CHAPTER 1a:

BASIC CONCEPTS OF THERMODYNAMICS

CONTENTS

- Thermodynamics and Energy
- Dimensions and Units
- Systems and Properties
- State, Processes and Cycles
- Temperature
- Pressure and Measuring Devices
- Problem Solving Technique

LESSON OBJECTIVES

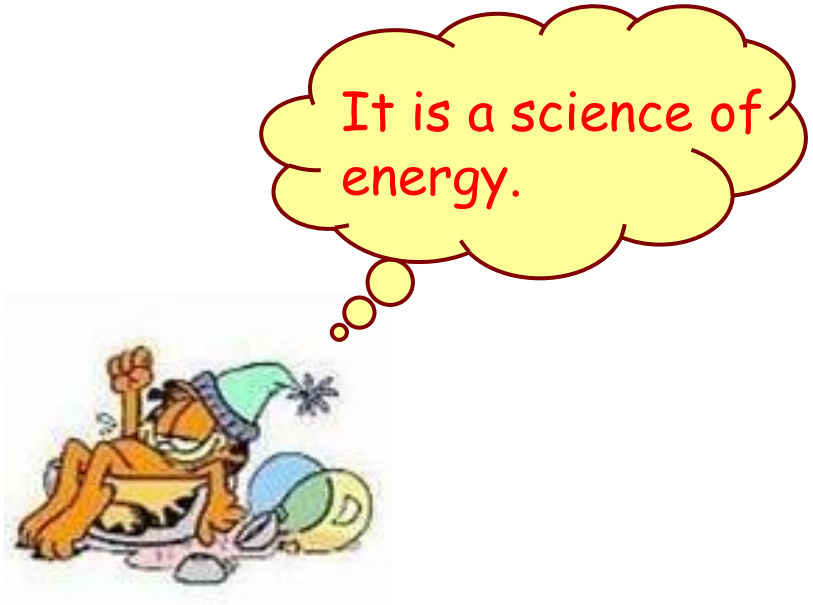
At the end of the lesson, you should be able to:-

- Identify application of thermodynamics
- Define & differentiate between closed system and control volume (open system)
- Differentiate between intensive and extensive properties

What Is Thermodynamics?

Greek Words

Therme (heat) + **Dynamis (Power)**



Early description:

Convert heat into power.

Current Definition:

The study of energy and energy transformations, including power generation, refrigeration and relationship among the properties of matter.

Thermodynamics involve the conservation of energy principle.

APPLICATION

- House-hold utensils:
  - Air-conditioner, heater, refrigerator
  - Humidifier, pressure cooker, water heater, shower, iron
  - Computer & TV

- Engines:
  - Automotive, aircraft, rocket

- Plant/ Factory
  - Refinery, power plants, nuclear power plant

DIMENSIONS & UNITS

TABLE 1–1

The seven fundamental (or primary) 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 (cd)
Amount of matter	mole (mol)

