Chapter # 1

Getting Started

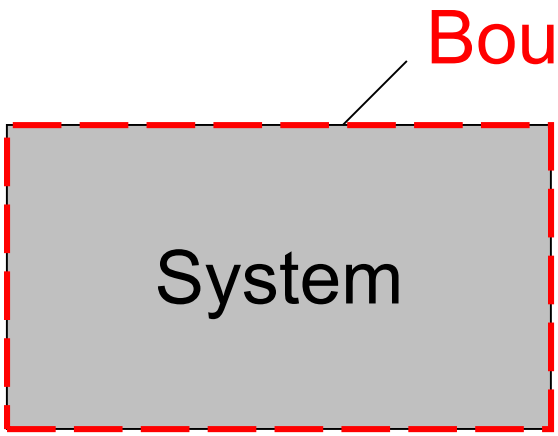
Introductory Concepts and Definitions

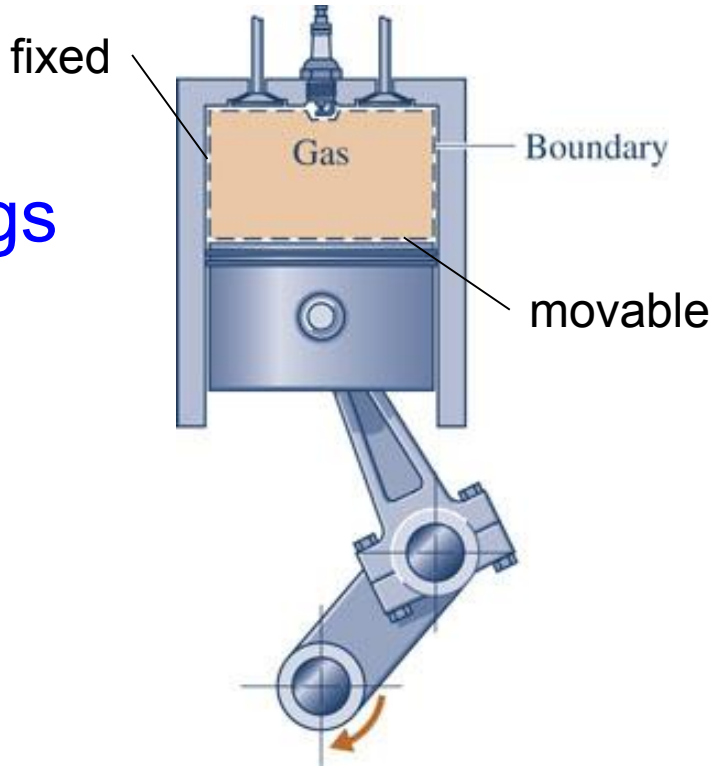
Objectives

- Identify the unique vocabulary associated with thermodynamics through the precise definition of basic concepts.
- Explain the basic concepts of thermodynamics such as system, state, property, equilibrium, process, and cycle.

SYSTEM, SURROUNDING, BOUNDARY

- **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. It can be *fixed* or *movable* and has no thickness.



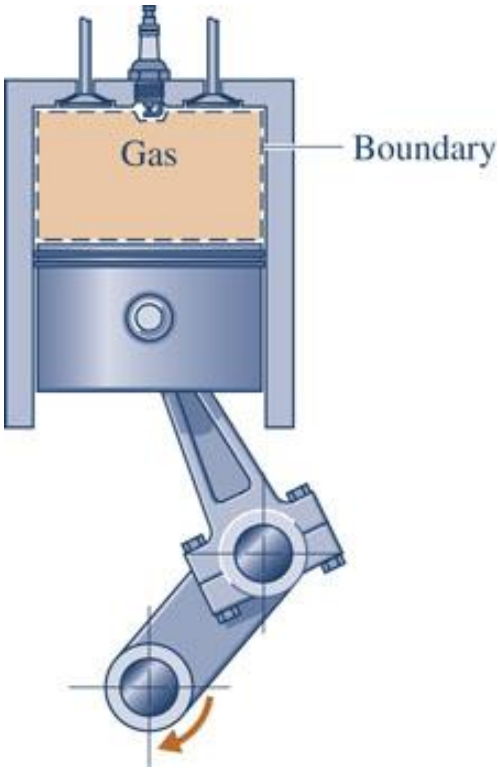


TYPES OF SYSTEMS

- Systems may be considered to be *closed* or *open*.

Closed system (Control Mass):

A fixed amount of mass, and no mass can cross its boundary.



