ME 266 Thermodynamics 1

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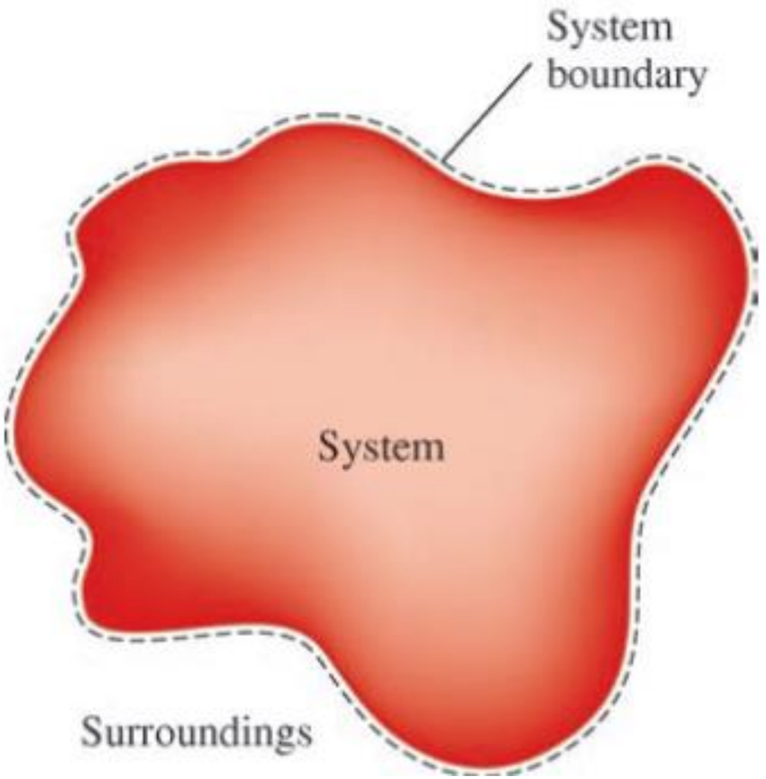
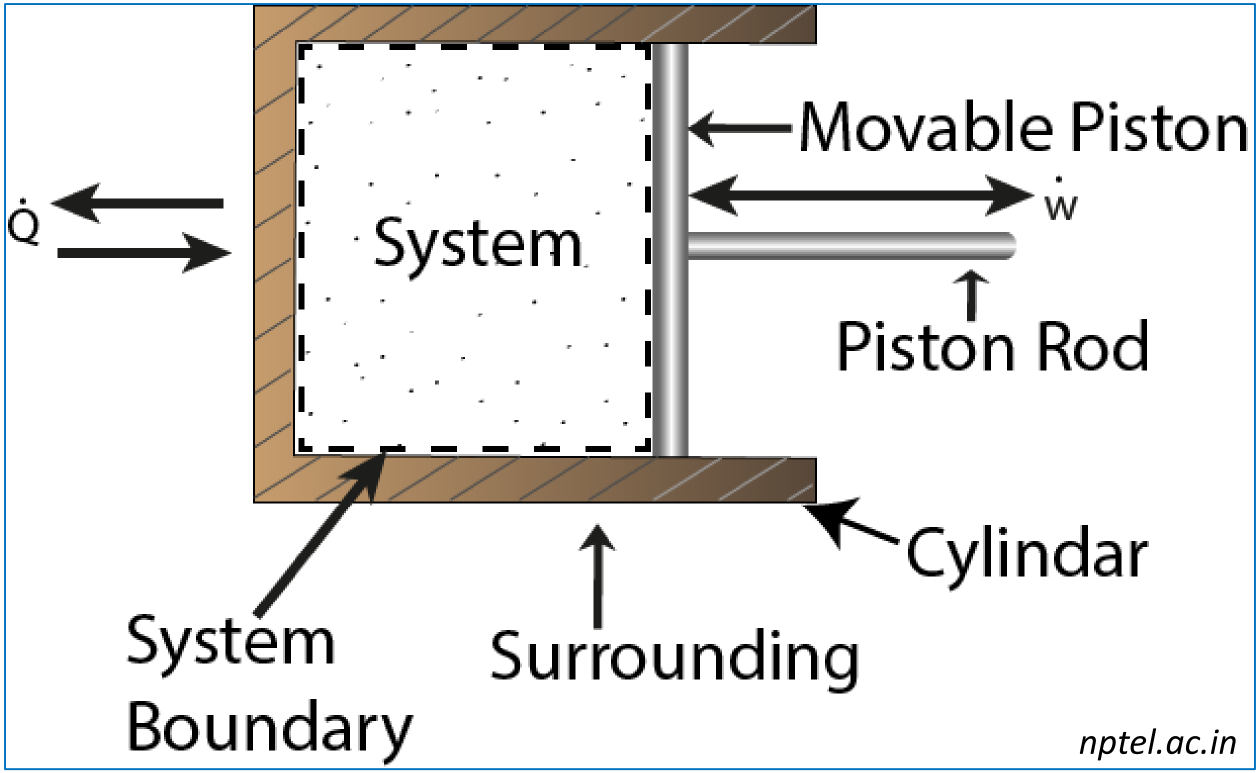
Introductory Concepts and Definitions