TABLE 1–2

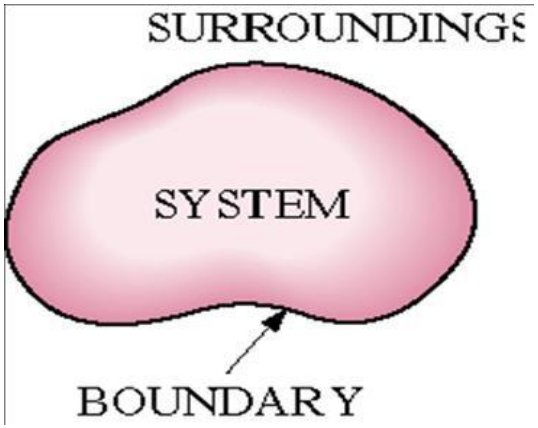
Standard prefixes in SI units

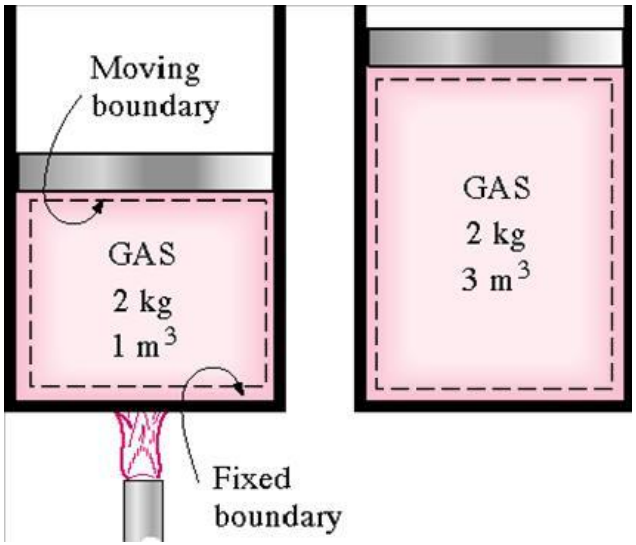
Multiple	Prefix
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p

SYSTEMS & CONTROL VOLUMES

Thermodynamic system (system) → quantity of matter or a region in space chosen for study.

Surroundings → the mass or region outside the system (external)

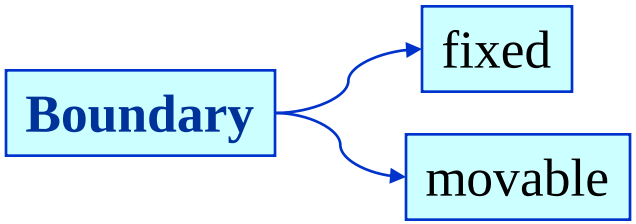


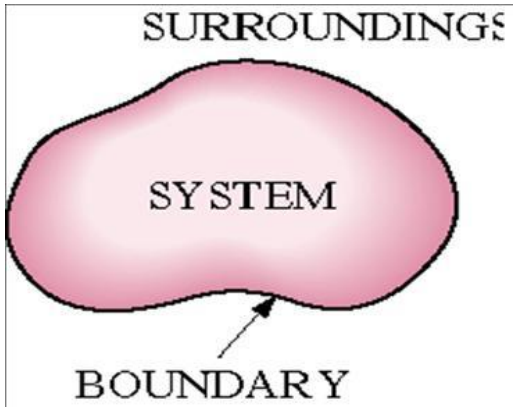


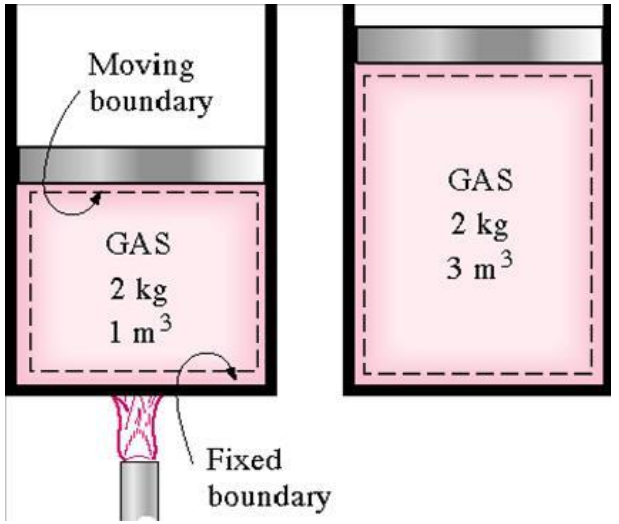
SYSTEMS & CONTROL VOLUMES (cont'd)

Boundary ➡

- the real or imaginary surface that separates the system from its surrounding
- contact surface shared by both the system & surroundings
- has zero thickness & can either contain any mass nor occupy volume in space.