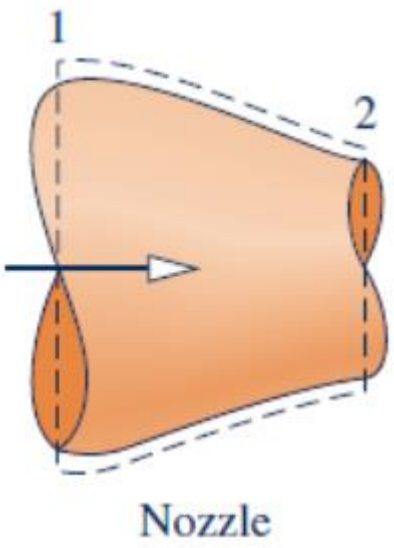
Mass ✗

Energy ✓ ✗

An ***Isolated system*** is a special type of closed system that does not interact in any way with its surroundings.

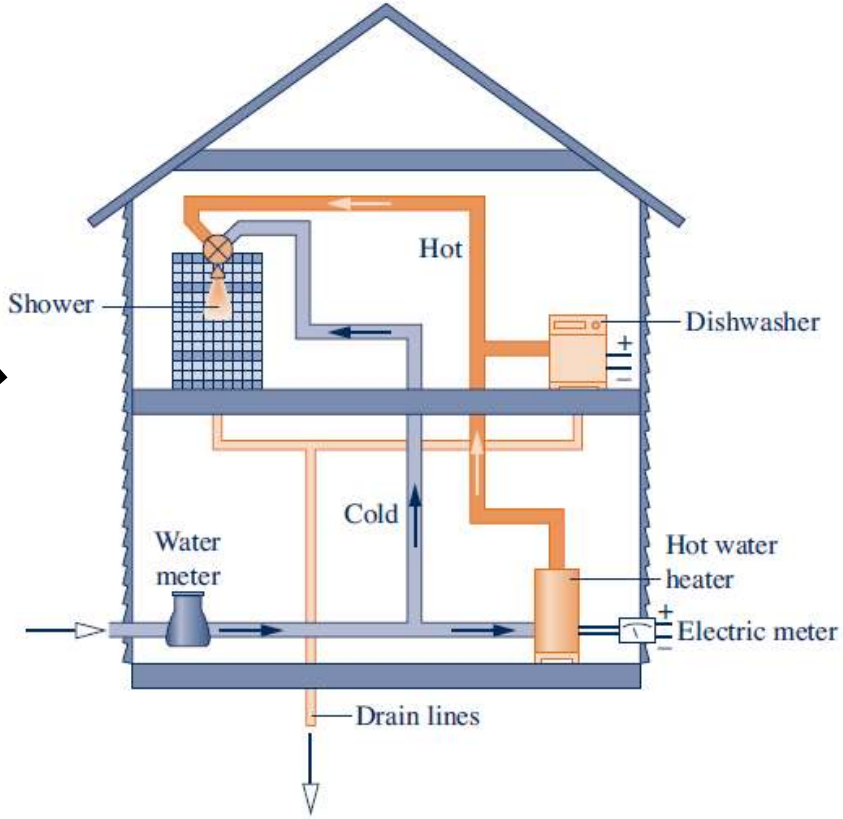
TYPES OF SYSTEMS

- **Open system (control volume)**:
- Both mass and energy can cross the boundary of a control volume.
- It usually encloses a device that involves mass flow such as a compressor, turbine, or nozzle.
- **Control surface**: The boundaries of a control volume. It can be real or imaginary, fixed or moving.



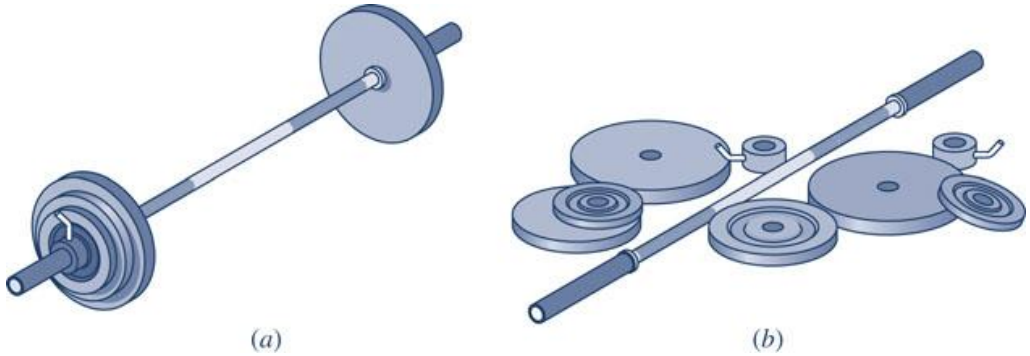
Mass ✓

Energy ✗ ✓



PROPERTIES OF A SYSTEM

- **Property:** A macroscopic characteristic of a system to which a numerical value can be assigned at a given time without knowledge of the previous behavior of the system.
- Some familiar properties are pressure ***P***, temperature ***T***, volume ***V***, and mass ***m***.
- Properties are considered to be either *intensive* or *extensive*.
- **Extensive properties:** Those whose values depend on the size—or extent—of the system. Its value for an overall system is the sum of its values for the parts into which the system is divided.



