# Thermodynamics (ESC-S202)

## Lecture-3

## Introduction of Thermodynamics

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# Introduction of Thermodynamics

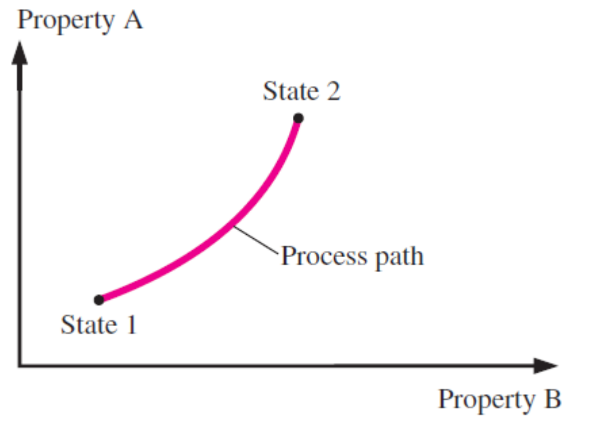
## Process

- Any change that a system undergoes from one equilibrium state to another is called a **process.**

## Path

- The series of states through which a system passes during a process is called the **path** of the process.

- To describe a process completely, one should specify the initial and final states of the process, as well as the path it follows, and the interactions with the surroundings.

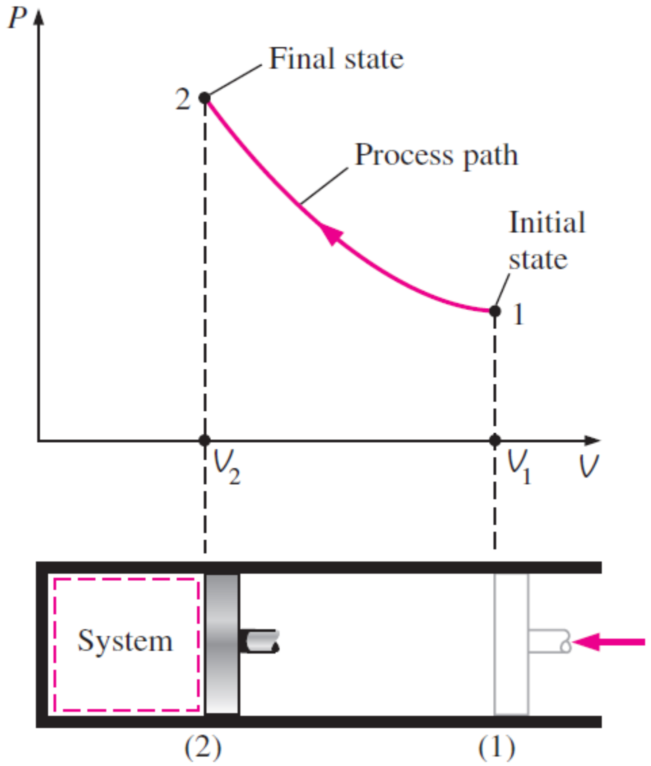


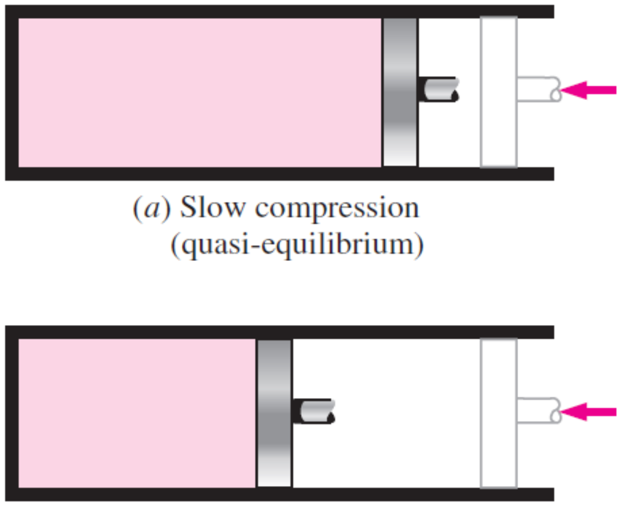

**Process and Path**

[Source-Thermodynamics an Engineering Approach-Y. Cengel]