SYSTEMS & CONTROL VOLUMES (cont'd)

TYPES OF SYSTEM

Closed System (control mass)

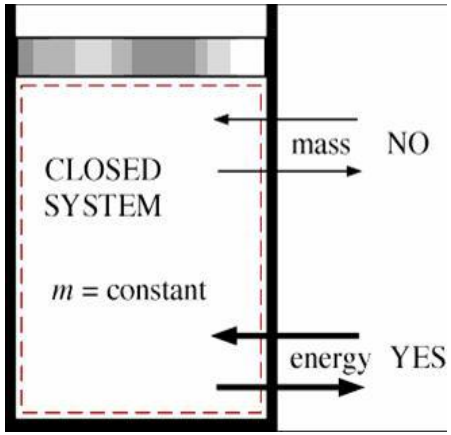
No mass transfer across boundary

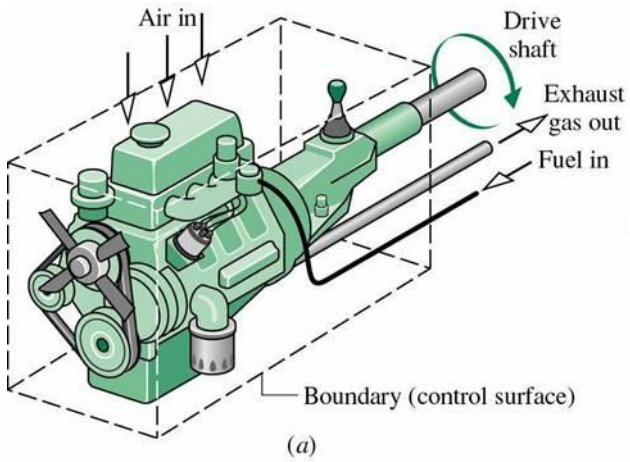
Isolated System

No mass or energy transfer

Open System (control volume)

Mass transfer across boundary

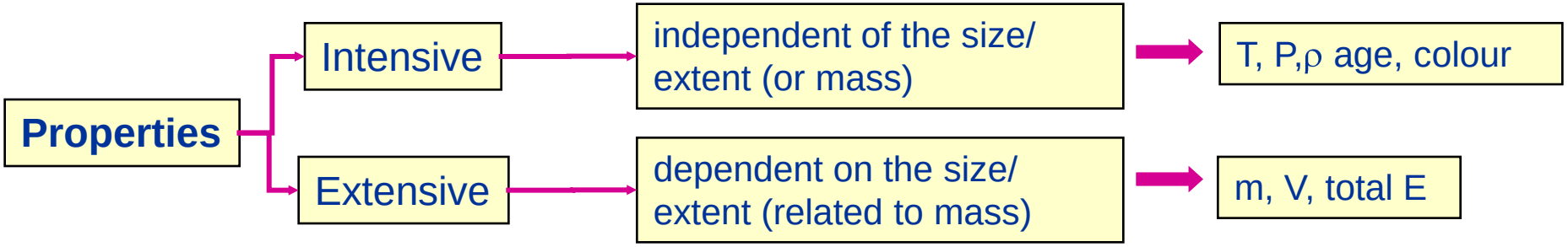


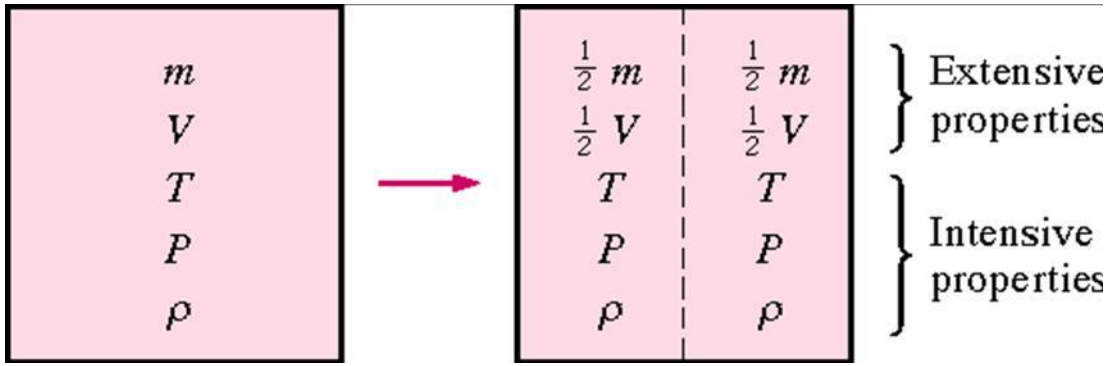


PROPERTIES OF A SYSTEM

Property - any macroscopic characteristic of a system

- Some familiar properties are **P**, **T**, **V** and **m**.
- Others: viscosity, thermal conductivity, thermal expansion coefficient and etc





