or compression is directly proportional to the force applied to the spring.

This is really only an approximation because most springs are not truly "ideal" and thus do not behave completely linearly. If the spring becomes over compressed, stretched or fatigued the relationship is non-linear and the approximation weakens.

Mathematically:



$$F_s = -k\Delta x$$

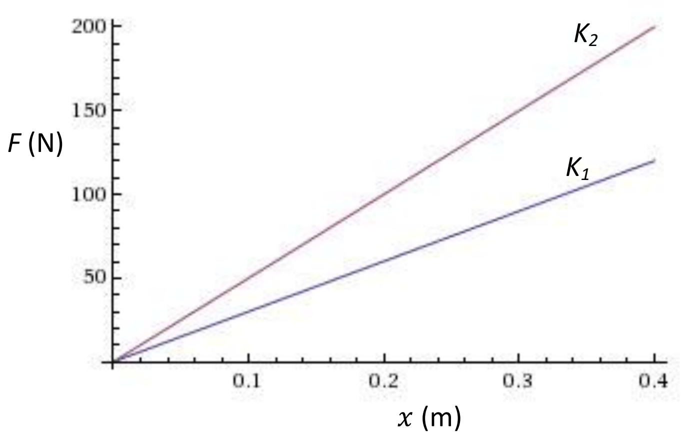
K – spring constant (N/m)
x - stretch or compression

The negative sign is due to the fact that the force the spring exerts is opposite in direction to the applied force.

The ***spring constant***, ***k***, of an elastic object relates to the springs "stiffness" or "looseness". It is different for all springs. The *larger* the value of *k*, the more difficult it is to stretch or compress the spring.

Graphically:

Two springs are shown below. The same forces are applied to each spring and the amount of stretch was recorded.



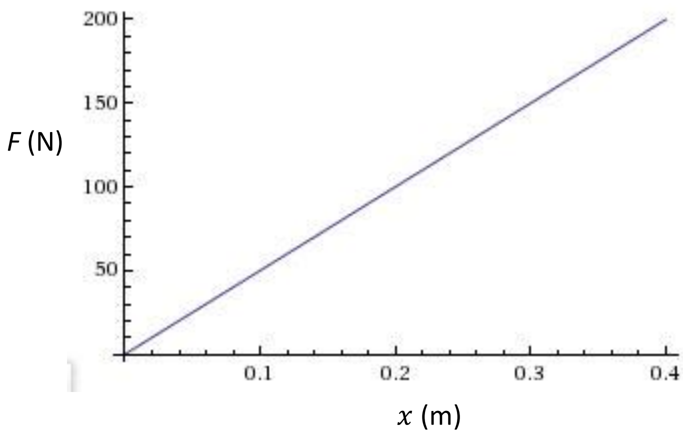
The <u>slope</u> of the line of the $F\ vs.\ x$ graph is the <u>spring constant</u> of the spring.

In the graph spring 1 has a lower spring constant than spring 2; hence a lower slope.

Spring Potential Energy

When a spring is compressed or stretched **elastic potential energy** is stored in it. The amount of energy stored in the spring can be calculated using the derived equation below.

Calculating the energy stored in a spring begins with the work-energy theorem



$$W = \Delta E = F_{av} \Delta d$$

Using the average force and noting that the distance is stretch or compression.

$$E_s = \frac{F_1 + F_2}{2} \Delta x$$

Here we know that $F_1 = 0$ and that $F_2 = k\Delta x$ from Hooke's Law. So we get,

$$\Delta E_s = \frac{k\Delta x}{2} \Delta x$$

This equation can be simplified to

$$E_s = \frac{1}{2} k \Delta x^2$$

Note: This **same result** can be achieved by **calculating the area** between the line and the x-axis from a $F\ vs.\ x$ graph. You might have just realized the *Work is in fact an integral calculation*.

Task: From the graph above **a)** calculate the slope of the line (spring constant) **b)** calculate the amount of energy is required to stretch the spring from 0.1 m to 0.3 m (use both methods).