APPLICATION
OF
FIRST LAW OF THERMODYNAMICS

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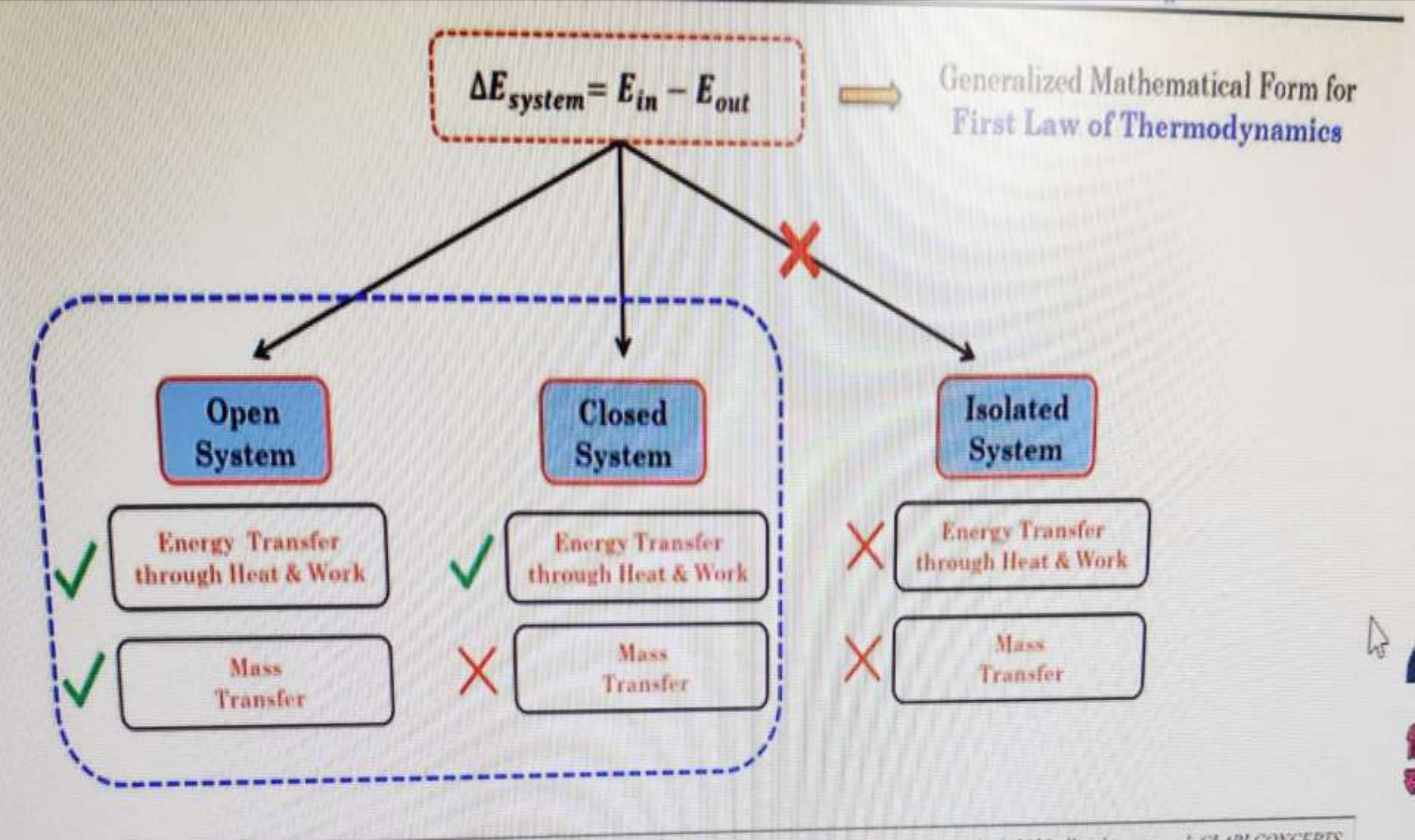
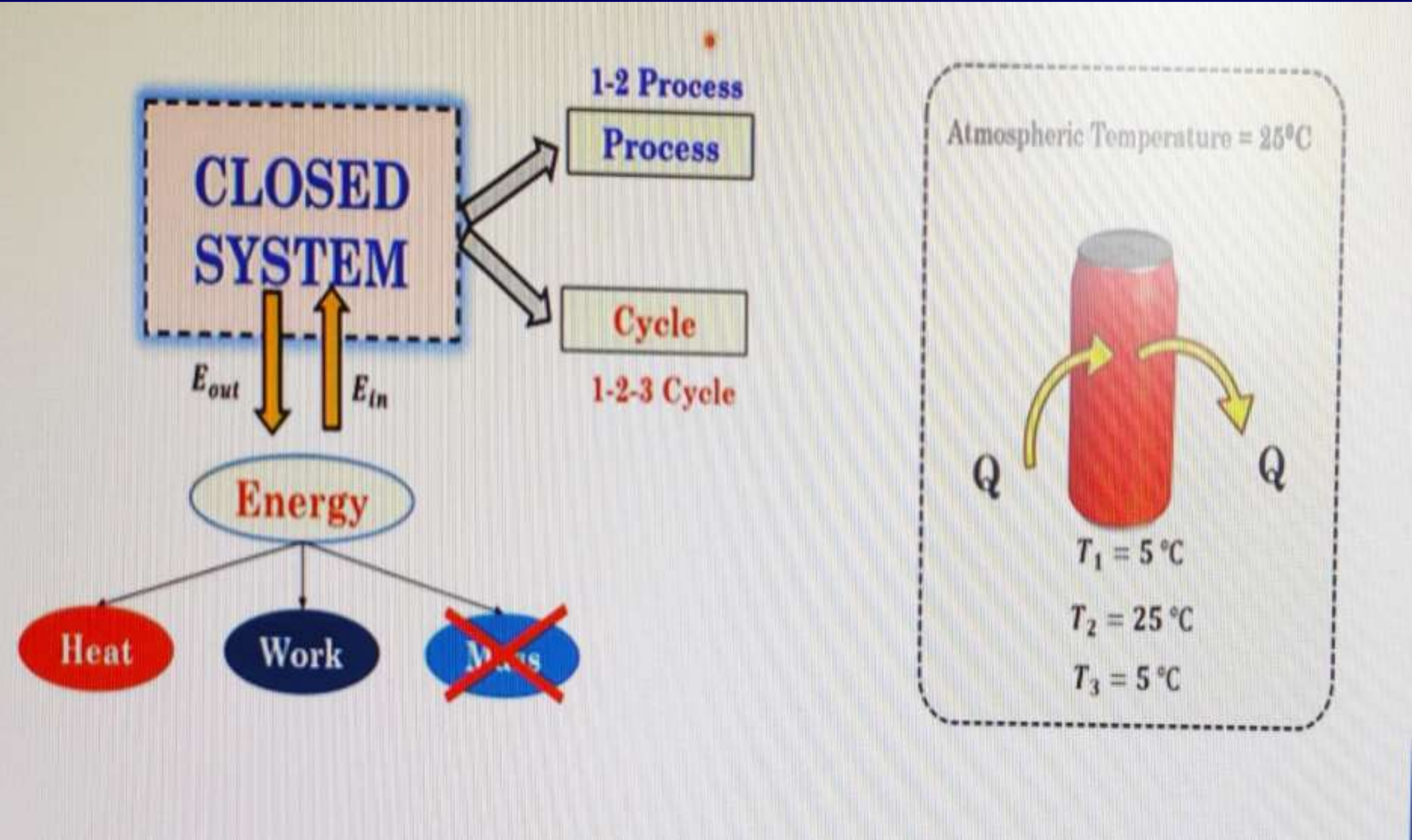
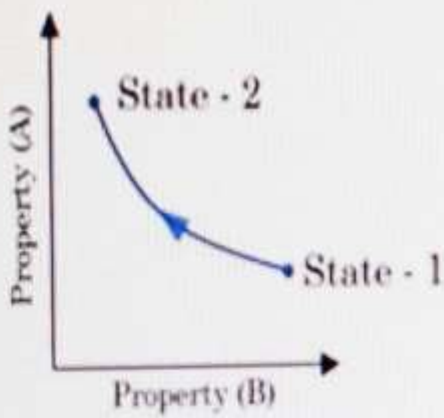
FIRST LAW OF THERMODYNAMICS



