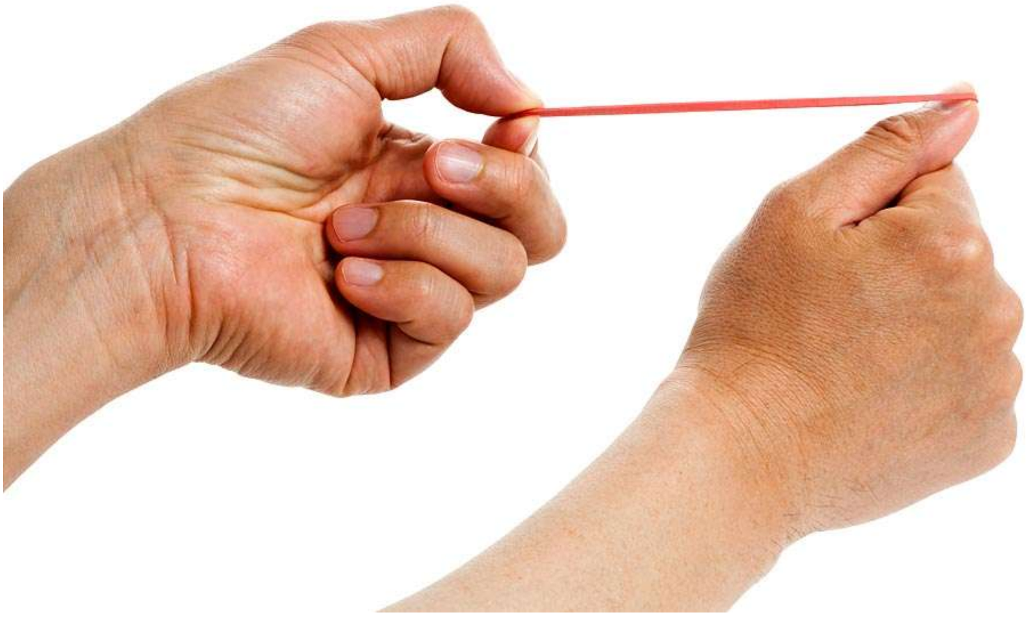
Elastic Potential Energy



1. Types of energy
2. Calculating energy from force graphs
3. Force generated (absorbed) by springs & energy stored
4. Sample problems
5. Summary

Mechanical Energy

energy of motion

$E_k = \frac{1}{2}mv^2$

energy of position

$E_g = mgh$

Conservation of Energy

$E_{Ti} = E_{Tf}$

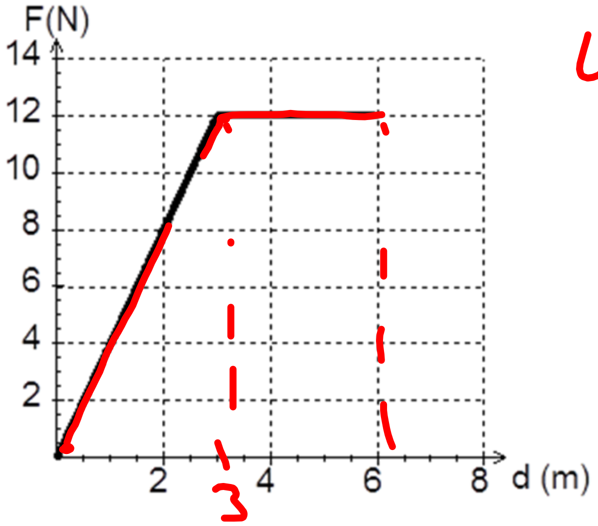
total initial energy = total final energy

Science Asylum

Relating Energy and Force

$$W = \Delta E = \vec{F} \Delta \vec{d}$$

Calculating work when the applied force is not constant.



