CHAPTER ONE

Introductory Concepts and Definitions

Objective

- To introduce you to some of the fundamental concepts and definition that are used in the study of Engineering Thermodynamics.

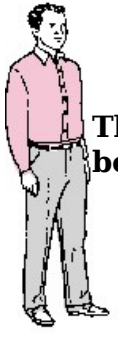
Thermodynamics and Energy

- Thermodynamics can be defined as the **science of *energy*.**
- Thermodynamics is a **Science** that deals with **heat and work** and the changes they can produce.
- e.g. change of temperature (T), pressure (P) etc.



Applications of Thermodynamics

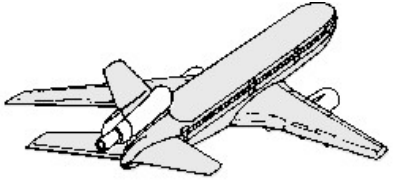




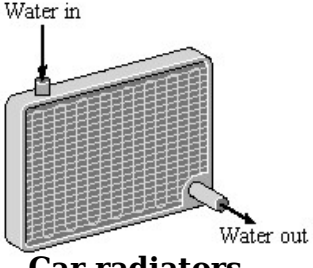
The human body



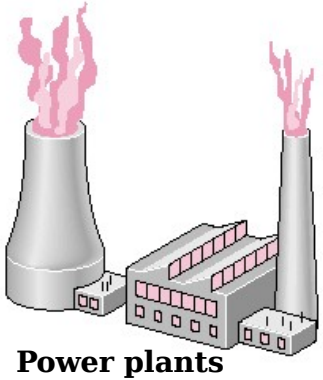
Air-conditioning systems



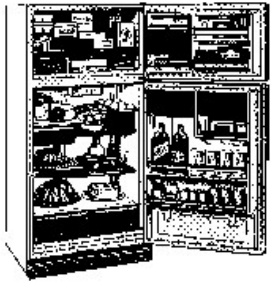
Airplanes



Car radiators

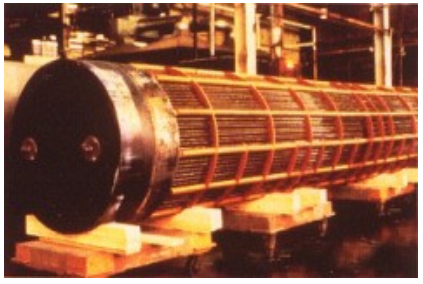


Power plants

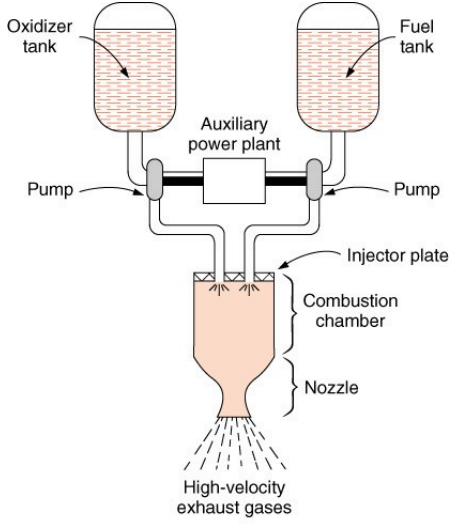


Refrigeration systems

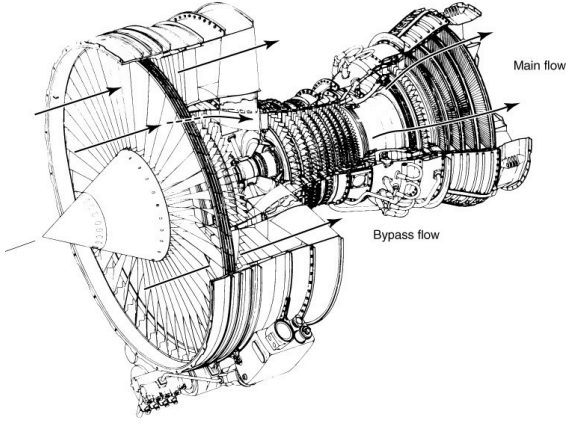
Applications of Thermodynamics





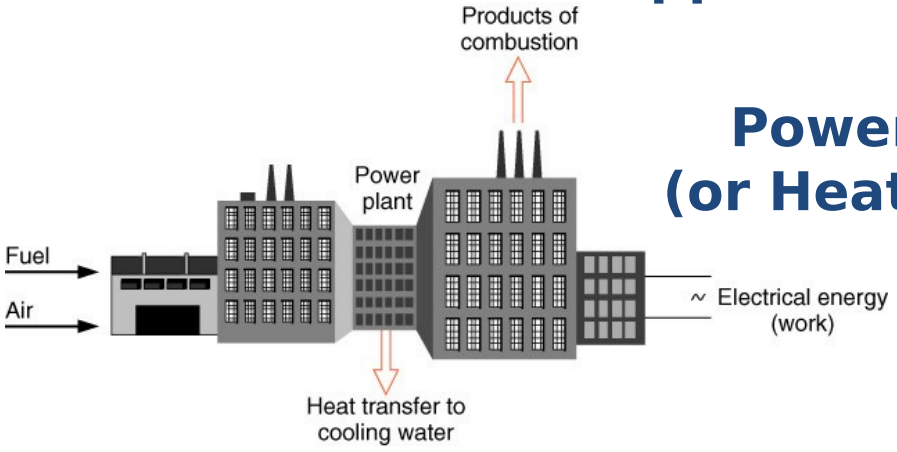


