Info to Memorize: Energy and Work

Definition of Work

The amount of work done by a steady force is the amount of force multiplied by the distance an object moves parallel to that force: $W = F \cdot \Delta x_{\parallel}$

Positive work is done by a force parallel to an object's displacement.

Negative work is done by a force antiparallel to an object's displacement.

Work is a scalar quantity – it can be positive or negative, but does not have a direction.

The area under a force vs. displacement graph is work.

Equations for different forms of energy

All forms of energy have units of joules, abbreviated J.

- **Kinetic energy:** $KE = \frac{1}{2}mv^2$. Here, m is the mass of the object, and v is its speed.

- **Gravitational potential energy:** $PE = mgh$. Here, m is the mass of the object, g is the gravitational field, and h is the vertical height of the object above its lowest position.

- The term *mechanical energy* refers to the sum of a system's kinetic and potential energy.

- **Spring potential energy:** $PE = \frac{1}{2}kx^2$. Here, k is the spring constant, and x is the distance the spring is stretched or compressed from its equilibrium position. (See the section below about springs)

Work-energy theorem

Before starting a work-energy problem, define the object or system being described.

The work-energy theorem states that the net work done by external forces changes the system's mechanical energy:

$$W_{ext} = (KE_f - KE_i) + (PE_f - PE_i)$$

If the total energy of the system does not change, then our equation becomes the Law of Conservation of Energy

$$PE_i + KE_i = PE_f + KE_f$$

Force of a spring:

A spring pulls with more force the farther the string is stretched or compressed.

The force of a spring is given by the equation $F = kx$. Here, k is the spring constant of the spring, and x is the distance the spring is stretched or compressed.

The spring constant is a property of a spring, and is always the same for the same spring.

The standard units of the spring constant are N/m.

Vertical springs:

When dealing with an object hanging vertically from a spring, it's easiest to consider the spring-earth-object system.

The potential energy of the spring-earth-object system is $PE = \frac{1}{2}kx^2$, where x is measured from the position where the object would hang in equilibrium.

Power

Power is defined as the amount of work done in one second, or energy used in one second:

power = work / time

The units of power are joules per second, which are also written as watts.

An alternate way of calculating power when a constant force acts is *power = force · velocity*