Thermodynamics: is the science of energy. It specifically deals with heat and work and those properties of substances that have a relation to heat and work.

Areas of Application of Engineering Thermodynamics may involve:

- Automobile engines
- Gas turbine Power Stations
- Steam turbine Power Stations
- Propulsion systems for aircraft and rockets
- Refrigeration
- Heat from electronic equipment

Concepts and Definitions

System: Is a device containing a quantity of matter (for example: gas) that is being studied.

Surrounding: The region outside the system boundaries.

Boundaries: The surface that separates the system from its surrounding.

Example: The **piston-cylinder device** can be considered as a system, the **inner surfaces** of the piston and the cylinder form the **boundary** and anything that lies outside these boundaries can be considered as a **surrounding**.

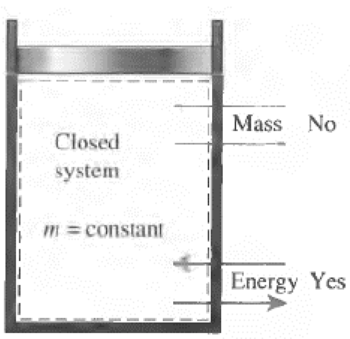
System

Close System | Control Volume | Isolated System

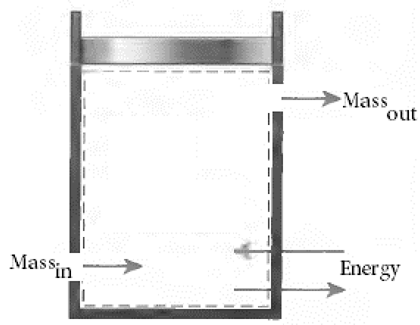
Close system: no mass can cross its boundary. But energy, in the form of heat or work, can cross the boundary.

Control Volume: Both mass and energy can cross the boundary of the system.

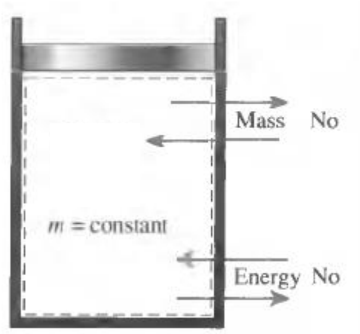
Isolated System: Neither mass nor energy can cross the boundary.



Close System



Control Volume



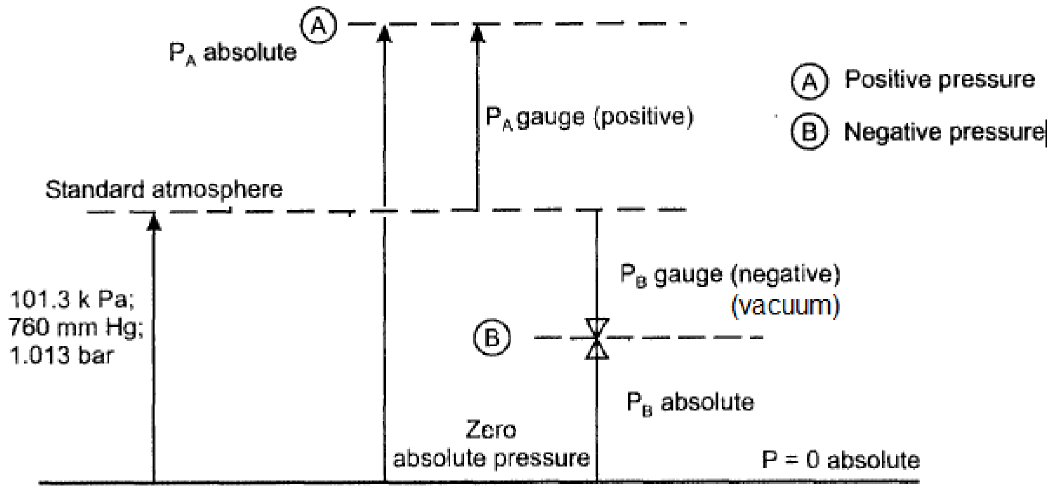
Isolated System

Properties of Systems

Pressure: is defined as a normal force exerted by a fluid per unit area.

$$p = \frac{F}{A}\ , The\ unit\ of\ the\ pressure\ is\ \frac{N}{m^2} = pascal\ (pa)$$

Pressure is usually measured relative to the atmospheric pressure which is known as **Gauge pressure**. In thermodynamic, we always use absolute pressure which is measured relative to absolute vacuum (absolute zero pressure).



