We begin by re-examining the relationship between the application of a force to an object and the resulting change in state of the object. We reason that if a force acts on an object and it starts to move, then the change in velocity is related to the force applied. Even if the velocity of the object is constant, there exists a relationship between displacement and applied force.

Energy is defined as being linked to the state of an object, and energy changes are recorded as state changes, For example, temperature is linked to the heat energy contained in an object, and the phrases 'heating up' and 'cooling down' are understood to correspond to a change in the heat energy.

So, in a similar way we will define 'kinetic energy' as related to the velocity state of the object. 'Potential energy' will be linked to the location of the object. To 'do work' is to change the energy state of the system. Increasing the energy state is defined as being the result of 'positive work' and a decrease in the energy state is the result of 'negative work'.

We are thus able to define a relationship between the change in the kinetic energy of the object and the work done on the object. This is the work-energy theorem:

$$W_{net} = \Delta K_{net},$$

$$W = \int \vec{F} \bullet d\vec{x}$$

$$\Delta K = 1/2\ m\ (v_{final}^2 - v_{initial}^2)$$

The benefit to the work-energy theorem is that it involves a dot product, and thus a scalar result.

In contrast to friction, some forces act in such a way as to store energy in the system. Such energy storage systems are said to contain potential energy, representing energy that *could* be used to do work at some future time.

These forces can be classified as conservative forces. A conservative force is one that performs 'negative work' when an object is displaced in one direction, and 'positive work' as the object returns to the original position, leading to a zero net change in energy. When objects are acted upon by conservative forces, then any changes in the potential energy of the system are compensated by changes in the kinetic energy of the system so that the total energy remains unchanged, or conserved.

We can classify friction as a non-conservative force, but the force of gravity or the force exerted by a spring conforms to the definition of a conservative force since a 'round trip' results in no change of the system energy. The reason for spending time defining the effect of conservative and non-conservative forces is in preparation for the development of the work-energy theorem.

This theorem allows us to predict the future state or condition of that system. It unites the roles of conservative and non-conservative forces into a single equation:

$$E_O = K_O + U_O + W_{NCF} = K_F + U_F = E_{F,}$$

with

E_0 = initial energy of system

W_{NCF} = work done by non-conservative forces,

E_F = the final energy in the system.

Our emphasis now turns to identifying and characterizing the production, storage and dissipation of energy in a system by conservative and non-conservative forces.