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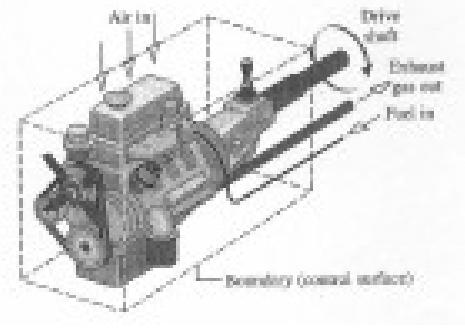


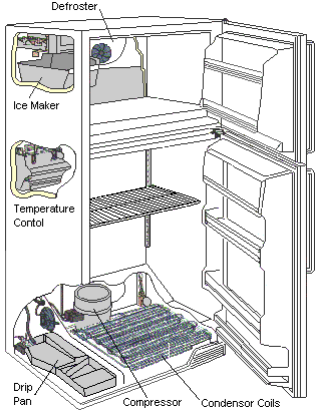
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Applications of Thermodynamics



Power plant (or Heat engine)





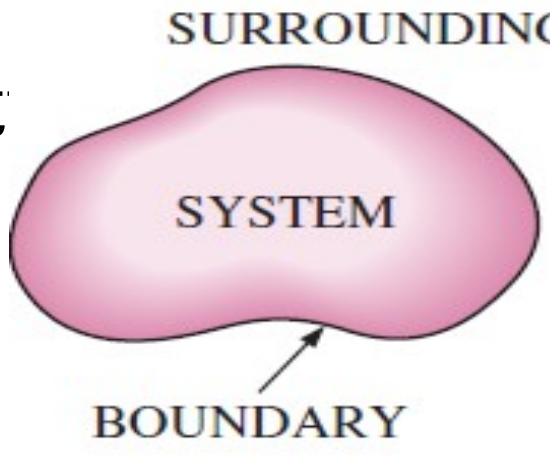
Refrigerator (or Air-conditioner)



Closed, Open and Isolated System

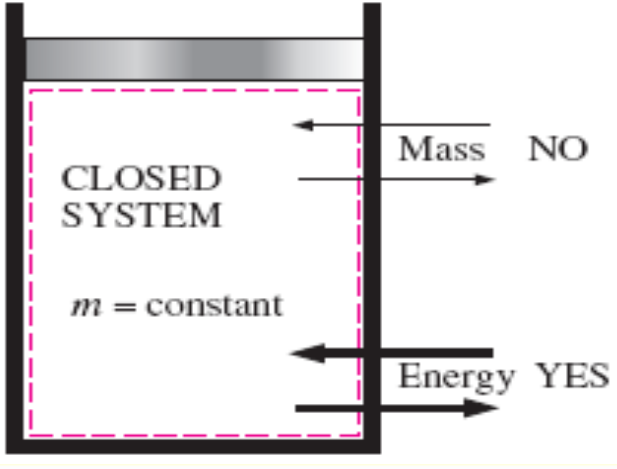
- In thermodynamics ***system*** (simply system) is defined as a quantity of matter or a region in space chosen for study. Or simply, whatever we want to study is system.
- Everything **external to the system** is called the ***surroundings***.
- The real or imaginary surface that **separates** the system from its surroundings is called the ***boundary***.

- The boundary of a system can be ***fixed or movable.***
- Systems may be considered to be ***closed or open,*** depending on whether a fixed mass or a fixed volume in space is chosen for st