- *System*
  - *Closed*
  - *Open*
  - *Isolated*
- *surroundings*
- *system boundary*
- *working fluid*



Introductory Concepts and Definitions

- System boundaries may be drawn to reflect the type of analysis one wishes to perform.



Introductory Concepts and Definitions

Control Volume is defined by a surface (real or imaginary) enclosing a volume of interest.

Introductory Concepts and Definitions

- **Property**
- State
- Process
- Path
- Flow process
- Cycle
- Equilibrium
- Quasi-equilibrium

A *property is a quantifiable macroscopic characteristic* of a system.

e.g. mass, volume, density, pressure, temperature, etc

Introductory Concepts and Definitions

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The thermodynamic *state of a system is defined by the values of* all of the system thermodynamic properties.

Introductory Concepts and Definitions

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A process occurs whenever a system changes from one state to another state.

E.g. when the temperature or pressure of a system changes.

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Types of Processes

Constant-temperature process– Isothermal

Constant-Pressure process- Isobaric

Constant-Enthropy process- Isentropic

Constant-Volume – Isochoric

More will be encountered in this course!

Introductory Concepts and Definitions

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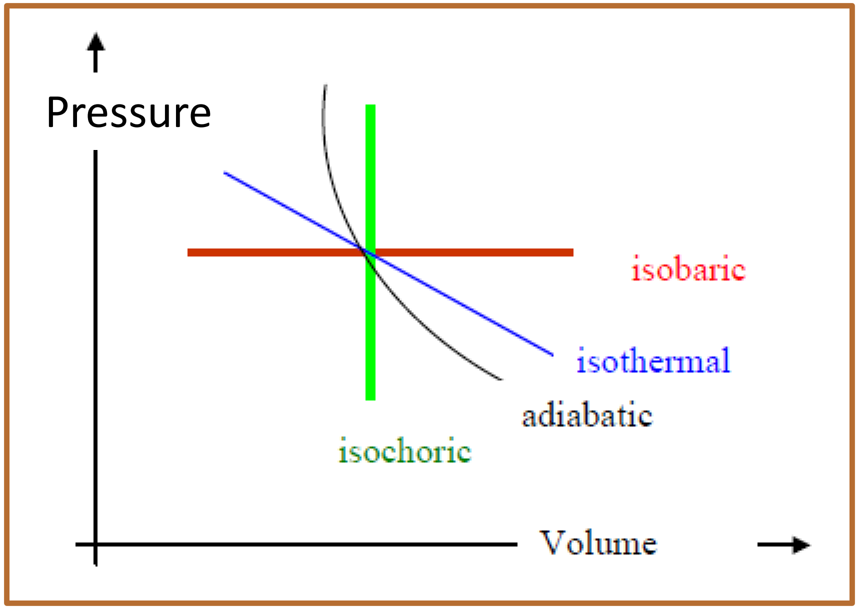

A PATH is the series of states through which a system passes during a process.

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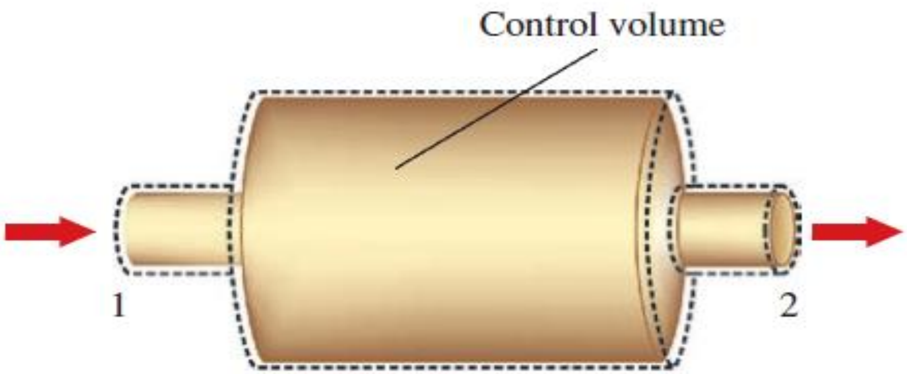

A *flow process occurs whenever the state of a fluid entering* a control volume is different from the state of the fluid exiting the control volume.

