Work and Changes in Energy

As mentioned earlier, work can be defined as a change in kinetic energy $W = \Delta E_k = \frac{1}{2}m(\Delta\vec{v})^2$

This definition can be expanded to a change in the total energy of the system.

$$W = \Delta E_t$$

or

$$W = (E_{k_2} + E_{g_2} + \ldots) - (E_{k_1} + E_{g_1} + \ldots)$$

What this implies is that if you take all the inventory of all the forms of energy before and after a particular interaction, you can determine the amount of work that has been done. Since there several forms in which energy can be exchanged in a collision, we will simplify our questions to the essentials.

Example: Consider a car collision on icy road. Assume one car slams into a stationary vehicle. To determine the amount of work done the vehicle that was initially at rest.

Here are the following parameters to consider, gravitational energy E_g, kinetic energy E_k, sound energy E_{sound}, Heat E_{heat} and the list goes on. This is excessive detail for this level physics.

We will limit ourselves to questions involving friction, kinetic energy, gravitational potential energy and spring potential energy.

Review of Grade 11 Concepts

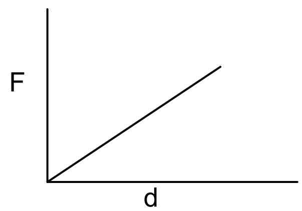
Gravitational potential energy near the earth's surface is defined as $E_g = mgh$. Therefore, the change in gravitational energy is defined as $\Delta E_g = mg\Delta h$. As the height increases, E_g increases.

Example: A 1000kg car initially traveling at 30m/s coast up a hill with an incline of 30^o and stops once it reached a height of 35m

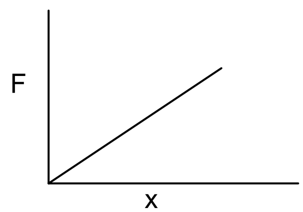
a) Find the amount of energy in system at the bottom of the hill
b) Find the amount of energy in system at the top of the hill
c) Work done by friction
d) Force of Friction
e) Coefficient of friction

Spring Potential Energy

Work is defined as $W = \vec{F} \cdot \Delta\vec{d}$ or $W = F \cdot \Delta d$ if F and d are collinear. Work is also defined as the area beneath an F vs. d curve.



Consider the spring $F_s = k(\Delta x)$. The Force vs. Displacement graph looks like this.



The Work under this Force vs. x graph can be calculated as follows

$$W = Area\,beneath\,curve$$

$$W = \frac{1}{2}bh$$

$$W = \frac{1}{2}\Delta x F \quad but\ F = k\Delta x$$

$$W = \frac{1}{2}\Delta x k \Delta x$$

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

Therefore work done to compress or extend a spring is defined as $\boxed{W = \frac{1}{2}k\Delta x^2}$

In General, spring energy is defined as.

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

Where E_s is in Joules (J),

k is the spring constant in N/m, and

x is the extension or compression of the spring in meters (m)