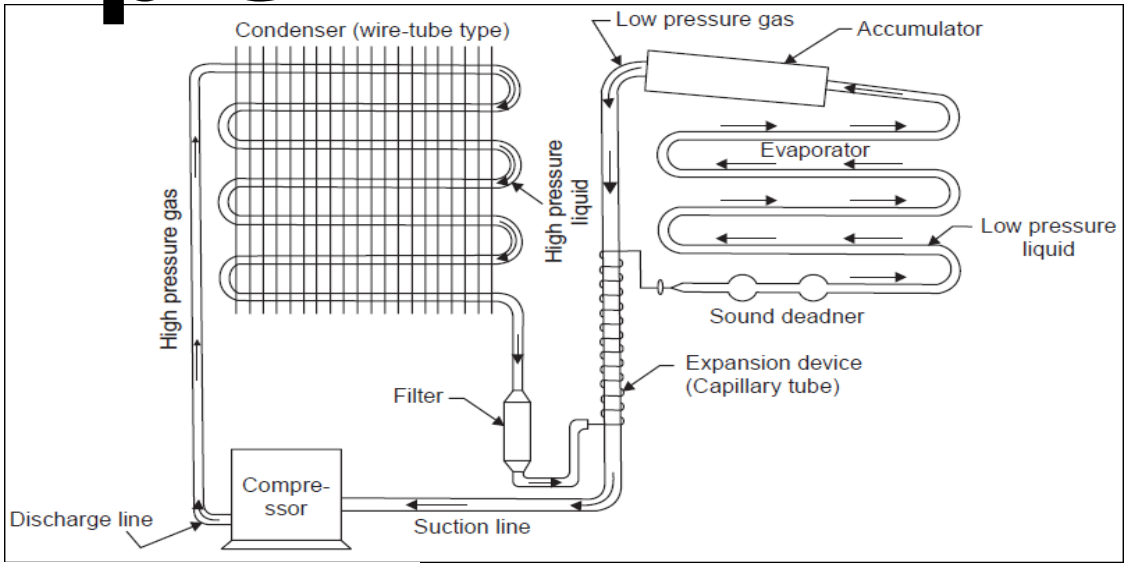
Closed System

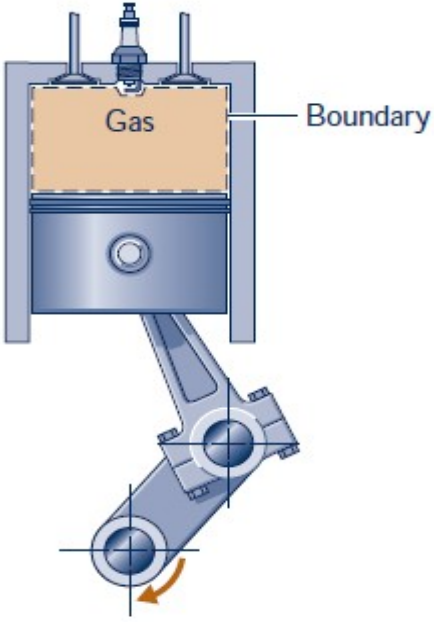
- Also called ***non-flow*** system.
- Consists of a fixed amount of mass and ***no mass*** may cross the system.
- The closed system boundary may move.
- Energy in the form of ***heat and work*** can cross the boundaries of a cl

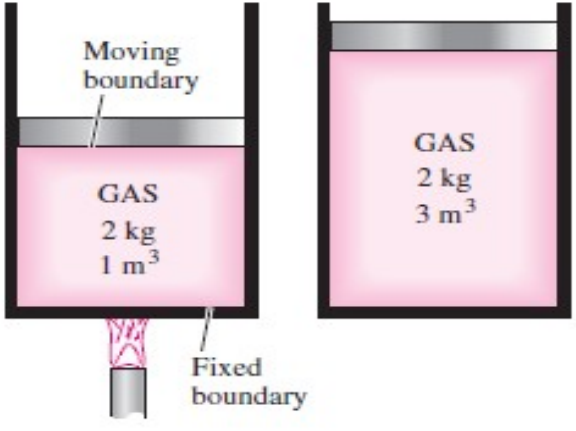


Example

- Sealed tanks
- Piston cylinder device
- Refrigeration

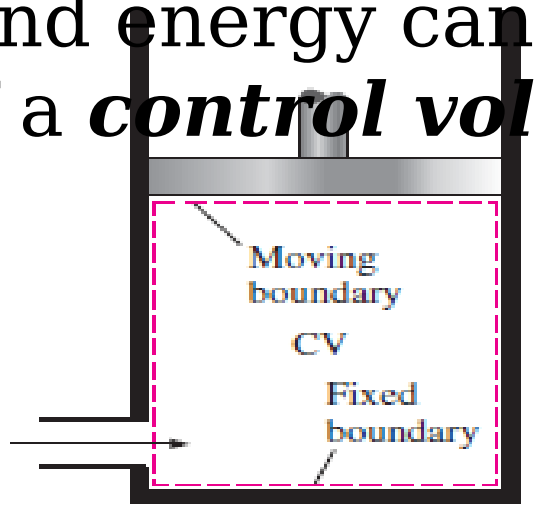






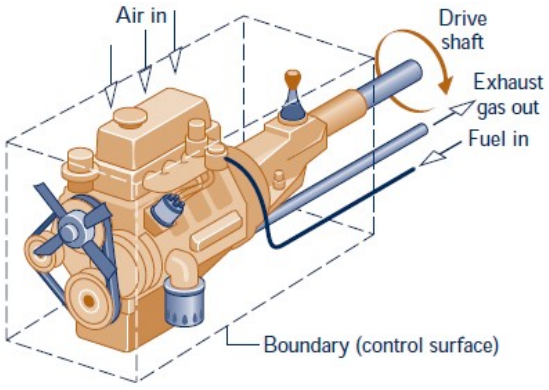
Open System

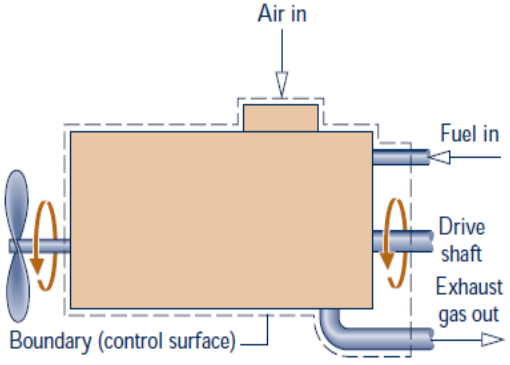
- Also called ***flow*** system.
- ***Mass*** as well as ***energy*** crossing the boundary.
- It is called a ***control surface*** because both mass and energy can across the boundary of a ***control volume***.