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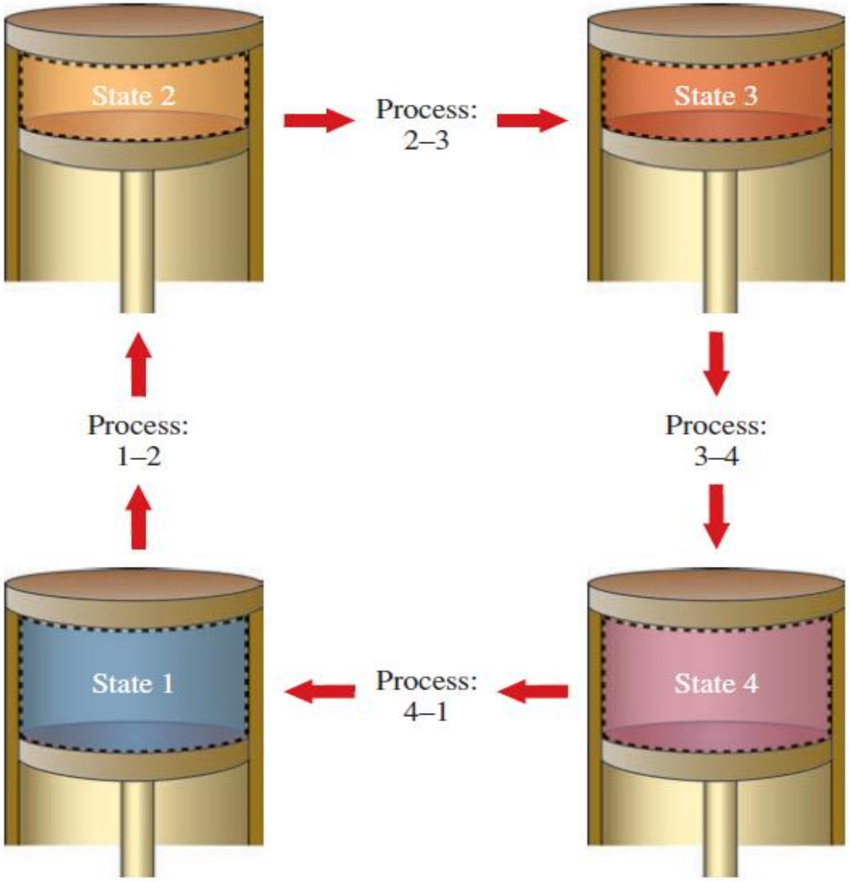

A thermodynamic cycle consists of a sequence of processes in which the working fluid returns to its original thermodynamic state.

Introductory Concepts and Definitions

- Property
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- **Equilibrium**
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When the properties of a thermodynamic system are constant from point to point and when there is no tendency for change with time, a condition of *thermodynamic equilibrium* is said to exist.

Introductory Concepts and Definitions

- Property
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- Cycle
- **Equilibrium**
- Quasi-equilibrium

Conditions for Complete Equilibrium

Thermal equilibrium

Uniform system temperature and is same temperature as its surroundings.

Mechanical equilibrium

achieved when the pressure throughout the system is uniform and there are no unbalanced forces at the system boundaries.

Phase equilibrium

Phase equilibrium requires that the amount of a substance in any one phase not change with time.

Chemical equilibrium

system is in chemical equilibrium if its chemical composition does not change with time, that is, no chemical reactions occur.

Introductory Concepts and Definitions

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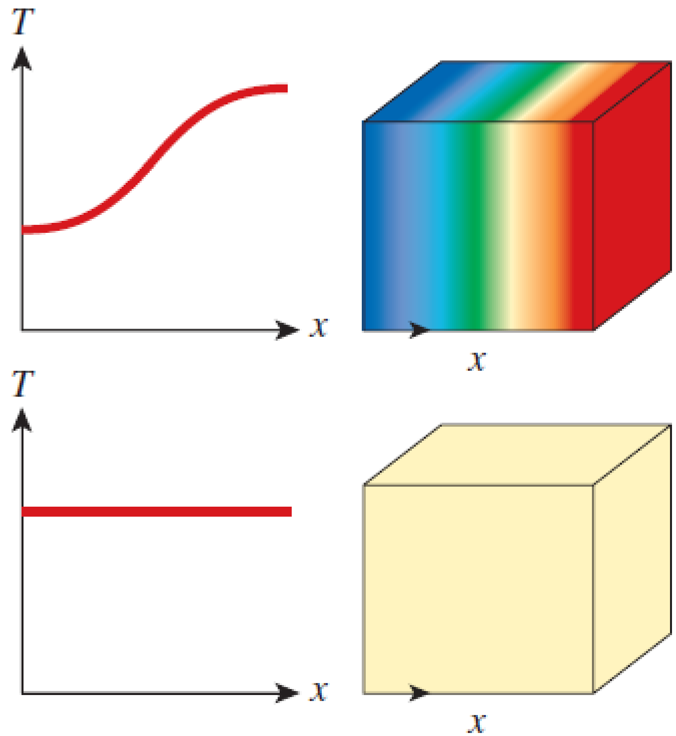
- **Equilibrium**
- Quasi-equilibrium

