Thermodynamics

Lecture 1

Thermodynamics

- **Thermodynamics**: The science of energy transfer and its effect on the physical properties of substances.
- **Energy**: The ability to cause changes.
- The name *thermodynamics* stems from the Greek words *therme* (heat) and *dynamis* (power).

Work is defined as:

The quantity of energy transferred from one system to another by ordinary mechanical processes.

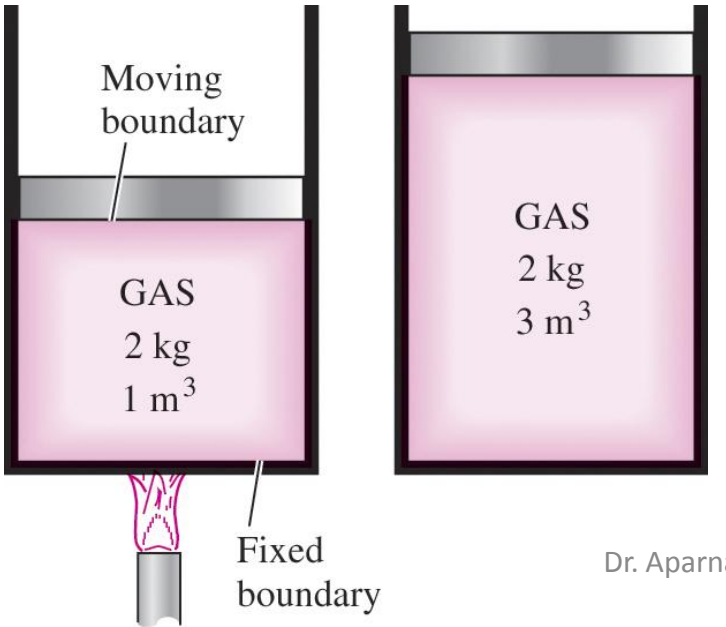
Heat is defined as:

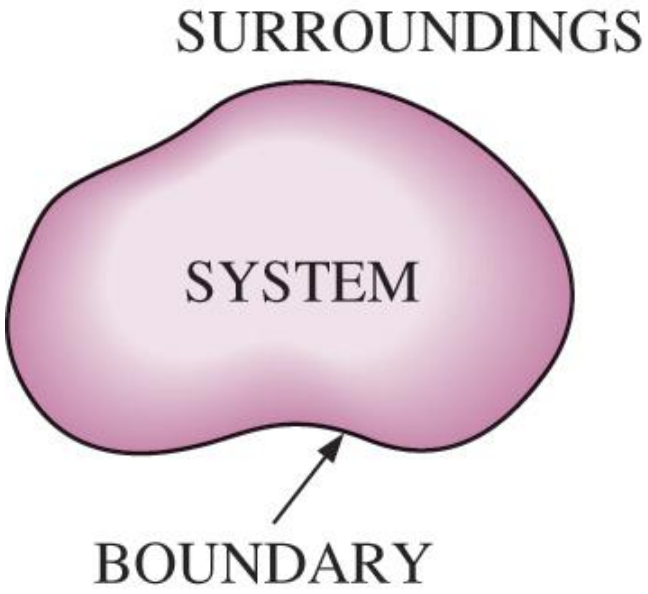
A transfer of energy from one body to another body at a lower temperature.

From this we can see that thermodynamics describes the relationship between heat and work.

THERMODYNAMIC SYSTEM

- **System**: A quantity of matter or a region in space chosen for study.
- **Surroundings**: The mass or region outside the system
- **Boundary**: The real or imaginary surface that separates the system from its surroundings.
- The boundary of a system can be *fixed* or *movable*.