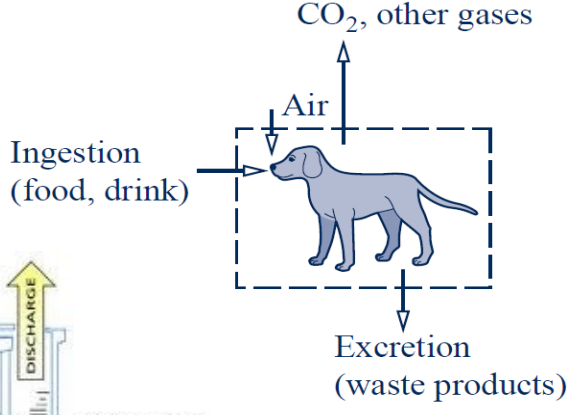
Example

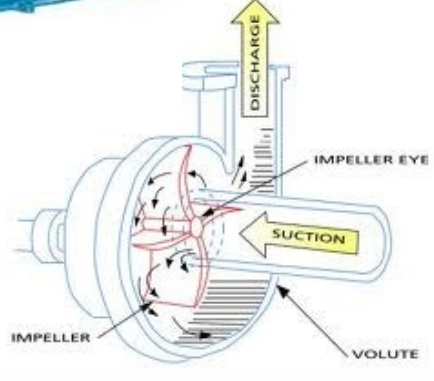
- Pumps
- Compressor
- Heat exchanger

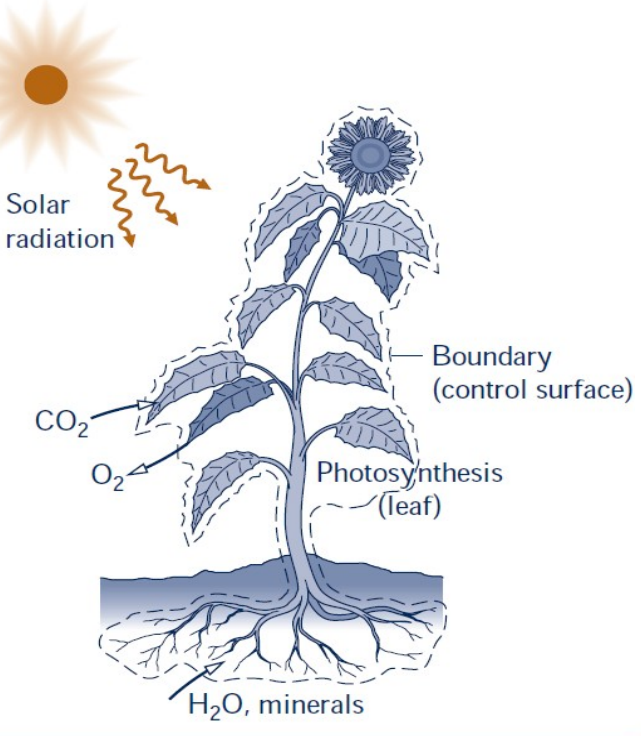






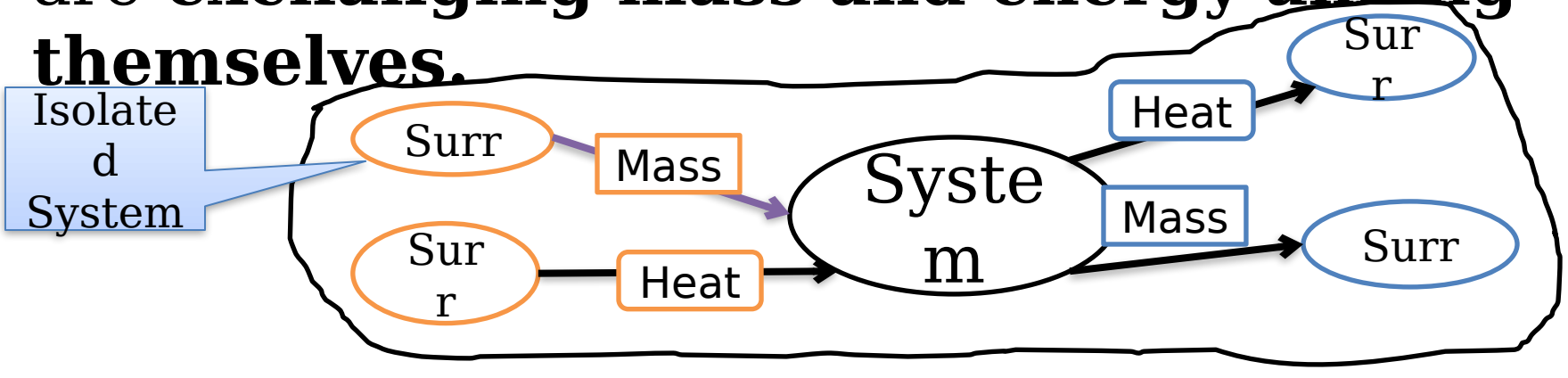






Isolated System

- A general system of fixed mass where ***no heat*** or ***work*** may cross the boundary.
- A closed system with **no energy crossing the boundaries** and is normally a collection of a main system and its surrounding that are **exchanging mass and energy among themselves.**



State, Equilibrium, Process and Properties

- A ***phase*** is defined as a quantity of matter that is homogeneous throughout. When more than one phase is present, the phases are separated from each other by the phase boundaries.
- In each phase the substance may exist at various pressures and temperatures or, to use the thermodynamic term, in various ***states***.