Work (change in energy) = area under F-d graph

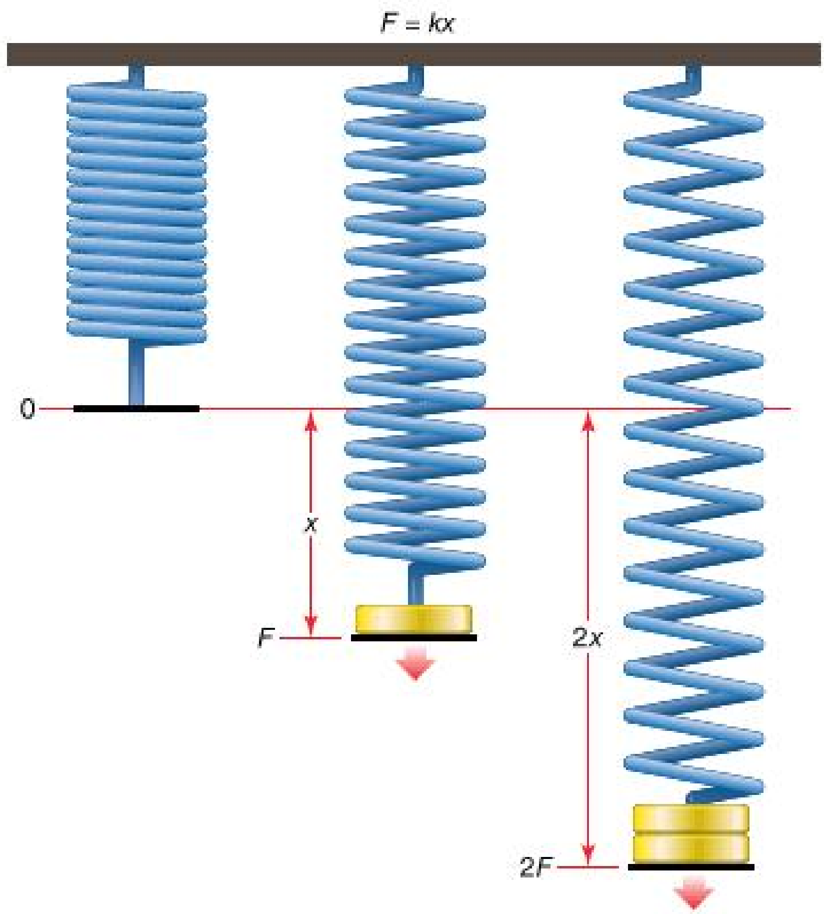
$$W = \Delta E = \frac{1}{2}(3)(12) + (3)(12) = 54\ J$$

$$1\ J = 1\ N \cdot m = 1\ kg\ m^2/s^2$$

If this force is acted on a stationary mass of 1kg and all of the energy is kinetic, how fast will the object be travelling?

$$\Delta E = 54\ J \rightarrow E_k$$

$$v = \sqrt{\frac{2E_k}{m}} = 10.4\ m/s$$

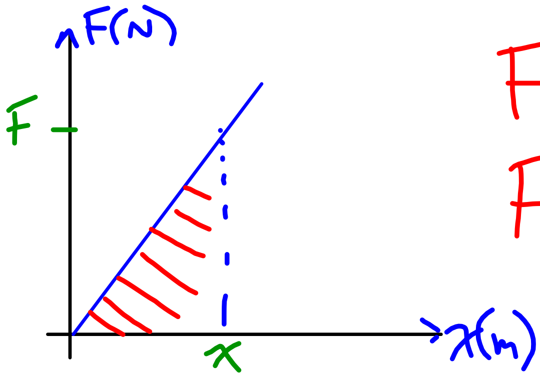


F = kx
0
x
F
2x
2F

Potential Energy (a deeper examination)

Hooke`s Law (for an ideal spring)

The force needed to extend (or compress) a spring a certain distance '*x*' is proportional to that distance.



$F \propto x$

$F = kx$

k - spring constant (also called Hooke's constant)

units on k = N/m

Energy Stored in a Spring

= area under force-dist graph (triangle)

