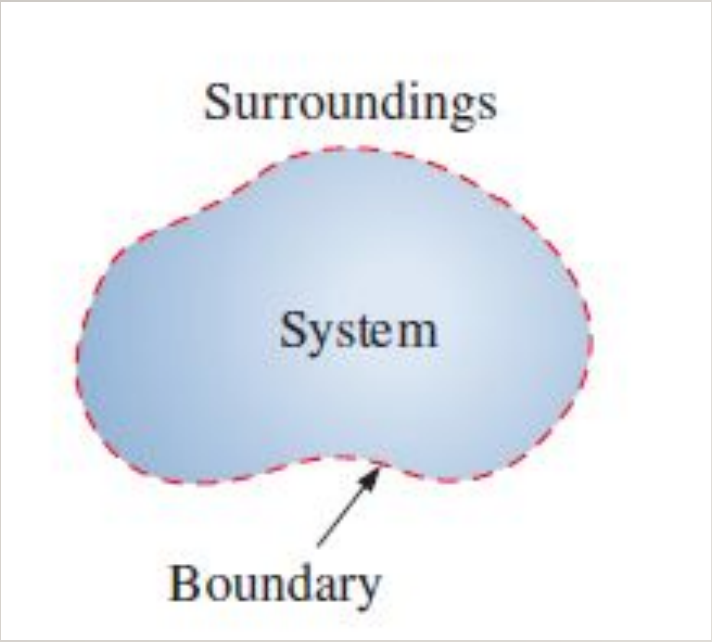
Thermodynamics

Thermodynamics deals with the concepts of heat and temperature and the inter-conversion of heat and other forms of energy. The four laws of thermodynamics govern the behaviour of these quantities and provide a quantitative description. William Thomson, in 1749, coined the term thermodynamics.

- Thermodynamics is the science of energy (Probably we may say the power of heat) .
- Energy is the ability to do work.
  - **Conservation of energy principle (first law of thermodynamics):** During an interaction (i. e. a process), energy can change from one form to another but the total amount of energy remains constant.

APPLICATION OF THERMODYNAMIC



System

A thermodynamic system is a specific portion of matter with a definite boundary on which our attention is focused. The system boundary may be real or imaginary, fixed or deformable.
There are three types of systems:

- **Isolated System** – An isolated system cannot exchange energy and mass with its surroundings. The universe is considered an isolated system.
- **Closed System** – Across the boundary of the closed system, the transfer o energy takes place but the transfer of mass doesn't take place. Refrigerator, compression of gas in the piston-cylinder assembly are examples of closed systems.
- **Open System** – In an open system, the mass and energy both may be transferred between the system and surroundings. A steam turbine is an example of an open system.

Interactions of thermodynamic systems			
Type of system	**Mass flow**	**Work**	**Heat**
Isolated System	X	X	X
Open System	✓	✓	✓
Closed System	X	✓	✓

Surrounding

Everything outside the system that has a direct influence on the behaviour of the system is known as a surrounding.

Thermodynamic Process

A system undergoes a thermodynamic process when there is some energetic change within the system that is associated with changes in pressure, volume and internal energy.

There are four types of thermodynamic processes that have their unique properties, and they are:

- **Adiabatic Process** – A process where no heat transfer into or out of the system occurs.
- **Isochoric Process** – A process where no change in volume occurs and the system does no work.
- **Isobaric Process** – A process in which no change in pressure occurs.
- **Isothermal Process** – A process in which no change in temperature occurs.

A thermodynamic cycle is a process or a combination of processes conducted such that the initial and final states of the system are the same. A thermodynamic cycle is also known as cyclic operation or cyclic processes.