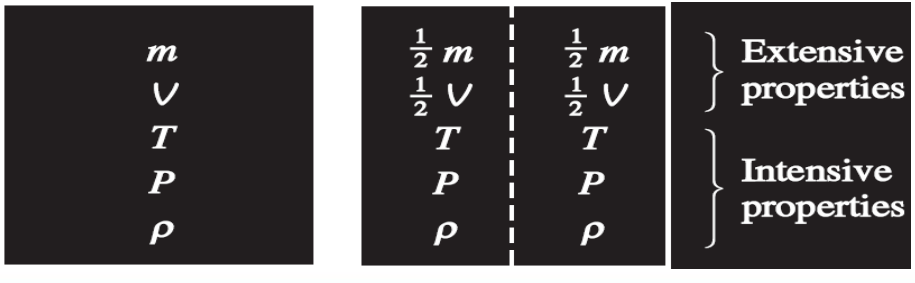
State

- Condition of the system at an **instant of time** as described or measured by its **properties.**
- Consider a system not undergoing any change. The properties can be measured or calculated throughout the entire system. This gives us a set of properties that completely describes the condition of a state.
- At a given state, all the properties are known; **changing one property changes the state.**

- Each of the ***properties*** of a substance in a given state has only one definite value, and these properties always have the same value for a given state, regardless of how the substance arrived at the state.
- Thermodynamic properties can be divided into two general classes: ***intensive*** and ***extensive***. An ***intensive*** property is ***independent*** of the ***mass***; the value of an ***extensive*** property ***varies*** directly ***with the mass.***

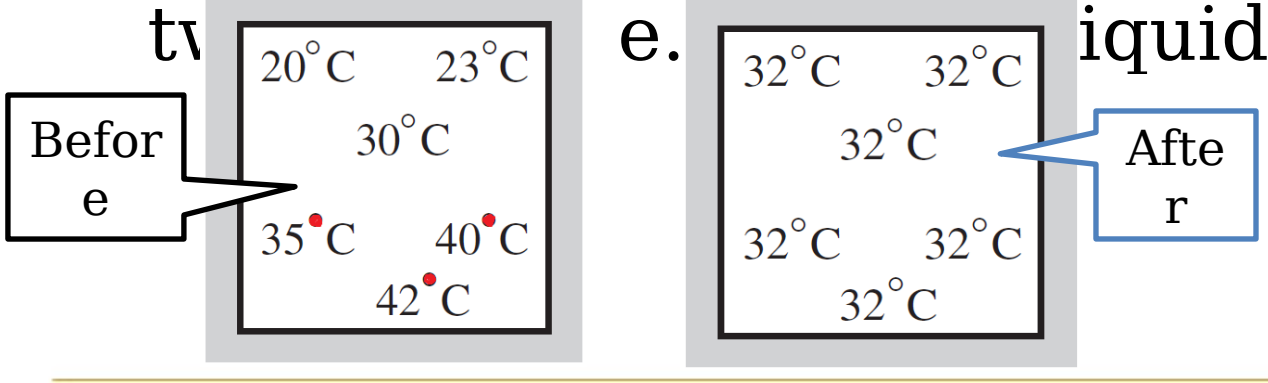
Property

- Any characteristic of a system is called a ***property***.
- Some familiar properties are ***pressure*** *(P),* ***temperature*** *(T),* ***volume*** *(V), and* ***mass*** *(m).*
- There are two types of property; ***intensive*** *or* ***extensive***
  - ***Intensive*** properties are those that are independent of the ***size*** of a system.
    - » Temperature,
    - » Pressure
    - » Age
    - » Color
  - ***Extensive*** properties are those that are depend on the size of the system.
    - » Mass
    - » Volume
    - » Total energy