$= \frac{1}{2} x F$ $(F = kx)$

$$E_e = \frac{1}{2} k x^2$$

E_e - elastic potential energy

Units

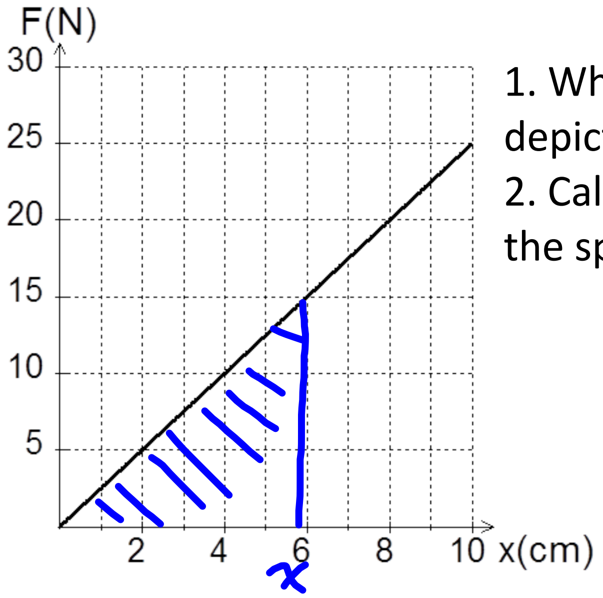
$\rightarrow \frac{N}{m} \cdot m^2$

$\rightarrow \frac{kg\,m/s^2}{m} \cdot m^2$

$\rightarrow kg\,m^2/s^2$

$\rightarrow$ Joule ✓

Example 1: An ideal spring (i.e. obey's Hooke's Law)



1. What is the spring constant of the spring depicted in the diagram to the left?
2. Calculate how much energy is stored in the spring if it is compressed 6 cm.

(or stretched)

1. $k =$ slope or $k = \frac{F}{x}$

$= 250\ N/m$

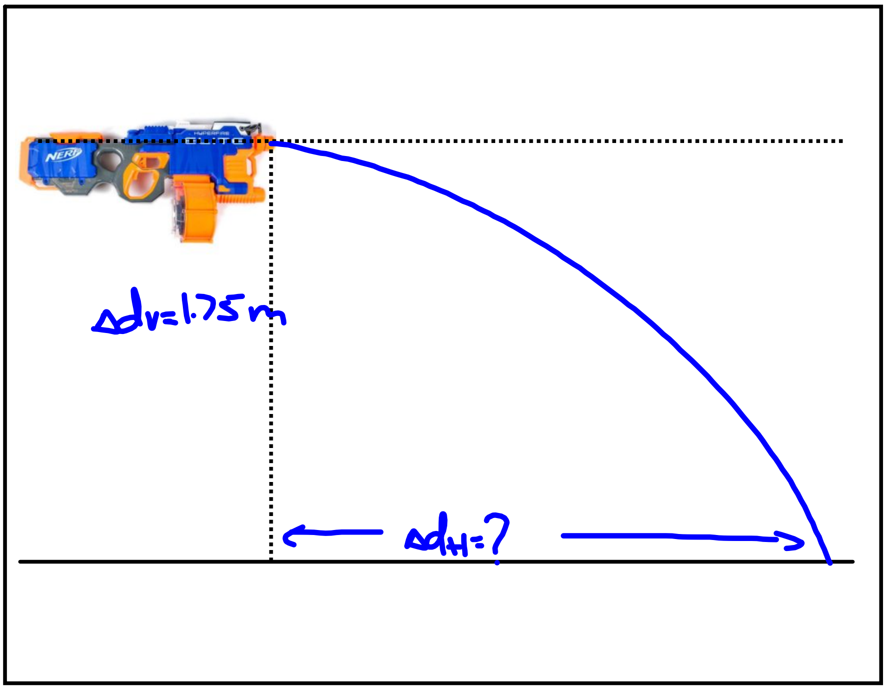
2. $E = \frac{1}{2}kx^2$ $\quad x = 0.06\,m$

$= 0.45\ J$

Example 2 : Nerf Gun

A NERF gun is powered by a spring with a spring constant of 175N/m. The mass of the NERF dart is 0.050kg and the spring is compressed 10cm. You can assume the dart is launched horizontally.

a. What is the launch velocity of the NERF dart.
b. If the NERF gun is held 1.75 m above the ground, how far does the NERF dart travel before hitting the ground



Part A: launch velocity

convert E_e into E_k

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

$$v = \sqrt{\frac{k}{m}}\,\Delta x$$

$$= 5.92\,m/s$$

Part B: Horizontal launch

$V_{V1} = 0$, $V_H = 5.92\,m/s$

$$\Delta t = \sqrt{\frac{2\Delta d_V}{a}}$$

$$= 0.598\,s$$

$$\Delta d_H = V_H \Delta t$$

$$= 3.54\,m$$

Summary

Ideal Spring Formula $F = kx$

Kinetic Energy $E_k = \frac{1}{2}mv^2$

Gravitational Potential Energy $E_g = mgh$

Spring Potential Energy $E_e = \frac{1}{2}kx^2$