- **Specific properties** - extensive properties per unit mass
- E.g. specific volume $v = \frac{V}{m}$

DENSITY & SPECIFIC GRAVITY

- Density (kg/m^3) depends on T & P

$$\rho = \frac{m}{V}$$

- Specific gravity or relative density (ratio of the density of a substance to the density of some standard substance at a specified temperature e.g. water)

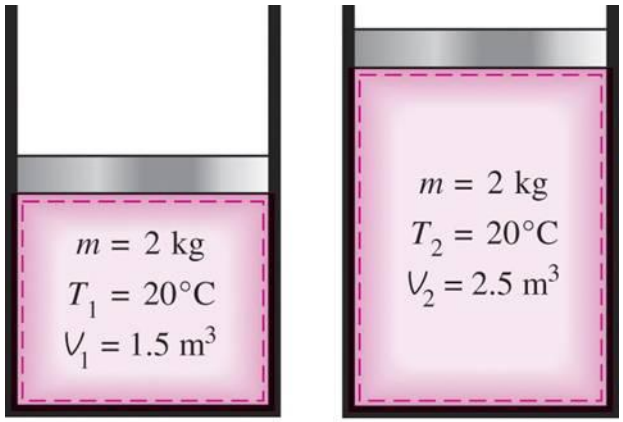
$$SG = \rho_S = \frac{\rho}{\rho_{H_2O}}$$

- Specific weight – is the weight of a unit volume of a substance

$$\gamma_S = \rho g$$

STATE & EQUILIBRIUM

State ➡ A set of properties that describe the condition of a system at certain time



(*a*) State 1 (*b*) State 2

- At a given state, all the properties of a system have fixed values.
- If the value of one property changes, the state will change to a different one.
- If the state changes, the system is said to have undergone a process

STATE & EQUILIBRIUM

Equilibrium ➡

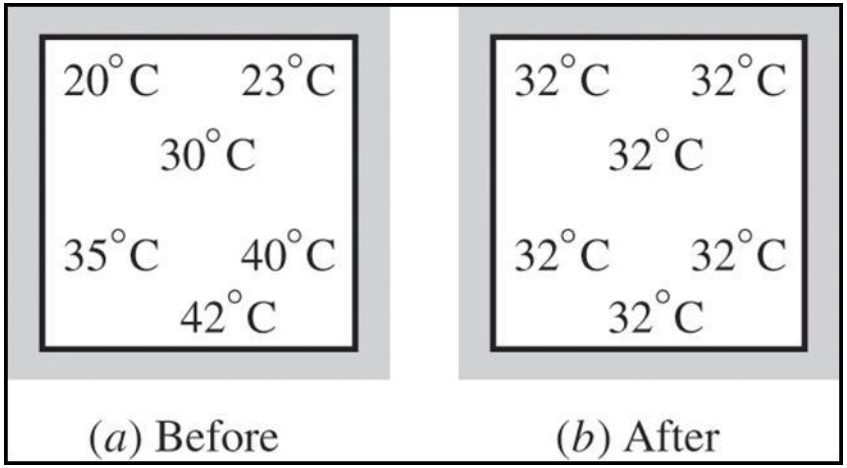
- A state of balance.
- In an equilibrium state, there are no unbalanced potentials (or driving forces) within the system.

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.



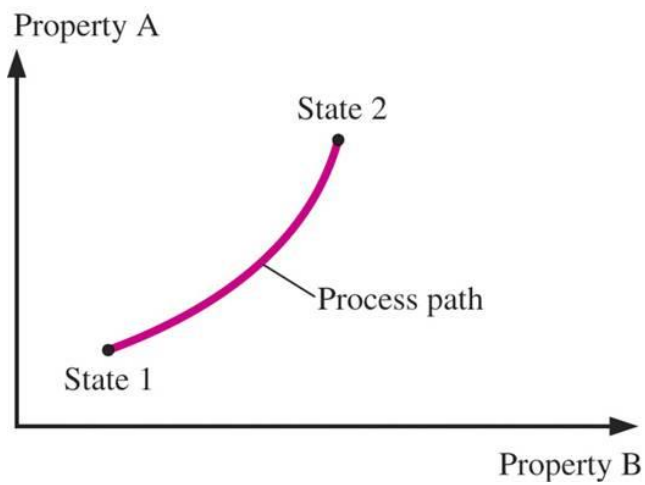
A closed system reaching thermal equilibrium.