To convert from gauge pressure to absolute pressure:

$(P_A)_{absolute} = P_{atm} + (P_A)_{Gauge}$, $(P_B)_{absolute} = P_{atm} - (P_B)_{Vacuum}$

Temperature: a measure of hotness or coldness. The unit of the temperature is Celsius (^{o}C). In thermodynamic, we always use Kelvin (K) instead.

To convert from Celsius to Kelvin:

K = C + 273

Density (ρ): The ratio of the mass of a fluid to its volume.

$\rho = \frac{Mass\ of\ fluid}{Volume\ of\ fluid}$ (kg / m^3).

Specific volume (υ): is defined as the volume of a fluid occupied by a unit mass. Thus, it is the reciprocal of the density.

$$\upsilon = \frac{Volume\ of\ fluid}{Mass\ of\ fluid} = \frac{1}{\rho}\ (m^3 / kg).$$

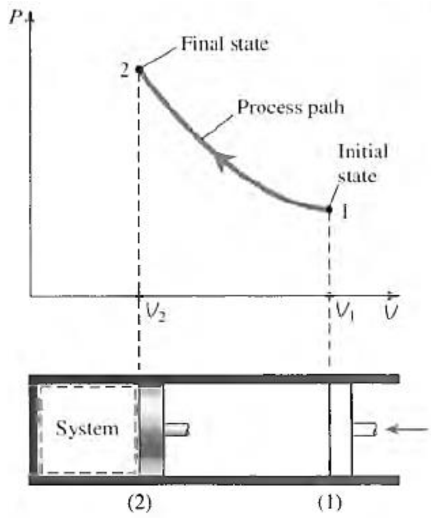
State and Process

State: set of properties (temperature, pressure and volume) that completely describes the condition of the system.

Process: change that a system undergoes from one state to another.

Processes and states are usually visualized by using **Process diagram**. One of the most commonly used is the **PV** diagram.

PV diagram: It is a diagram with pressure on the vertical axis (y-axis) and volume on the horizontal axis (x-axis). The compression process of a gas inside a piston cylinder can be represented on the PV diagram as follow:



Ideal Gas Law

An equation that relates the pressure, temperature and the volume of a substance.

$$\boxed{P\,V = m\,R\,T}$$

P: Absolute pressure (P_{gauge} +P_{atm})

T: Absolute temperature (in kelvin T = Temperature in Celsius + 273)

m: Mass

R: Gas constant and it is different for each gas (287 $\frac{J}{Kg.K}$ for air) and can be determined from:

$$R = \frac{R_u}{M}$$

R_u is the universal gas constant and it the same for all gases, R_u = 8.314 $\frac{J}{mole\ .K}$

M is the Molar mass and can be find from:

$M = m/N$ (mass /No. of Mole). Therefore,

$$\boxed{P\,V = N\,R_u T}$$

Ex1) The gage pressure of an automobile tire is measured to be 210 Kpa before a trip and 220 Kpa after the trip at a location where the atmospheric pressure is 95 Kpa. Assuming the volume of the tire remains constant and the air temperature before the trip is 25°C, determine air temperature in the tire after the trip.

Zeroth Law of Thermodynamic

when a body is brought into contact with another body that is at a different temperature, heat is transferred from the body at higher temperature to the one at lower temperature until both bodies attain the same temperature. At that point, the heat transfer stops, and the two bodies are said to have reached **thermal equilibrium.**

The **zeroth law of thermodynamics** states that two bodies are in thermal equilibrium if both have the same temperature.