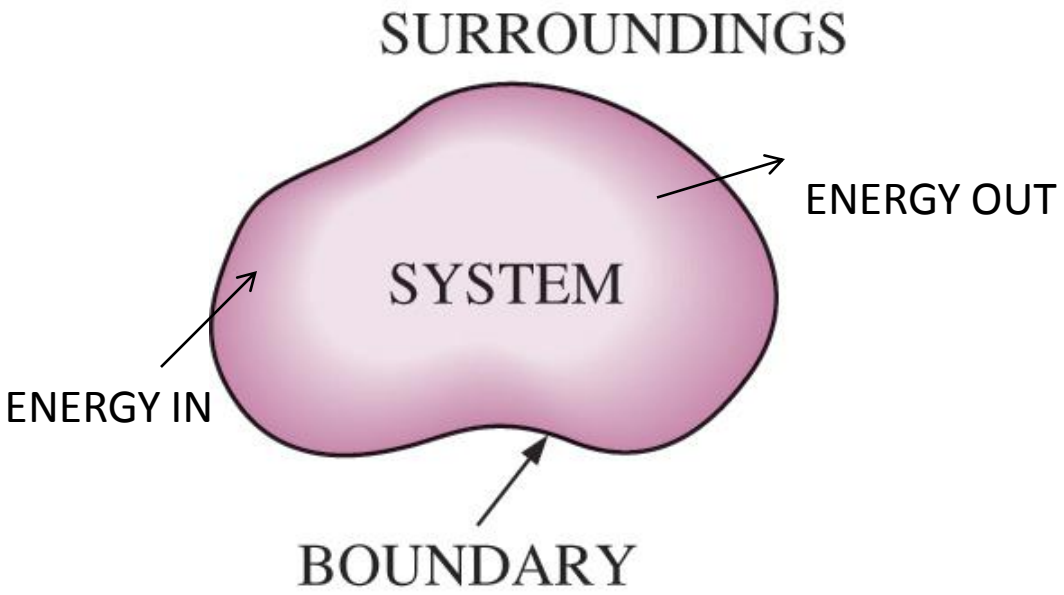
Systems

- There are three classes of system

1. Closed system
2. Open system
3. Isolated system

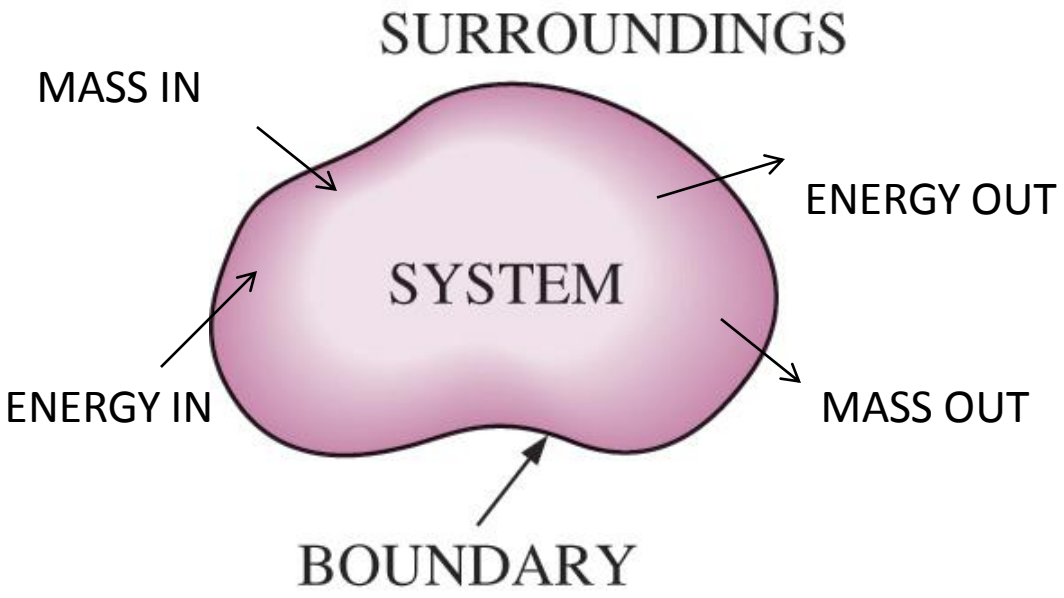
Closed System

- It is a system of fixed mass.
- There is no mass transfer cross system boundary
- Energy may cross system boundary
- Volume is NOT fixed