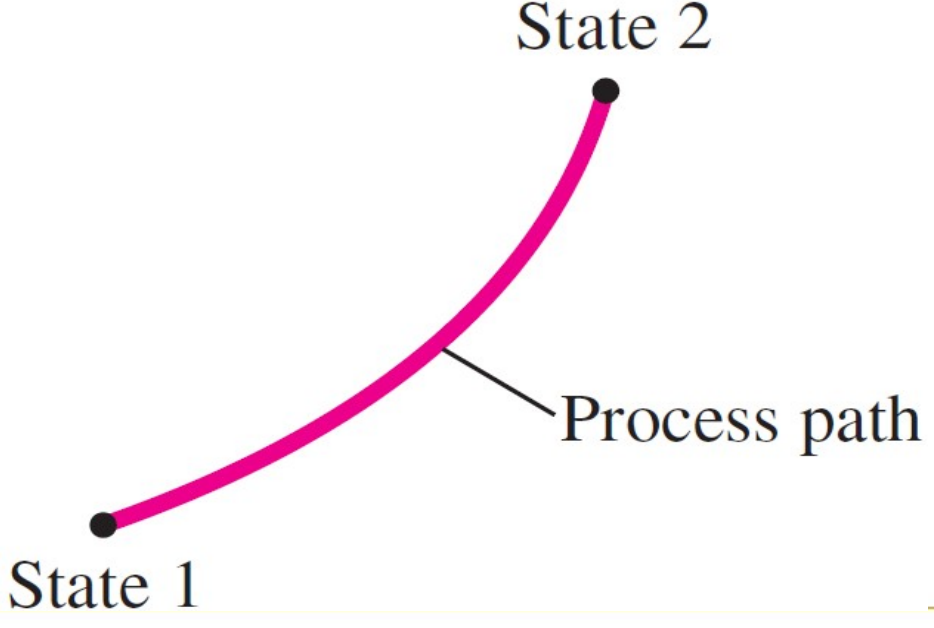
Equilibrium

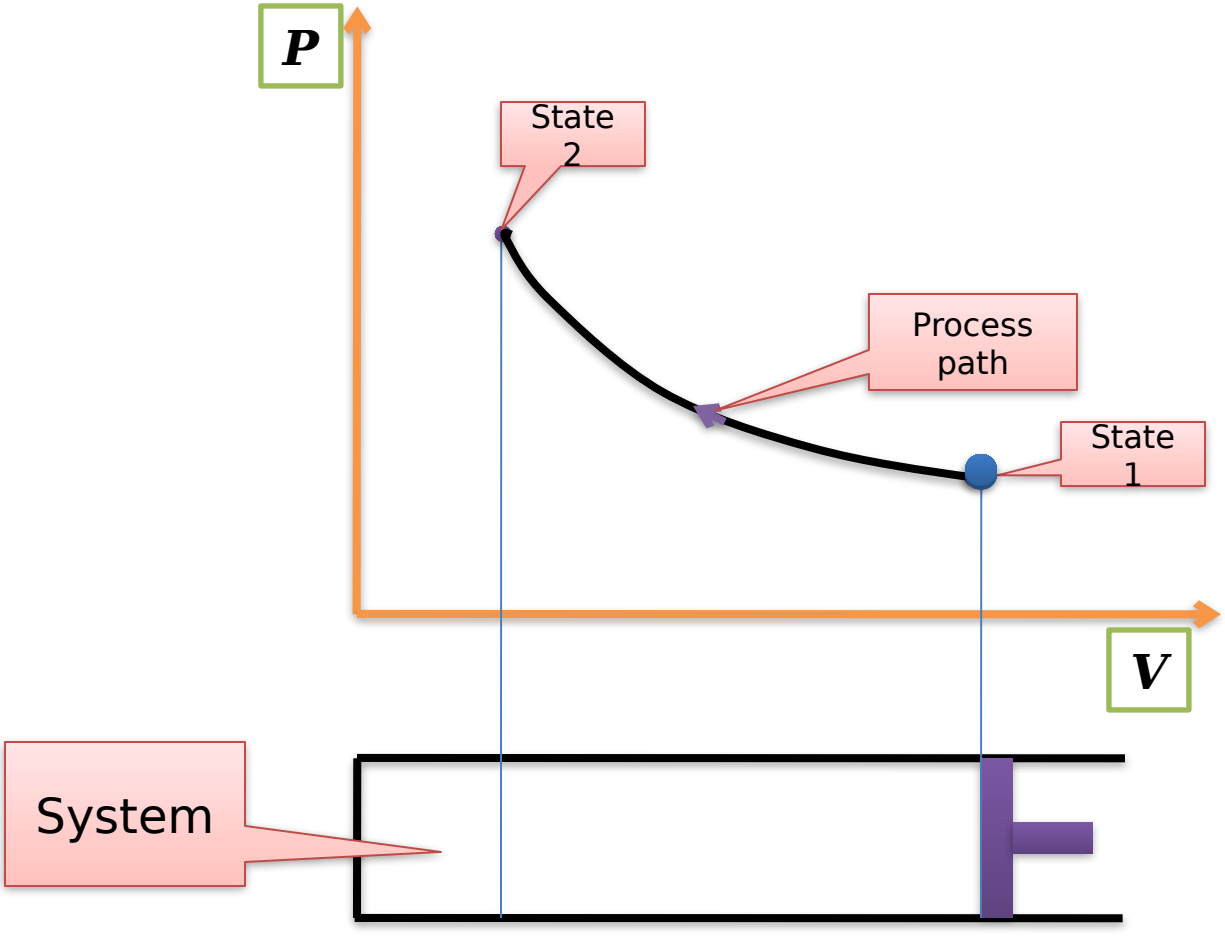
- The word ***equilibrium*** implies a state of balance.
- A system is said to be in thermodynamic equilibrium if it maintains thermal (uniform temperature), mechanical (uniform pressure), phase (the mass of tw e. iquid water, in



Process

- When any of the properties of a system change, the state changes and the system is said to have undergone a ***process*.**
- A ***process*** is a transformation from one state to




P
State 2
Process path
State 1
V
System

- In most of the process that we will study, one thermodynamic properties is held ***constant***.
- Some of the

