Flipping Physics Lecture Notes:

Energy Transferred Into and Out of a System
http://www.flippingphysics.com/energy-transfer-system.html

We have talked a lot about work and energy in this class. Now it is time to discuss the most general equation we have which relates work and energy:

$$\Delta E_{system} = \sum T$$

This equation states that the change in energy of the system equals the net energy transferred into or out of the system. That may seem a little obvious, however, it is a great place to start and we are going to derive some equations from this obvious starting place.

Energy can be transferred into or out of the system in many ways:

- Mechanical Waves – Sound waves are a great example of energy transferring from one system to another through a disturbance of a medium.
- Work – A force applied can transfer energy into or out of a system by doing work on the system.
- Heat – Heat is a way to transfer energy from one system to another via a difference in temperature.
- Electricity – Electrical current can transfer energy from one system to another, think of an electric motor converting electric potential energy to kinetic energy of the rotating motor.
- Radiation – Electromagnetic waves like visible light, microwaves, etc. Consider that a microwave oven transfers energy to food through microwave radiation.

For a long time in this class, the only source of energy transfer into or out of a system we will consider will be a mechanical one. That means the net energy transferred into or out of the system will be done by the work done by a force applied. Also, the change in energy of a system is equal to the change in mechanical energy of the system plus the change in internal energy of the system:

$$\Delta E_{system} = \sum T \Rightarrow \Delta ME + \Delta E_{internal} = W_{F_a}$$

If there is no force applied transferring energy into or out of the system via work, then we get:

$$\Rightarrow \Delta ME + \Delta E_{internal} = 0$$

The change in internal energy of the system is caused by the work done by nonconservative forces like friction. In other words, the work done by nonconservative forces on a system converts mechanical energy into internal energy of the system. You should recognize this because when you rub your hands together, they get warmer. The kinetic energy of the motion of your hands is being converted, via work done by friction, to internal energy in your hands, they get warmer. That equation looks like this:

$\Delta E_{internal} = -W_{NC}$ (where NC stands for nonconservative forces)

In other words, the general equation about energy transfer we started with, if there is zero work done by a force applied on the system, looks like this:

$$\Delta E_{system} = \sum T \Rightarrow \Delta ME + \Delta E_{internal} = W_{F_a} \Rightarrow \Delta ME - W_{NC} = 0 \Rightarrow W_{NC} = \Delta ME$$

Which is the work due to friction equals change in mechanical energy of a system we used before, only now we have derived it. And, now that we have defined nonconservative forces, we can identify this as the work done by nonconservative forces on a system equals the change in mechanical energy of the system.

And if we go one step further and say there is zero work done by nonconservative forces, we get this:

$$\Rightarrow 0 = \Delta ME = ME_f - ME_i \Rightarrow ME_i = ME_f$$

Which is the conservation of mechanical energy we have used before, only now we have derived it. ☺

To review: Starting with the general concept that the change in energy of the system equals the net energy transferred into or out of the system:

$$\Delta E_{system} = \sum T$$

And the fact that the work done by nonconservative forces on a system converts mechanical energy into internal energy of the system:

$$\Delta E_{internal} = -W_{NC}$$

We were able to prove that, when there is no force applied doing work on the system, that the work done by nonconservative forces on a system equals the change in mechanical energy of the system:

$W_{NC} = \Delta ME$ (no work done by force applied)

And further, if there is also no work done by nonconservative forces on the system, mechanical energy is conserved:

$ME_i = ME_f$ (no work done by force applied and no work done by nonconservative forces)

Please, please, please remember whenever you use these equations you have to identify your initial and final points.

You also need to identify which object(s) are a part of your system. The importance of which will be obvious when you watch my next video, "Energy Systems Clarified".
http://www.flippingphysics.com/energy-systems.html