Fundamental (primary) dimensions and units

Dimension	SI Unit	English Unit
Mass	kg	lb_m
Length	m	ft
Time	s	s
Temperature	K	R
Amount of matter	mol	lb_{mol}
Electrical current	A	A
Amount of light	cd	candles

Dimension: **physical properties or characteristics of a system** •

Primary Dimensions: mass *m*, length *L*, time *t*, and temperature *T* -

Secondary Dimensions (or derived dimensions): velocity *V*, energy *E*, - force *F*, and volume *V*

Units: magnitudes assigned to dimensions •

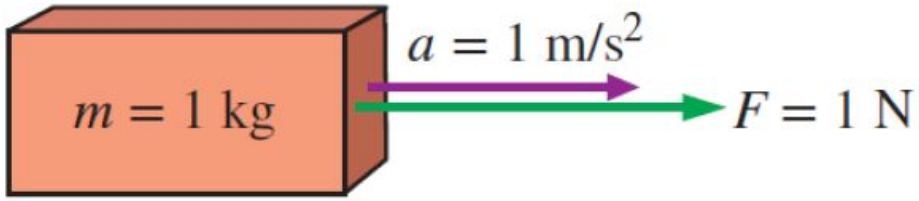
Two Unit Systems: English and SI or *System Internationale* •

In physics, a **force, (F)** is an effect that can change the motion of an object.

Force = (Mass) (Acceleration)

or $F = m\,a$

The force unit is the newton (N), and it is defined as the force required to accelerate a mass of 1 kg at a rate of 1 m/s^2. The below figure (Figure 1-4) represents the definition of force units.



Work, (W), which is a form of energy, can simply be defined as force times distance.

Therefore, it has the unit "newton-meter (N.m)," which is called a **joule (J)**. That is,

$$1\ J = 1\ N.m$$

Energy, (E), represents the ability of the system to do a work.

Joule (J) is the unit of Energy.

In physics, **power** is the amount of energy transferred or converted per unit time. That is,

$$Power = \frac{Energy}{Time}$$

Therefore, it has the unit "joule (J) per time (s)" which is called a **Watt (W)**.

Thermodynamic properties

- Enthalpy
- Density
- Entropy
- Internal energy
- Temperature
- Pressure
- Property
- Heat capacity
- Mass

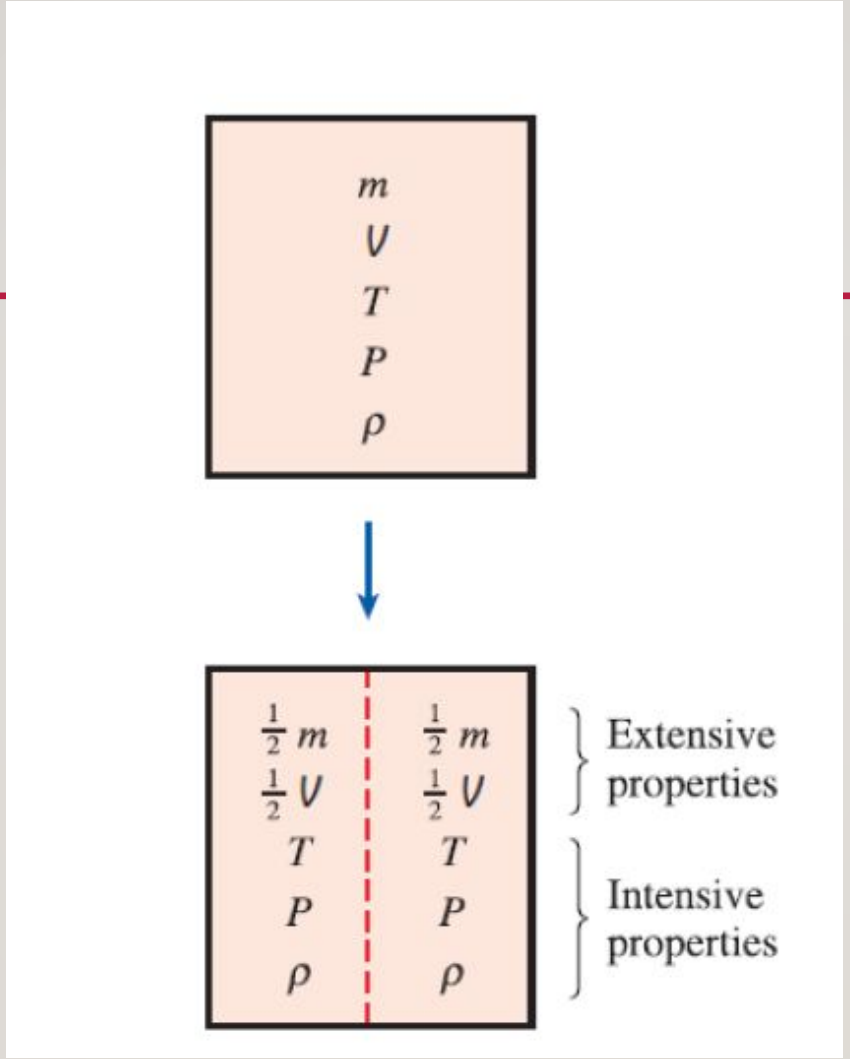
The following thermodynamic properties are typically used to describe the interactions between a system and its surroundings:

