4.14.1 Kinetic Energy

Energy is the ability to do work. When a force performs work on an object, the result is a change in the kinetic energy of the object. The work done by the net forces on an object equals the change in the kinetic energy of the object.

Because of Newton's second law, we know that when a constant net force F is applied to an object of mass m, it experiences acceleration according to $a = F/m$. As a result, the object's speed changes from an initial value v_0 to a final value v over a time interval. We can relate Newton's second law to speed by way of (4.23), $v^2 = 2as + v_0^2$, as follows. First, because of (4.26) and because $F = ma$, we can write

$$W = Fs = mas.$$

Note that both (4.23) and the above equation contain the term as. Solving (4.23) for as gives $as = \frac{1}{2}(v^2 - v_0^2)$, and substituting this into $Fs = mas$ gives

$$W = Fs = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2. \tag{4.27}$$

Equation (4.27) relates work to the difference between two terms, each of which has the form $\frac{1}{2}$(mass)(speed)^2. This quantity is called *kinetic energy*. The kinetic energy of an object with mass m and speed v is given by

$$E = \frac{1}{2}mv^2. \qquad \textit{Kinetic Energy} \tag{4.28}$$

By (4.27) and (4.28), work is just the difference between an initial kinetic energy and a final kinetic energy. That is, for some initial kinetic energy E_0 and final kinetic energy E, $W = E - E_0$. Because work is just the difference between two kinetic energies, work and kinetic energy are expressed in the same SI unit: the joule (J).

From (4.28) we see that

Kinetic energy is proportional to the square of velocity.

For instance, when a car's velocity doubles, its kinetic energy quadruples. Suppose it is going 30 kilometers per hour and takes 30 meters after braking to come to a complete stop (that being the distance it takes to completely dissipate the motion energy into heat). Then, if its speed doubles to 60 kilometers per hour (assuming the same road conditions), it will take four times as long to stop (120 meters) because the car has four times the amount of kinetic energy to dissipate.[4]

There are many forms of energy, including electrical, thermal, chemical, radiant, nuclear, and mechanical. Acoustical energy is a kind of mechanical energy.