Kinetic and Potential Energy

Energy is defined as the ability to do work. When the work is actually being done, we term the energy "kinetic." When the work is waiting to be done, or when there is the potential for work to be performed, we term the energy "potential." Kinetic energy is the energy of motion, potential energy comes from work having been done on an object which was then stored. For example, a rubber band zinged from your finger has kinetic energy. While it was stretched, waiting for you to release it, it had potential energy. The rubber band was stationary, but work had been done on it to move it to its present position.

Now, we know that the farther we pull back a rubber band, the faster and farther it will fly. Consider this situation in terms of potential and kinetic energy: When I pull back the rubber band to a great distance, I am doing more work to it than if I pulled it back only a small distance. More work means more energy is provided to and stored by the rubber band. When I release the rubber band, it has more energy to move. More energy means more work can be done by the rubber band. There is a connectedness, then, between potential and kinetic energy for matter.

For moving objects, we can easily calculate kinetic energy using the formula:

$$KE = (\text{mass} \times \text{velocity}^2)/2 \text{ or } 1/2\ mv^2$$

Although mass and velocity both have great effects on kinetic energy, it is velocity, more significantly, that determines kinetic energy.

Sample Problem

What is the kinetic energy of a 45 kg object moving at 13 m/sec?

1. First we identify the information we are given in the problem:
    - mass = 45 kg
    - velocity = 13 m/sec
2. Next, we place this information into the kinetic energy formula:
    - $KE = 1/2\ mv^2$
    - $KE = 1/2\ (45\ kg)(13\ m/sec)^2$
3. Solving the equation gives a kinetic energy value of 3802.5 J.

    Note: The unit for energy is the same as for work: the Joule (J).

Sample Problem

The kinetic energy of a boat is calculated at 52,000 J. If the boat has a mass of 39,000 kg, with what velocity is it moving?

1. We identify the information given in the problem:
    - KE = 52,000 J
    - mass = 39,000 kg
2. We now place the information into the kinetic energy formula:
    - $KE = 1/2\ mv^2$
    - $52{,}000\ J = 1/2\ (39{,}000\ kg)(v)^2$
    - $52{,}000\ J/(1/2 \times 39{,}000\ kg) = v^2$

3. Solving the equation gives a velocity value of 1.63 m/sec.

Potential energy, on the other hand, is energy of position, not of motion. The amount of potential energy possessed by an object is proportional to how far it was displaced from its original position. If the displacement occurs vertically, raising an object off of the ground, let's say, we call this gravitational potential energy. We can calculate the gravitational potential energy of an object with this formula:

GPE = weight x height

An increase in the weight of an object or the height to which it is raised will result in an increase in the potential energy the object possesses. Once the object is dropped, the potential energy begins to decrease due to reduced height, but we also now see an increase in kinetic energy because the velocity is also increasing.

Sample Problem

A 37 N object is lifted to a height of 3 meters. What is the potential energy of this object?

1. Identify the information given to you in the problem:
   - weight = 37 N
   - height = 3 meters
2. Insert the information into the gravitational potential energy formula:
   - GPE = weight x height
   - GPE = 37 N x 3 meters
3. Solving the problem gives a potential energy value of 111 J.

Sample Problem

A 30 kg child climbs 15 meters up a tree. When he stops to have a look around, what is the child's potential energy?

1. First we identify the information provided in the problem:
   - mass = 30 kg
   - height = 15 meters
2. Right away, you should note that you are not given the weight of the child, but rather the mass. First you must convert the child's mass to his corresponding weight on Earth.
   - weight = mass x gravity
   - weight = 30 kg x 9.8 m/sec^2
   - weight = 294 N
3. Now, insert the information for weight and height into the gravitational potential energy formula:
   - GPE = weight x height
   - GPE = 294 N x 15 meters
4. Solving the problem gives a potential energy value of 4410 J.