- mass m
- pressure P
- temperature T
- volume $\mathbb{V}$ and specific volume v
- internal energy U and specific internal energy u
- enthalpy H and specific enthalpy h
- entropy S and specific entropy s

These properties can be classified into two categories based on their dependence on the mass of a system. More detailed explanations of their physical meanings

- **Extensive properties** depend on the mass of a system. Properties, such as mass m, volume $\mathbb{V}$, internal energy U, enthalpy H, and entropy S are extensive properties. Their values change accordingly as the mass of a system changes.
- **Intensive properties** are independent of the mass of a system. Pressure P, temperature T, specific volume v, specific internal energy u, specific enthalpy h, and specific entropy s are intensive properties.

All **specific properties** are intensive properties, as they refer to the corresponding extensive properties per unit mass, e.g., specific volume $v = \mathbb{V}/m$ and specific internal energy $u = U/m$.

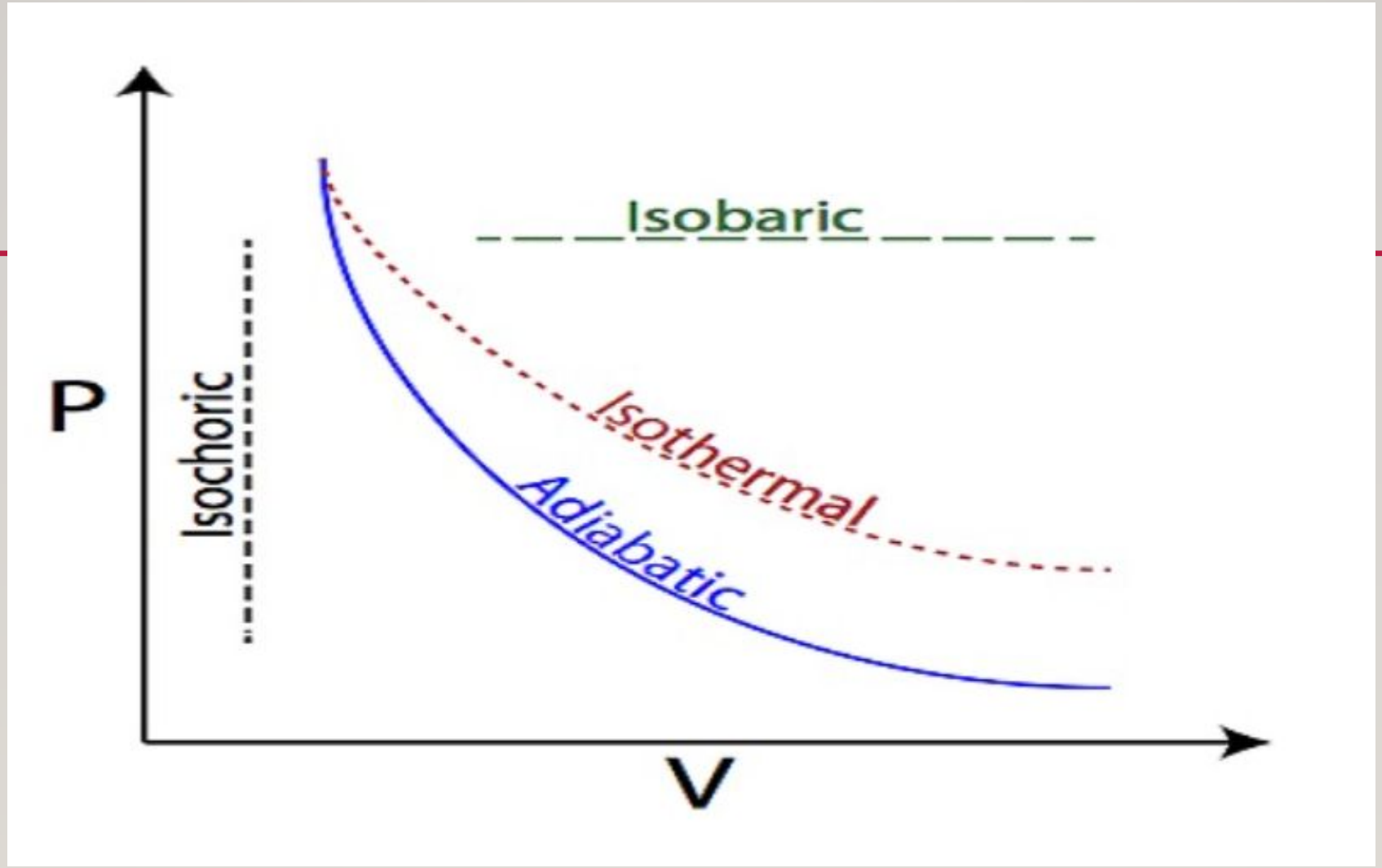

m
V
T
P
ρ
½ m
½ V
T
P
ρ
½ m
½ V
T
P
ρ
Extensive properties
Intensive properties

Thermodynamic Process:

Thermodynamic Process can be defined as when some changes in the energy of a system take place. The changes in the energy of the system can happen due to changes in the volume, pressure, or Internal energy of a system.

There are four types Of thermodynamic processes as follows.

1. Adiabatic Process
2. Isochoric Process
3. Isobaric Process
4. Isothermal Process


P
V
Isochoric
Isobaric
Isothermal
Adiabatic

1. Adiabatic Process

Adiabatic process in thermodynamics can be defined as the process in which no heat transfer takes place. That means the heat can neither enter nor leave the system in an adiabatic process.

2. Isochoric Process

Isochoric process in thermodynamics can be defined as the process in which volume doesn't change. That means the system does not work since its volume is constant.

3. Isobaric Process

Isobaric process in thermodynamics can be defined as the process in which there is no change in pressure takes place. That means the system pressure remains constant throughout the isobaric process.

4. Isothermal Process

Isothermal process in thermodynamics can be defined as the process in which there is no changes in temperature takes place. That means the temperature of the system remains constant throughout the isothermal process.

Thermodynamic Cycle

The thermodynamic cycle includes a number of processes which is conducted to keep the initial and final state of the system the same. It is also known by the name of cyclic process or operations.

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Enthalpy

In thermodynamics, the energy of a system is measured in enthalpy or we can say that the enthalpy of a system represents the total energy in it. So we can say that enthalpy which is denoted by H is equal to the sum of internal energy E and product of the pressure P and volume V of the system.

$H = E + PV$

H = Enthalpy

E = Internal Energy

P = Pressure in a system

V = Volume of a system

Entropy

Entropy in thermodynamics measure the disorderliness or randomness of a system. The value of entropy depends on the state in which the system is. For example – Steam has higher entropy than water because it has higher disorderliness or randomness of molecules compared to water. It is generally denoted by the letter S.