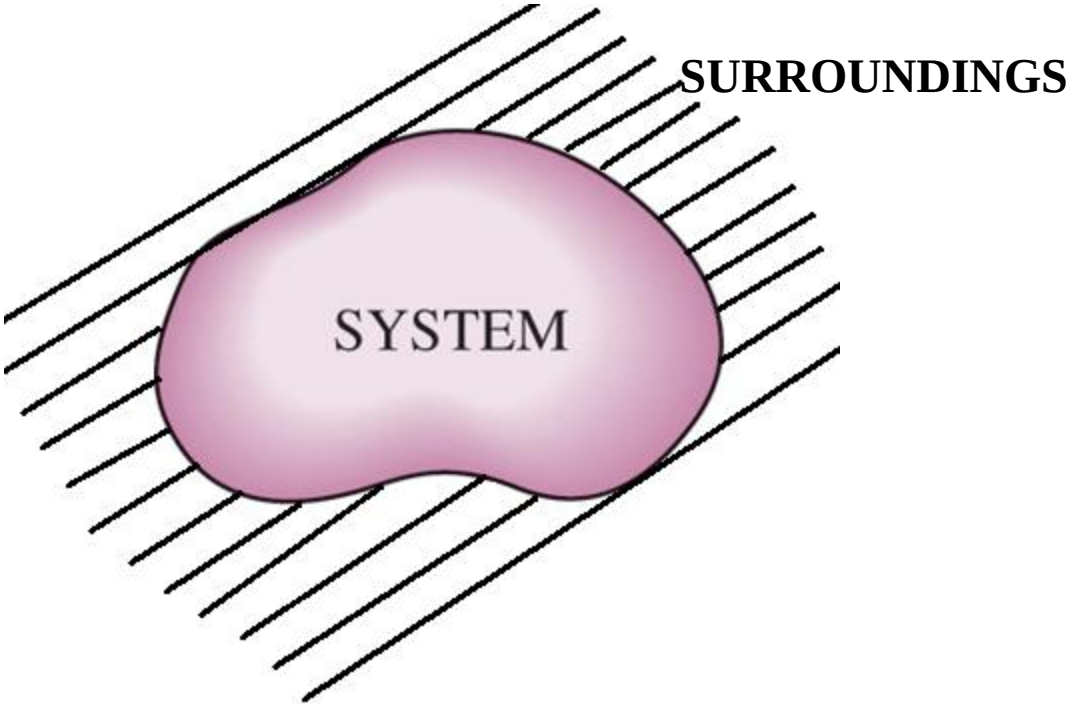
Open System

- Mass may cross system boundary
- Energy may cross system boundary
- Volume may/may not be fixed



Isolated System

- There is no interaction between the system and the surroundings.
- It is of fixed mass and energy
- There is no mass or energy transfer across the system boundary.



Thermodynamic laws

- Zeroth law of thermodynamics
- First law of thermodynamics
- Second law of thermodynamics

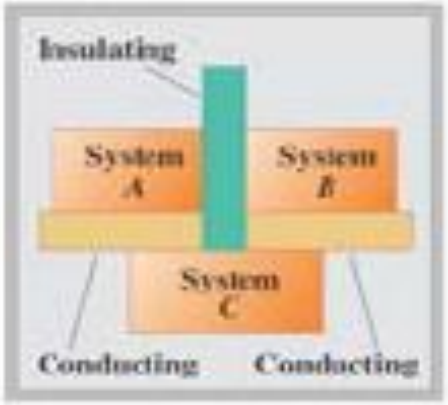
➢ The property which distinguishes thermodynamics from other sciences is temperature.

➢Temperature is associated with the ability to distinguish hot from cold.

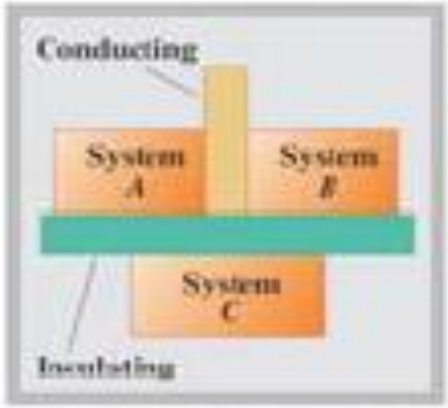
Zeroth law of thermodynamics

The Zeroth Law of Thermodynamics

- Systems A, B, and C are not originally in thermal equilibrium.
- Surround A, B, and C so that they are insulated from any external influence.
- In the top figure, A and C will come to equilibrium while at the same time, B and C will also. Eventually, all three – A, B, and C will come to equilibrium. In the lower figure, only A and B will come to equilibrium.
- This is the essence of the Zeroth Law.



(a) If systems *A* and *B* are each in thermal equilibrium with system *C* ...



(b) ... then systems *A* and *B* are in thermal equilibrium with each other.

The first law of thermodynamics

An expression of the conservation of energy principle.

The first law asserts that *energy* is a thermodynamic property.

If Q –amount of heat transfer to the system
W- amount of work transfer from the system
Then net energy transfer