Process	Property held constant
Isobaric	
Isothermal	
Isochoric	
Isentropic	

Pressure

Temperature

Volume

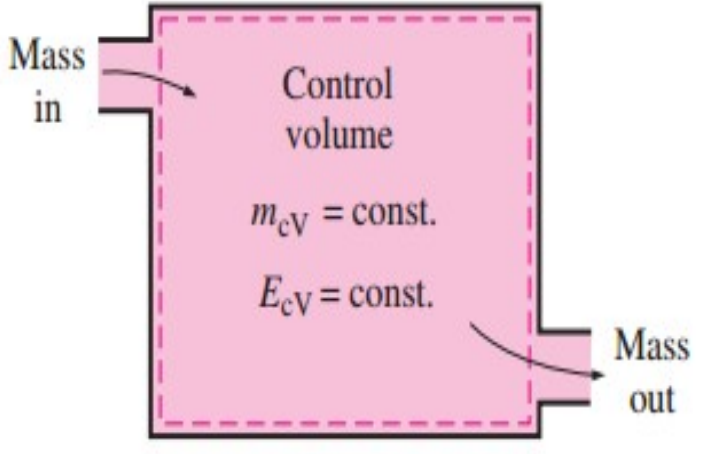
Entropy

The Steady-Flow Process

- The terms steady and uniform are used frequently in engineering.
- The term ***Steady*** implies no change with ***time***.
- The opposite of steady is ***unsteady,*** or ***transient.***
- The term ***uniform*** implies no change with ***location*** over a specified region

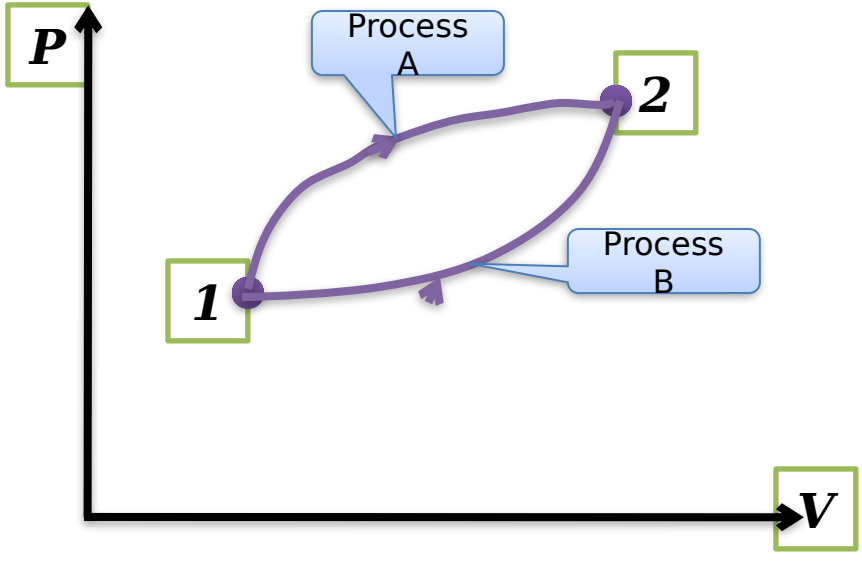
- A Devices that operates for long periods of time under the same conditions, and they are classified as steady-flow devices.
- During a steady-flow process, fluid properties within the control volume may change **with position but r**
- The mass and energy conter
  a control volume remain co

Ex. Turbines, Pumps, Boilers,
Condensers, and Heat Excha



Cycle

- Series of process in which the ***initial state*** of the first process is ***identical*** to the ***final state*** of the last process.



Dimensions and Units

- Any physical quantity can be characterized by ***dimensions***.
- The arbitrary magnitudes assigned to the dimensions are called ***units***.
- In engineering thermodynamics, basically, there are ***four*** dimensions. (primary dimension)
    - **Mass, Length, Time and Temperature**
- The others are simply derived from primary units.

- The seven fundamental of dimensions and their units in SI

Dimension	unit
Length	Meter(m)
Mass	kilogram(kg)
Time	second(s)
Temperature	Kelvin(k)
Electric Current	ampere(A)
Amount of Light	candela(c)
Amount of matter	mole(mol)

Specific Volume, Pressure and Temperature

Specific Volume

- The volume occupied by a unit mass of a substance, and it is designated by **n.**

$$v = \frac{Volume}{mass} = \frac{V}{m}\ (m^3/kg) = \frac{1}{\rho}$$

- Specific density /gravity
  - The density of substance divided by the density of water.

