Work and Energy

Two correct but relatively unhelpful definitions of work and energy are:

- Work is the transfer of energy to or from an object by means of force acting on the body. When energy is transferred to the object, positive work is done on the object. When energy is transferred from the object, negative work is done on the object.
- Energy is the ability to do work.

As can be seen, these definitions are circular.

- Work can be defined as a force acting through a distance. Only the component of the force that is parallel to the displacement does work.
- Mathematically, work is defined as the ***dot product*** or ***scalar product*** of force and displacement.
  $\boxed{W = \mathbf{F} \bullet \mathbf{d} = Fd\cos\theta}$
- Work is a scalar.
- The SI unit for work is the joule (j). $\boxed{1j = 1N \bullet m = 1\frac{kg \bullet m^2}{s^2}}$

- The kinetic energy of a moving object is defined as $\boxed{E_k = \frac{1}{2}mv^2}$
- The reason for this definition is that this is the quantity that changes when forces do work.
- The SI unit for work is the joule (j). This is the same unit as work because of the fact that the only thing that work does is move energy.
- Potential energy is defined as energy is not associated with the motion of an object but can be converted to kinetic energy.
- When ***conservative*** forces do negative work, potential energy is increased.
- Gravitational and elastic forces (springs) are two conservative forces. That is, they produce potential energy when they do negative work.
  - The work done by or against gravity can be calculated with $\boxed{W_g = mgh}$ where *h* is the vertical displacement of the object.
  - The work done by or against a spring can be calculated with $\boxed{W_{elastic} = \frac{1}{2}kx^2}$ where *k* is the spring constant and *x* is the distance the spring is stretched or compressed.
  - The energy calculated from these equations is converted to/from kinetic energy depending on whether the force is stopping or accelerating the objectr.
- Friction is a non–conservative force. That is, it generates heat when it does negative work and the energy is lost. No potential energy is produced and no work can be done in the future as a result.
- When forces do work on objects, the work–kinetic energy theorem is useful in analyzing the process.
- The net work done on an object is equal to the change in its kinetic energy:
  $\boxed{\sum W = \Delta E_k}$
- If an object is being stopped by a spring while falling, the spring does negative (–) work while gravity does positive (+) work on the object.
- One very important reason for using the Work – Kinetic Energy theorem to solve some problems is the fact that problems can be solved using the initial and final conditions without regard for the fact that some forces change during the process resulting in non-constant acceleration.
- Problems should be solved by writing an equation that has a term for each force that does work on one side and an expression for the change in kinetic energy on the other.