PROCESSES & CYCLES

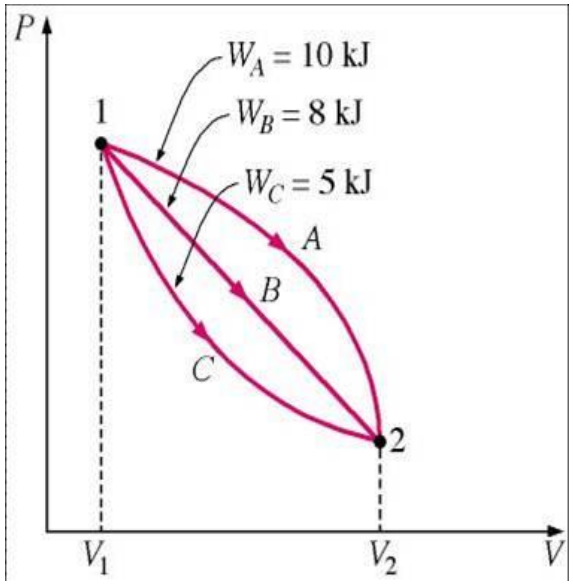
PROCESS ➡ A transformation from one state to another

- If a system exhibits the same values of properties at two different times, it is in the same state at these times
- A system is said to be at steady state if none of its properties changes with time

PATH ➡ The series of states through which a system passes during a process.

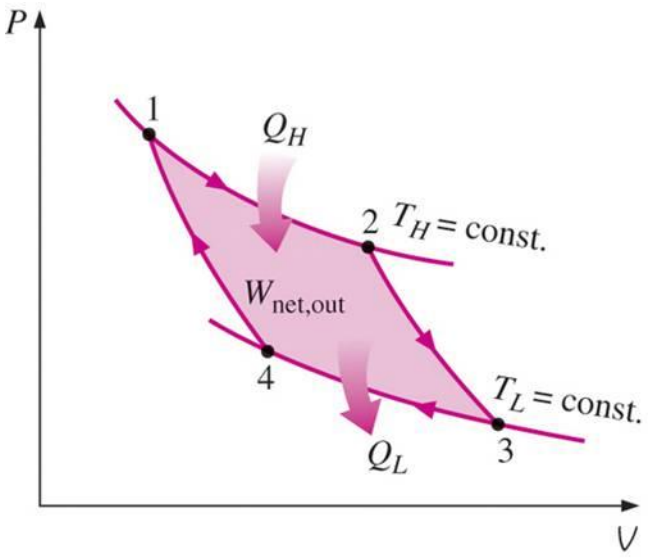


A quantity is a property if its change in value between two states is independent of the process.



PROCESSES & CYCLES

A thermodynamic cycle → Sequence of processes that begins and ends at the same state



Carnot power cycle

- Properties at the end are the same as at the beginning.
- No net change of state

PROCESSES & CYCLES

Quasi-Equilibrium / Quasi-static Process

- When a process proceeds in such a manner that the system remains infinitesimally close to equilibrium state at all times.
- Sufficiently slow process that allows the system to adjust to itself internally so that properties in one part of the system do not change any faster than those at other parts.
- An idealized process, do not represent an actual process
- They are used because they are easy to analyze and serve as a standards to which actual processes can be compared

True or False?

- An automobile engine is categorized as a closed system.
- An isolated system is a system that does not have any interaction with its surroundings
- Weight is an extensive property of a system.
- Power of a system is the property of that system.

Class Takeaway

1. Distinguish closed system and open system with examples.

Close System	Open System

Class Takeaway

Substance:

Properties	P= 1 bar T = -10°C	P = 1 bar T = 10°C	P = 1 bar T = 100°C
State			
Process		→	→

Exercise

Explain the mass and energy transfers that occur in a gas turbine engine. Draw a schematic diagram of the system.