1st Law of Thermodynamics

The First Law of Thermodynamics simply states that energy can be neither created nor destroyed (conservation of energy). Thus power generation processes and energy sources actually involve conversion of energy from one form to another, rather than creation of energy from nothing

The 1st Law of Thermodynamics tells us that energy is neither created nor destroyed, thus the energy of the universe is a **constant**. However, energy can certainly be **transferred** from one part of the universe to another. To work out thermodynamic problems we will need to isolate a certain portion of the universe, the system, from the remainder of the universe, the surroundings.

The energy transfer between different systems can be expressed as:

$E_1 = E_2$ *(1)*

where

E_1 = *initial energy*

E_2 = *final energy*

The internal energy encompasses:

- The kinetic energy associated with the motions of the atoms
- The potential energy stored in the chemical bonds of the molecules
- The gravitational energy of the system

The first law is the starting point for the science of thermodynamics and for engineering analysis.

Based on the types of exchange that can take place we will define three types of systems:

- **isolated systems**: no exchange of matter or energy
- **closed systems:** no exchange of matter but some exchange of energy
- **open systems**: exchange of both matter and energy

The first law makes use of the key concepts of **internal energy**, **heat**, and **system work**. It is used extensively in the discussion of **heat engines**.

Internal Energy - Internal energy is defined as the energy associated with the random, disordered motion of molecules. It is separated in scale from the macroscopic ordered energy associated with moving objects; it refers to the invisible microscopic energy on the atomic and molecular scale. For example, a room temperature glass of water sitting on a table has no apparent energy, either potential or kinetic . But on the microscopic scale it is a seething mass of high speed molecules. If the water were tossed across the room, this microscopic energy would not necessarily be changed when we superimpose an ordered large scale motion on the water as a whole.

Heat - Heat may be defined as energy in transit from a high temperature object to a lower temperature object. An object does not possess "heat"; the appropriate term for the microscopic energy in an object is internal energy. The internal energy may be increased by transferring energy to the object from a higher temperature (hotter) object - this is called heating.

Work - When work is done by a thermodynamic system, it is usually a gas that is doing the work. The work done by a gas at constant pressure is W = p dV, where W id work, p is pressure and dV is change in volume.

For non-constant pressure, the work can be visualized as the area under the pressure-volume curve which represents the process taking place.

Heat Engines -Refrigerators, Heat pumps, Carnot cycle, Otto cycle

The change in internal energy of a system is equal to the head added to the system minus the work done by the system:

dE = Q - W (2)

where

dE = change in internal energy

Q = heat added to the system

W = work done by the system

1st law does not provide the information of direction of processes and does not determine the final equilibrium state. Intuitively, we know that energy flows from high temperature to low temperature. Thus, the 2nd law is needed to determine the **direction of processes**.

Enthalpy is the "thermodynamic potential" useful in the chemical thermodynamics of reactions and non-cyclic processes. Enthalpy is defined by

H = U + PV (3)

where

H = enthalpy

U = internal energy

P = pressure

V = volume

Enthalpy is then a precisely measurable state variable, since it is defined in terms of three other precisely definable state variables.

Entropy is used to define the unavailable energy in a system. Entropy defines the relative ability of one system to act to an other. As things moves toward a lower energy level, where one is less able to act upon the surroundings, the entropy is said to increase.

Entropy is connected to the Second Law of Thermodynamics.

For the universe as a whole the entropy is increasing.