Paper Demo !

- **Specific properties:** Extensive properties per unit mass.
- **Intensive properties:** Those that are independent of the mass of a system, such as temperature, pressure, and density. Its value is not additive as for extensive properties.

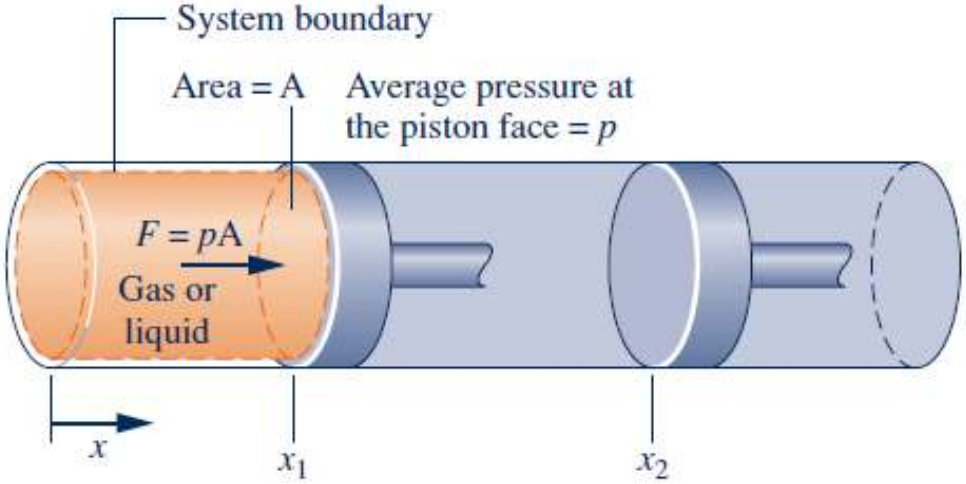
CONTINUUM ASSUMPTION

- Matter is made up of atoms that are widely spaced in the gas phase. Yet it is very convenient to disregard the atomic nature of a substance and view it as a continuous, homogeneous matter with no holes, that is, a **continuum**.
- The continuum idealization allows us to treat properties as point functions and to assume that properties vary continually in space with no jump discontinuities.
- This idealization is valid as long as the size of the system we deal with is large relative to the space between the molecules.
- This is the case in practically all problems.
- In this text we will limit our consideration to substances that can be modeled as a continuum.

STATE, PROCESS AND CYCLE

State: The condition of a system as described by its properties. The state often can be specified by providing the values of a subset of its properties. All other properties can be determined in terms of these few.

Process: A transformation from one state to another. When any of the properties of a system changes, the state changes, and the system is said to have undergone a process. *Can you think of an example?*



Path: The series of states through which a system passes during a process.

Cycle: A process during which the initial and final states are identical.

PROCESS TYPES

Isothermal process:
A process during which the temperature *T* remains constant.

Isobaric process:
A process during which the pressure *P* remains constant.

Isochoric (or isometric) process:
A process during which the specific volume *v* remains constant.

Isentropic (Isoentropic) process:
A process during which the entropy remains constant.

Adiabatic process:
A process during which heat transfer is zero.

Note: The term ***steady*** implies *no change with time*. The opposite of steady is ***unsteady***, or ***transient***.

EQUILIBRIUM STATE

- Thermodynamics deals with *equilibrium* states.
- **Equilibrium**: A state of balance.

  In an equilibrium state, there are no unbalanced potentials (or driving forces) within the system.
- **Thermal equilibrium**: If the temperature is the same throughout the entire system.
- **Mechanical equilibrium:** If there is no change in pressure at any point of the system with time.
- **Phase equilibrium:** If a system involves two phases and when the mass of each phase reaches an equilibrium level and stays there.
- **Chemical equilibrium:** If the chemical composition of a system does not change with time, that is, no chemical reactions occur.
- **Thermodynamic equilibrium:** When a system is in equilibrium regarding all possible changes of state.

- **Quasi-equilibrium process**: When a process proceeds in such a manner that the system remains infinitesimally close to an equilibrium state at all times.