DIFFERENCES BETWEEN ENTHALPY AND ENTROPY

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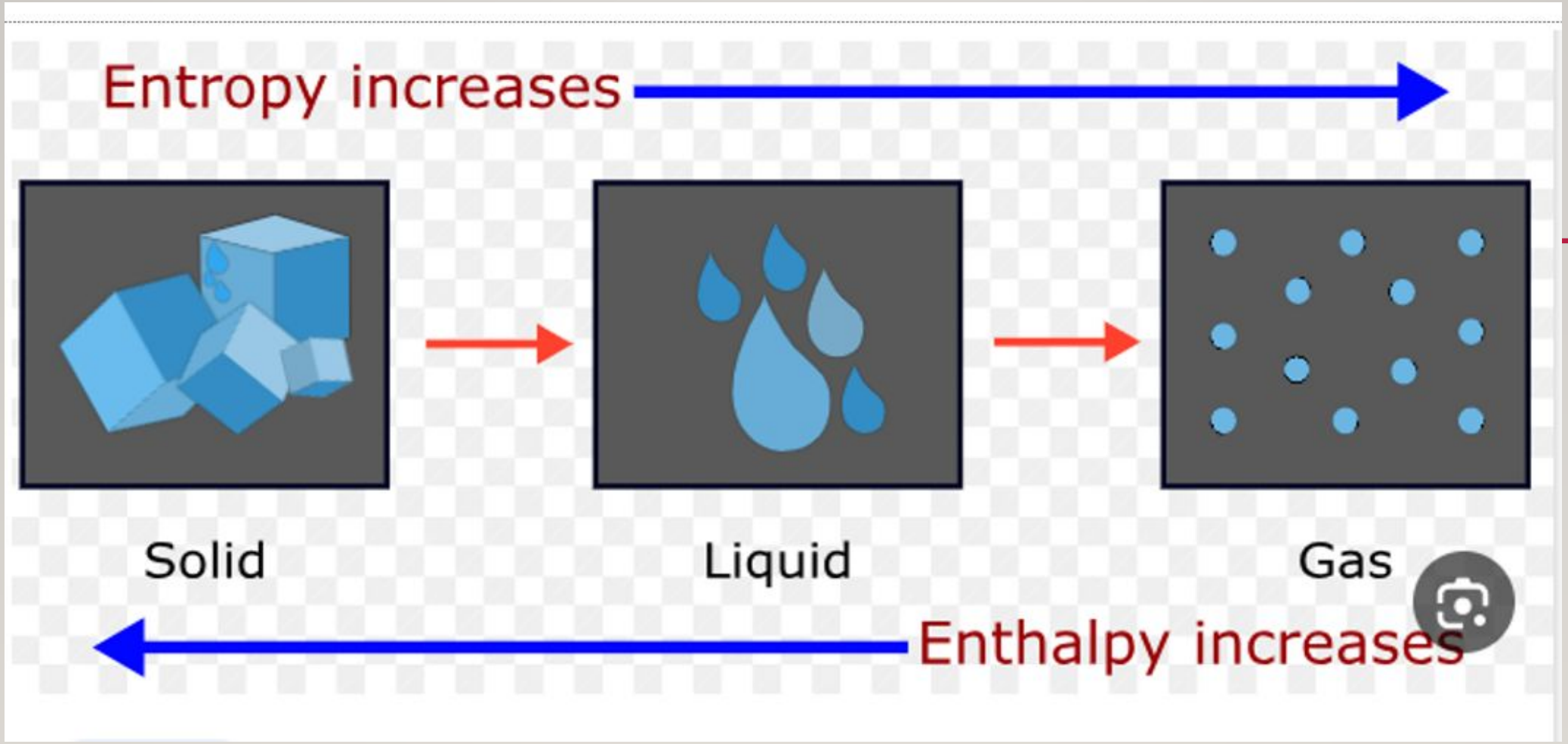
ENTHALPY

Enthalpy is denoted by 'h' refers to the measure of total heat content in a thermodynamic system under constant pressure.

ENTROPY

Entropy is denoted by 's' refers to the measure of the level of disorder in a thermodynamic system.


Entropy increases
Solid
Liquid
Gas
Enthalpy increases