Introduction to Energy

The Law of the Conservation of Energy

Energy cannot be created or destroyed; it may be transformed from one form into another, but the total amount of energy never changes.

What is Energy? …. This has long been a term in science that has been difficult to define. Some say it is "the ability to do work" … however we can view energy as the power derived from the utilization of physical or chemical resources.

Forms of Energy

There are 6 fundamental forms of energy

* Mechanical energy - energy due to a object's motion (kinetic) or position (potential)
* Thermal (heat) energy – energy related to the motion and activity of atoms
* Electromagnetic energy – light energy (for ex. light, gamma, x-ray, microwave, radio waves)
* Electrical energy – energy caused by the movement of electrons
* Nuclear energy – energy from nuclear transformations
* Chemical energy - energy that is available for release from chemical reactions. (ex. a match)

Energy Transformations

Although energy cannot be created or destroyed, it can be transformed from one type to another.

Energy Units

Energy is measured in Joules, or in some cases, calories. The joules unit is SI (the international Unit of Standards)

joule: The amount of energy used when a 1 watt electrical device is turned on for 1 second.

British thermal units (Btu): The amount of energy required to heat 1 pound of water by 1 degree.
1 Btu = 1,055 J

calorie: The amount of energy it takes to heat 1 gram of water by 1 degree Celsius
1 calorie = 4.184 J

People often confuse calories and Calories… a calorie is a basic scientific unit for energy while a Calorie with an uppercase refer to energy in food. A food calorie, like that listed on the packaging of a product, is written as Calorie and is equal to 1,000 calories, 1 kilocalorie (kcal)

kilowatt hour *kWh): The amount of energy expended by using 1 kilowatt of electricity for 1 hour
1 kWh = 3,600,000 J = 3.6 Megajoules (MJ)

watt (W): 1 watt is equal 1 joule per second (1 J/s)

horsepower (hp): One horsepower is equal to 746 watts
1 hp = 746 W

joule = 0.239005736 calories

Mechanical Energy – this type of energy has two forms: Kinetic and Potential.

Potential Energy – the energy of position or energy in storage.
For example: Water behind a dam, hammer over head, or food on a plate

What is Gravitational Potential Energy? *Potential energy due to an object's position*
What is Potential Energy? *Energy that is stored and waiting to be used later*
What is Elastic Potential Energy? *Potential energy due compression or expansion of an elastic object.*
What is Chemical Potential Energy? *Potential energy stored within the chemical bonds of an object*

$$PE = mgh$$

(Potential Energy = mass x height x gravity)
(where m = mass (kg), h = height (m) and g = acceleration due to gravity (9.8 m/s^2)

Kinetic Energy - is the energy of motion, the form capable of doing work
For example: Flowing water, a falling hammer or electrons regenerating ATP in a biological cell

What is Kinetic Energy? *Energy an object has due to its motion*

$$\mathbf{KE = 1/2mv^2}$$

Kinetic Energy = 0.5(mass x speed^2)

For example, what is the KE of 4 kg bowling ball moving at 10 m/s?

KE = 1/2 m v^2
= 0.5 (4kg) (10m/s)^2
= 200 J

Work is equal to the force that is exerted times the distance over which it is exerted. The unit of work combines the unit of force (N) with the unit of distance (m). Newton-meter (N-m) aka Joule.

$$\mathbf{W = F \times d}$$

For example, if you carried a 20 kg suitcase upstairs for a distance of 4m, how much work did you do?

F = ma
= (20 kg) (10m/s^2) = 200 N

W = F x d
= (200 N) (4m)
= 800 J

Power measures the rate of work done or the rate at which energy is expended. Power is the amount of work done, divided by the time it takes to do it. The units for power are the watt (W) or

$$\mathbf{P = W/t}$$

Power (watts) = work (joules) / time (seconds)

Since work performed equals energy expended, power (watts) = energy (joules) / time (sec)

* The watt is defined as the expenditure of 1 joule of energy in 1 second. *For example, a 75 watt light bulb consumes 75 J/sec*

For example, a strong incandescent light bulb uses 250 watts of electrical power. If the light is on for 3 hours, how much energy used? In addition, approximately how much would it cost if one kWh is $.08?

Energy (J) = power (watts) x time (sec)
= (250w) (3hr) = 750 Whr = .75 kWh

The cost = 8 cents / kWh x .75 kWh
= 6 cents

Energy Efficiency refers to the amount of energy being utilized compared to the amount going into a system. It is measured as a percentage. It is the ratio between the useful output of an energy conversion to the amount of energy entering a system.

Electrical Current
Ohm's law states that the current (I) flowing through an element in a circuit is directly proportional to the voltage drop or potential difference (V) across it: V = IR, where R means resistance – anything that gets in the way of the flow of current. What this means, more or less, is that the greater the resistance (measured in Ohms), the greater the voltage (measured in volts) required to push the current (measured in amps) through it.

Entropy is a measure of the disorder of a system. A solid has less entropy that a liquid, since the constituent particles in a solid are in a more ordered state. The flow of energy maintains order and life. Entropy states the opposite. Entropy takes over when energy ceases.