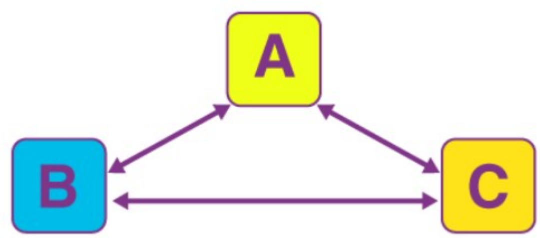
Zeroth Law of Thermodynamics and First law of thermodynamics:

Zeroth Law of Thermodynamics:

When a body, 'A', is in thermal equilibrium with another body, 'B', and also separately in thermal equilibrium with a body, 'C', then body, 'B' and 'C', will also be in thermal equilibrium with each other. This statement defines the Zeroth law of thermodynamics.

The law is based on temperature measurement.



The zeroth law of thermodynamics states that if two thermodynamic systems are each in thermal equilibrium with a third one, then they are in thermal equilibrium with each other.

There are also various ways to state the zeroth law of thermodynamics:

- In simple terms, it can be said, "Systems that are in thermal equilibrium exist at the same temperature".
- Zeroth law of thermodynamics takes into account that temperature is something worth measuring because it predicts whether heat will transfer between objects or not. This is true regardless of how the objects interact.
- Even if two objects are not in physical contact, heat can still flow between them by means of the radiation mode of heat transfer.
- On the other hand, the Zeroth law of thermodynamics states that if the systems are in thermal equilibrium, no heat flow will take place.

Thermal Equilibrium

- Temperature is a property that distinguishes thermodynamics from other sciences. This property can distinguish between hot and cold.

- When two or more bodies at different temperatures are brought into contact, then after some time, they attain a common temperature, and they are said to exist in thermal equilibrium.
- Systems are said to be in thermal equilibrium if there is no heat transfer, even if they are in a position to transfer heat, based on other factors.
- For example, if we put food in the refrigerator overnight, then the food is in thermal equilibrium with the air of the refrigerator.
- Heat no longer flows from food to the air or from the air to the food, and this state is known as thermal equilibrium.

Examples: The most common application of the Zeroth law of thermodynamics can be seen in thermometers. We can observe the Zeroth law in action by taking a very common thermometer having mercury in a tube. As the temperature increases, this mercury expands since the area of the tube is constant. Due to this expansion, the height is increased. Now, the increase in the height of the mercury label shows the changes in temperature and basically helps us to measure it.

First Law of Thermodynamics:

Just like mass, energy is always conserved, i.e., it can neither be created nor destroyed, but it can be transformed from one form to another. Internal energy is a thermodynamic property of the system that refers to the energy associated with the molecules of the system, which includes kinetic energy and potential energy.

Whenever a system goes through any change due to the interaction of heat, work and internal energy, it is followed by numerous energy transfers and conversions. However, during these transfers, there is no net change in the total energy.

Similarly, if we look at the first law of thermodynamics, it affirms that heat is a form of energy. What it means is that the thermodynamic processes are governed by the principle of conservation of energy. The first law of thermodynamics is also sometimes referred to as the law of conservation of energy.

A thermodynamic system in an equilibrium state possesses a state variable known as internal energy(E). Between the two systems, the change in the internal energy is equal to the difference of the heat transfer into the system and the work done by the system.

The first law of thermodynamics states that the energy of the universe remains the same. Though it may be exchanged between the system and the surroundings, it can't be created or destroyed.

The law basically relates to the changes in energy states due to work and heat transfer. It redefines the conservation of energy concept.

The first law of thermodynamics thus states that heat is a form of energy, and thermodynamic processes are, therefore, subject to the principle of conservation of energy. This means that heat energy cannot be created or destroyed. It can, however, be transferred from one location to another and converted to and from other forms of energy.

To help you understand the meaning of the first law, we can take the common example of a heat engine. In a heat engine, the thermal energy is converted into mechanical energy, and the process also is vice versa. Heat engines are mostly categorized as open systems. The basic working principle of a heat engine is that it makes use of the different relationships between heat, pressure and volume of a working fluid which is usually a gas. Sometimes phase changes might also occur involving a gas to liquid and back to gas.

The equation for the first law of thermodynamics is given as

$$\Delta U = q + W$$

Where,

- ΔU = Change in internal energy of the system
- q = Algebraic sum of heat transfer between system and surroundings
- W = Work interaction of the system with its surroundings

Limitations of First law of thermodynamics:

- The law states that whenever a system undergoes any thermodynamic process, it always holds a certain energy balance. However, the first law fails to give the feasibility of the process or change of state that the system undergoes. For instance, the first law fails to explain why heat flows from the hot end to the cold end when a metallic rod is heated at one end and not on the other and vice-versa. The first law only quantifies the energy transfer that takes place during this process. It is the second law of thermodynamics which provides the criterion for the feasibility of various processes.

- It is impossible to construct a machine that can continuously supply mechanical work without consuming any energy simultaneously. Such a hypothetical machine is known as the **perpetual motion machine** of the first kind. These types of machines violate the 1st law of thermodynamics and do not exist in reality.

First law of Thermodynamics for a Closed System

Work done for a closed system is the product of pressure applied and the change in volume that occurs due to applied pressure.

$$w = -P\,\Delta V$$

Where P is the constant external pressure on the system, and ΔV is the change in the volume of the system. This is specifically called "pressure-volume" work.

The internal energy of a system increases or decreases depending on work interaction that takes place across its boundaries.

The internal energy would increase if work is done on the system and decreases if work is done by the system. Any heat interaction that takes place in the system with its surroundings also changes its internal energy. But since energy remains constant (from the first law of thermodynamics), the total change in internal energy is always zero.

If energy is lost by the system, then it is absorbed by the surroundings. If energy is absorbed into a system, then it implies that the energy was released by the surroundings.

$$\Delta U_{system} = -\Delta U_{surroundings}$$

Where ΔU_{system} is the change in the total internal energy of the system, and $\Delta U_{surroundings}$ is the change in the total energy of the surrounding.