$$\rho_s = \frac{\rho}{\rho_{H_2O}}, \rho_{H_2O} = 1000 kg/m^3$$

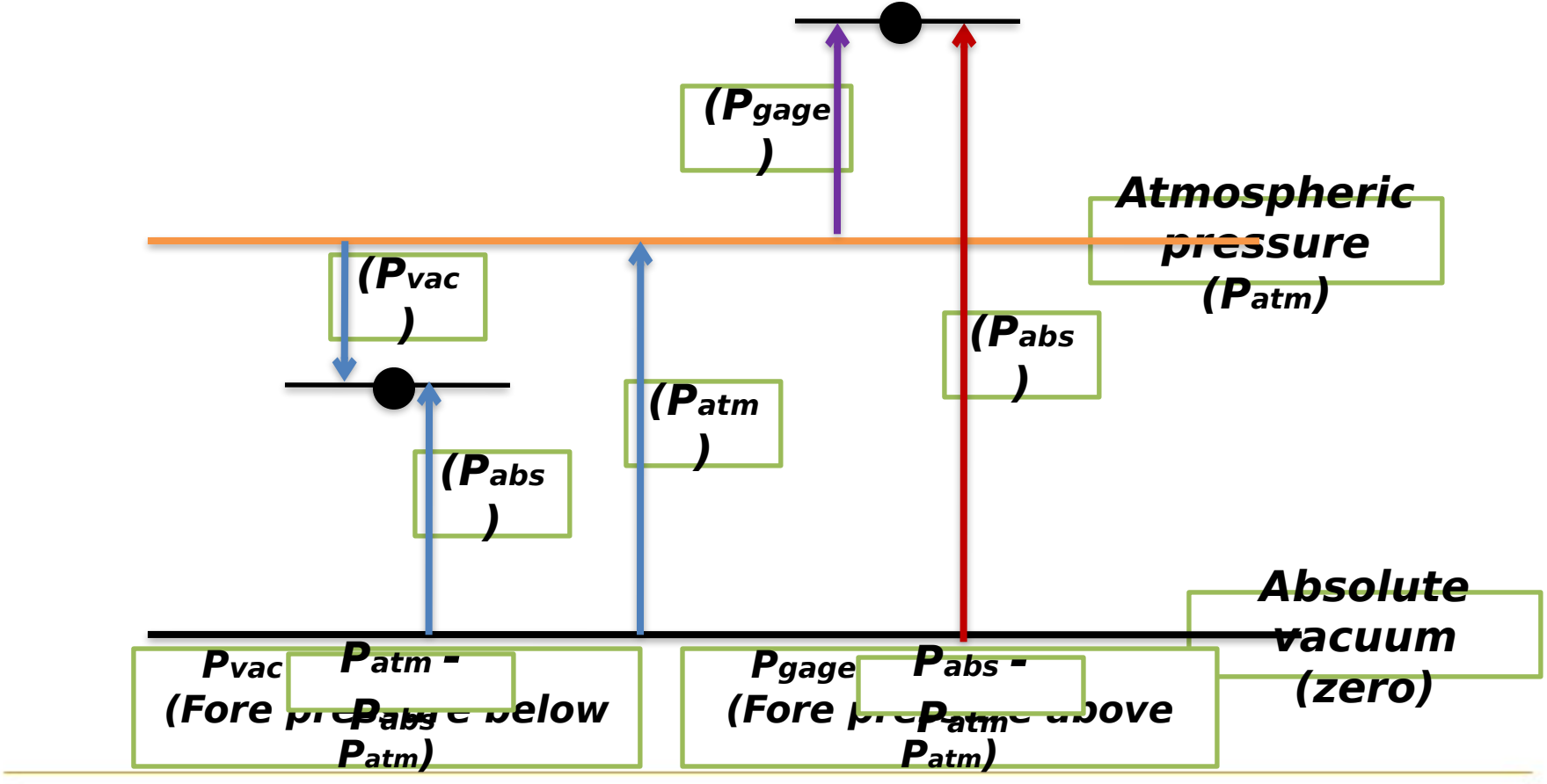
Pressure

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

$$P = \frac{Force}{Area} = \frac{F}{A} = \frac{N}{m^2} = Pascal = Pa$$

- The actual pressure at a given point is called the ***absolute pressure*** and it is measured relative to ***absolute vacuumed***.(absolute ***zero pressure***)
- However, pressure are often measured ***relative to atmospheric*** pressure, called ***gauge*** or ***vacuum*** pressure.

Atmospheric pressure is the force per unit area exerted into a surface sea level by the weight of air above that surface in the atmosphere of earth.

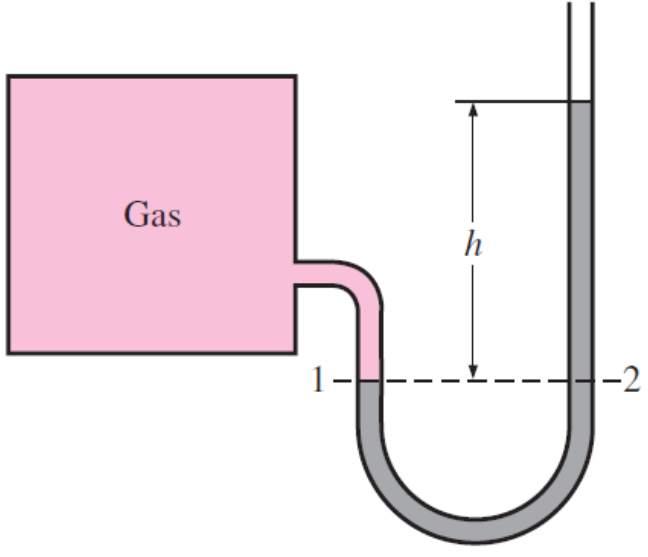


Manometer

- Measure small and moderate pressure differences.
- Manometer mainly consists of a glass or plastic ***U-tube*** containing one or more fluids such as mercury, water, alcohol, or oil.

- Pressure is the same in the horizontal direction for a fluid at rest

$$P_2 = P_{\text{atm}} + \rho g h$$



Temperature

- It is considered as a thermodynamic property that is the measure of the ***energy content*** of a mass.
- When ***heat*** energy is transferred to a body, the body's ***energy*** content increases and so does its ***temperature***.
- Two bodies are in ***thermal equilibrium ,***when they have reached the ***same temperature***.
- If two bodies are in ***thermal equilibrium*** with a ***third body***, they are also in thermal equilibrium with ***each other***. This simple fact is known as the ***zeroth law of thermodynamics.***