Potential Energy

But is energy really conserved? Consider the following example. Hold a small stone in your hand and then release it. Because you have not exerted any force on the stone – you simply let it go – you have not done any work on it. Yet, the stone immediately begins to accelerate under gravity, and its velocity therefore increases at a constant rate. We know from our definition of kinetic energy that the energy of a moving body is directly proportional to the square of its velocity. Hence, the kinetic energy of the falling stone is increasing all the time. Where is this extra energy coming from?

Consider the example of the stone again; this time, lift a small stone off the ground and hold it the palm of your hand. You have now done work on the stone and it should therefore have acquired kinetic energy. But it's just sitting there in the palm of your hand, with no velocity and therefore no kinetic energy. Where did its kinetic energy disappear to?

The answer to these two questions is the same: gravity. The falling stone picks up kinetic energy from gravity and the stone you lift in your hand surrenders its kinetic energy to gravity. All material bodies, in proportion to their mass, exude what is called a gravitational field; the gravitational field of the earth is the only one we notice in our everyday life. This field has the ability to absorb kinetic energy from bodies, store it and then release that energy back again.

This energy stored in a gravitational field is called gravitational potential energy. Potential energy is in general is defined as follows:

Potential energy is the energy a body possesses by reason of its position or state.

In the case of gravitational potential energy, the work done against gravity in lifting a mass (m) to a height (h) is given by:

work = force x distance moved in direction of force

$$W = mgh$$

The work done will be converted back into kinetic energy if the body is released. This expression therefore represents the gravitational potential energy of the body, PE.

$$PE = mgh$$

Consider our little stone again. When the stone is falling, it possesses both potential energy and kinetic energy. As it falls further, its speed (v) increases and so does its kinetic energy:

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

Its potential energy (mgh), however, decreases. Ignoring the energy acquired by the air molecules surrounding the stone as they are moved out of the way, the loss in potential energy of the stone is exactly equal to its gain in kinetic energy.