Thermal equilibrium



Introductory Concepts and Definitions

- Property
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- Flow process
- Cycle
- Equilibrium
- **Quasi-equilibrium**

A quasi-static or quasi-equilibrium process is a process that happens sufficiently slow such that departures from thermodynamic equilibrium are always so small that they can be neglected.

Introductory Concepts and Definitions

Path and Point Functions

The value of a property of a system is independent of the path of the process undergone by the system and is therefore referred to as a **point function (also called state function)**.

Quantities such as heat and work which are not properties of the system and dependent on the path of the process undergone by the system are classified as **path functions**.

Introductory Concepts and Definitions

Property

Path and Point Functions

If X is a property, then the change in its value is independent of path, hence:

$$\int_1^2 dX = X_2 - X_1$$

This requires that *dX* be an *exact differential* X_2-X_1 represents the change in the property as the system changes from state 1 to state 2.

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Property**

Path and Point Functions

Quantities such as **heat** and **work** which are not properties of the system and are dependent on the path of the process undergone by the system are classified as **path function**.

$$\int_1^2 dQ = Q_{12} \quad and \quad \int_1^2 dW = W_{12}$$

Note that a quantity is a property if, and only if, its change in value between states is independent of the path of the process.

INTRODUCTORY CONCEPTS AND DEFINITIONS

Extensive and Intensive Properties

- **Property**

- An ***<u>intensive property</u>*** is one that does not depend on the mass of the system.
- Temperature, pressure, density, and velocity are examples.
- If two (or more) systems are brought together, intensive properties are not summed.

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Property**

Extensive and Intensive Properties

An ***extensive property*** is one that does depend on the mass of the system; mass, volume, momentum, and kinetic energy are examples. If two systems are brought together the extensive property of the new system is the sum of the extensive properties of the original two systems.

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Property**

Extensive and Intensive Properties

If an extensive property is divided by the mass, a *specific property* is obtained.

Generally, uppercase letters are used to represent extensive properties (exception: *m* for mass) and lowercase letters to denote the associated specific property

INTRODUCTORY CONCEPTS AND DEFINITIONS

- Density
- Specific Volume
- Specific Weight
- Pressure

Mass density **(or simply density)**- mass per unit volume.

$$\rho = \frac{m}{V} \qquad (unit: kg/m^3)$$

Specific volume *- volume per unit mass.*

$$v = \frac{V}{m} = \frac{1}{\rho} \qquad (unit: m^3/kg)$$

weight density *(or specific weight) – Weight per unit volume.*

$$\gamma = \frac{W}{V} \qquad (unit: N/m^3)$$

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Density**
- **Specific Volume**
- **Specific Weight**
- **Pressure**

<u>Thermodynamic Pressure</u>

The ***pressure***, P, of a system is the total normal force, per unit area, exerted by the system within and at the boundary. *Collision with other molecules and with the walls of the containing vessel.*

The SI unit of pressure and stress is the Pascal (Pa).

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Density**
- **Specific Volume**
- **Specific Weight**
- **Pressure**

Thermodynamic Pressure

The SI unit of pressure and stress is the Pascal (Pa)

1 Pa = 1 N/m^2

It is convenient sometimes to work in multiples of Pa.

$$1\ \mathrm{kPa} = 10^3\ \mathrm{N/m^2}$$
$$1\ \mathrm{bar} = 10^5\ \mathrm{N/m^2}$$
$$1\ \mathrm{MPa} = 10^6\ \mathrm{N/m^2}$$

1 atm = 101 325 Pa = 1.013 25 bar = 760 mm Hg

INTRODUCTORY CONCEPTS AND DEFINITIONS

- **Density**
- **Specific Volume**
- **Specific Weight**
- **Pressure**

<u>Thermodynamic Pressure</u>

The pressure of a system is usually measured relative to the atmosphere, and it is called “gauge pressure”.

Absolute pressure

=

Gauge pressure

+

Atmospheric pressure