# Quasi-static Process

- When a process proceeds in such a manner that the system remains infinitesimally close to an equilibrium state at all times, it is called a **quasi-static,** or **quasi-equilibrium process.**



(*a*) Slow compression (quasi-equilibrium)

(*b*) Very fast compression (nonquasi-equilibrium)

- The process path indicates a series of equilibrium states through which the system passes during a process and has significance for quasi-equilibrium processes only.

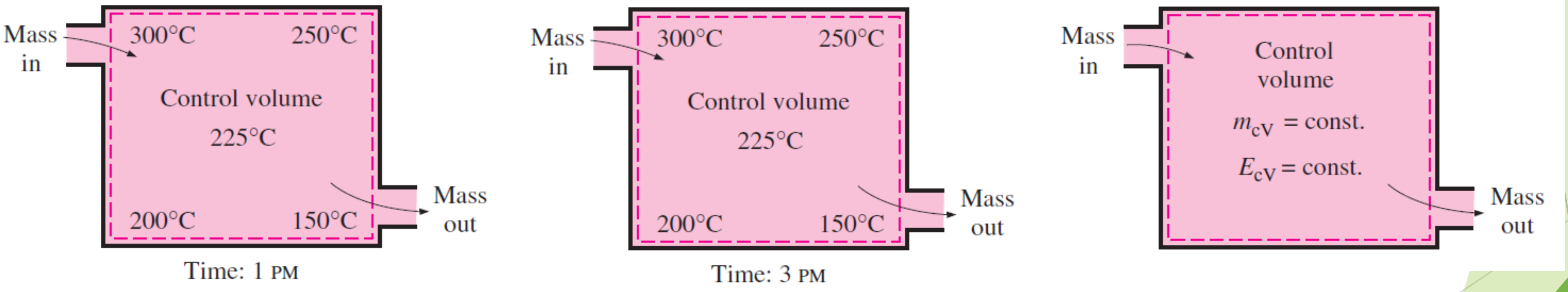
- For nonquasi-equilibrium processes, we are not able to characterize the entire system by a single state, and thus we cannot speak of a process path for a system as a whole.
- A nonquasi-equilibrium process is denoted by a dashed line between the initial and final states instead of a solid line.

## Cycle

- A system is said to have undergone a cycle if it returns to its initial state at the end of the process.
- For a cycle the initial and final states are identical.

## Steady-Flow Process

- The term steady implies no change with time.
- The fluid properties can change from point to point within the control volume, but at any fixed point they remain the same during the entire process.
- The volume V, the mass m, and the total energy content E of the control volume remain constant during a steady flow process.




**Steady Flow Process**
[Source-Thermodynamics an Engineering Approach-Y. Cengel]

## Macroscopic Approach

- In macroscopic approach we fix our attention to certain quantity of matter without considering the activities (or events) happening at molecular level.
- This macroscopic approach to the study of thermodynamics that does not require a knowledge of the behavior of individual particles is called classical thermodynamics.
- Measurement of Pressure of a gas container.

## Microscopic Approach

- In microscopic view we try to determine behavior of a system by the events happening at molecular level.
- Macroscopic behavior is an average of microscopic behavior of large number of molecules over a considerable period of time.
- A more elaborate approach, based on the average behavior of large groups of individual particles, is called statistical thermodynamics.
- Pressure can also be explained as the change of momentum due to molecular collision.

# Pressure

- Pressure is defined as force per unit area.
- It has the unit of newtons per square meter (N/m2), which is called a pascal (Pa).