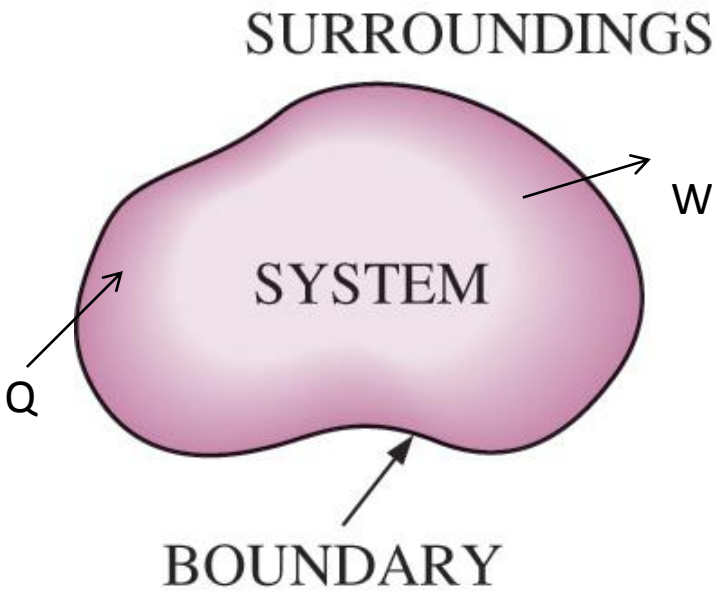
$$\Delta U = Q - W$$

$$Q = \Delta U + W$$

Heat flow into system

Increase in internal energy of system

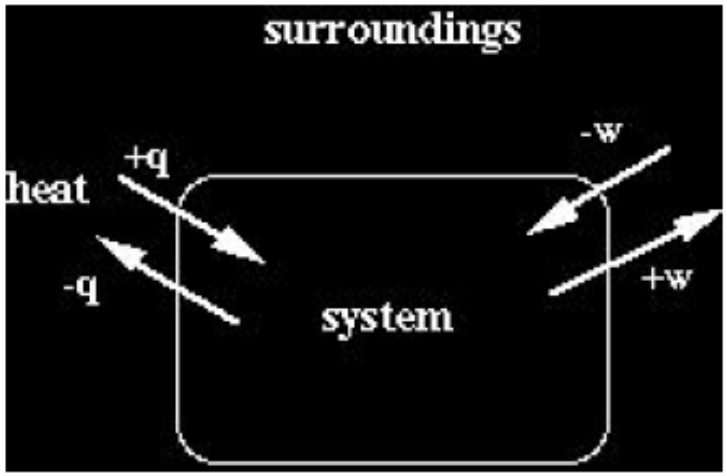
Work done by system



Some Conventions

- Signs for heat Q and work W in thermodynamics

Q is + if heat is added to system
Q is – if heat is lost by system
W is + if work is done by the system.
W is – if work is done on the system.



Thermodynamics process

Isobaric process

An isobaric process is a constant-pressure process.

$W = p(V_2 - V_1)$, p = constant

Isochoric Process

process in which volume is kept constant

W = 0, V = constant

Adiabatic process

An adiabatic process is defined as one with no heat transfer into or out of a system.

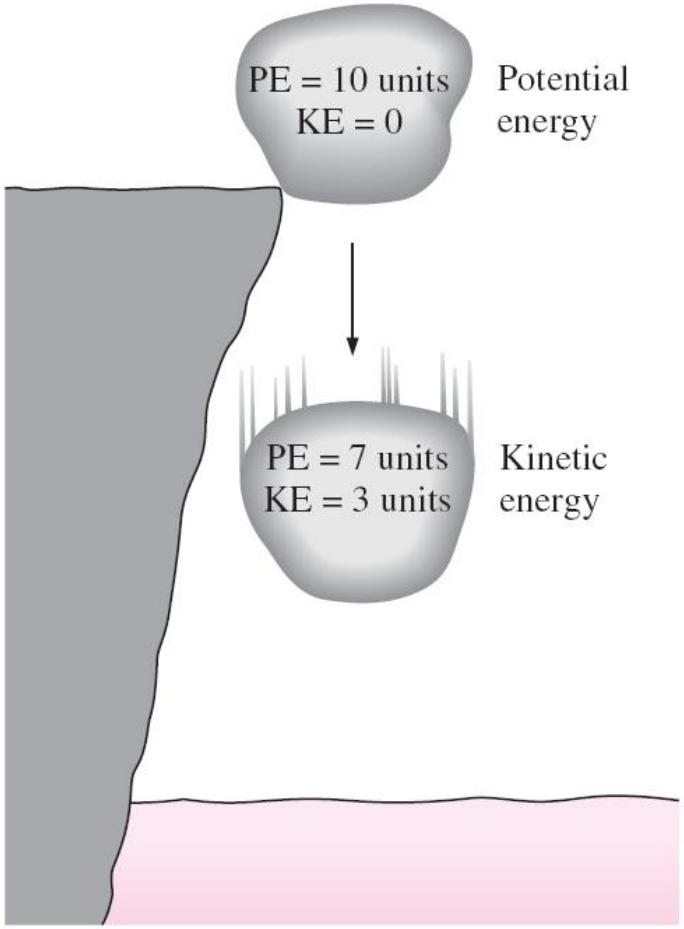
$\Delta U = -W, Q=0$

Isothermal process

An isothermal process is a constant-temperature process. For a process to be isothermal, any heat flow into or out of the system must occur slowly enough that thermal equilibrium is maintained.

$T = \text{constant}$

- **Conservation of energy principle**: During an interaction, energy can change from one form to another but the total amount of energy remains constant.
- Energy cannot be created or destroyed.



Energy cannot be created or destroyed; it can only change forms (the first law).