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

$$1 \text{ bar} = 10^5 \text{ Pa} = 0.1 \text{ MPa} = 100 \text{ kPa}$$

$$1 \text{ atm} = 101{,}325 \text{ Pa} = 101.325 \text{ kPa} = 1.01325 \text{ bars}$$

$$1 \text{ kgf/cm}^2 = 9.807 \text{ N/cm}^2 = 9.807 \times 10^4 \text{ N/m}^2 = 9.807 \times 10^4 \text{ Pa}$$

$$= 0.9807 \text{ bar}$$

$$= 0.9679 \text{ atm}$$

$$1 \text{ atm} = 14.696 \text{ psi}$$

## Absolute Pressure

- The actual pressure at a given position is called the absolute pressure, and it is measured relative to absolute vacuum (i.e., absolute zero pressure).

## Gauge Pressure

- Most pressure-measuring devices, however, are calibrated to read zero in the atmosphere and so they indicate the difference between the absolute pressure and the local atmospheric pressure. This difference is called the gage pressure.

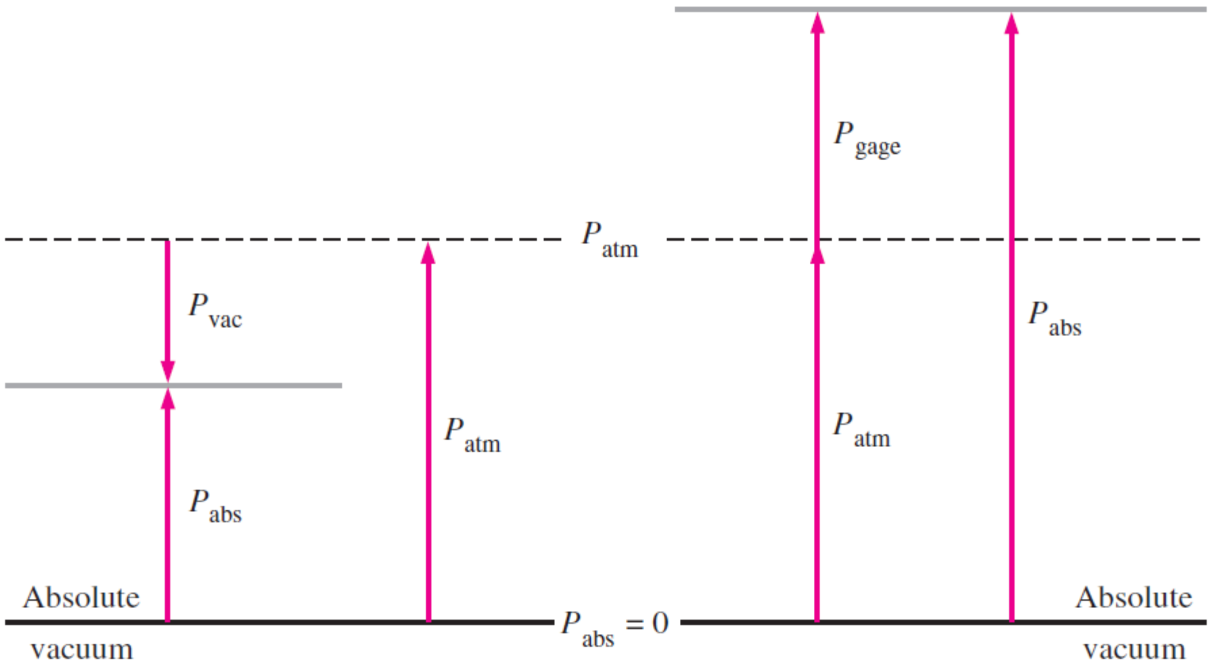
## Vacuum Pressure

- Pressures below atmospheric pressure are called vacuum pressures and are measured by vacuum gages that indicate the difference between the atmospheric pressure and the absolute pressure.

$$P_{\text{gage}} = P_{\text{abs}} - P_{\text{atm}}$$

$$P_{\text{vac}} = P_{\text{atm}} - P_{\text{abs}}$$

# Pressure




$$P_{gage} = P_{abs} - P_{atm}$$

$$P_{vac} = P_{atm} - P_{abs}$$