FIRST LAW OF THERMODYNAMICS FOR CLOSED SYSTEM



FIRST LAW OF THERMODYNAMICS



During a Process 1-2,

Heat added to the system is Q.

Work done by the system is W.

$$E_1 + Q - W = E_2$$

$$Q = E_2 - E_1 + W$$

$$Q = \Delta E + W$$

$$Q_{1-2} = \Delta E + W_{1-2}$$

→ **Applicable for Closed System undergoing any Process**

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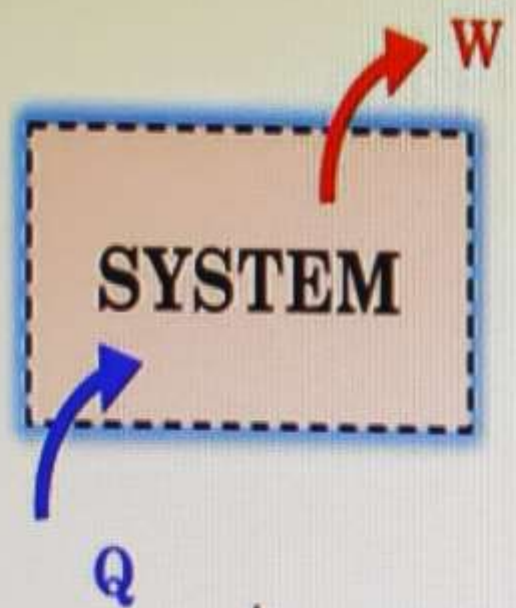
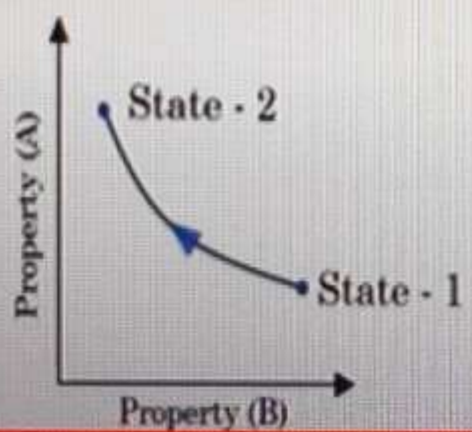




During a Process 1-2,

Heat added to the system is Q.

Work done by the system is W.

$$Q_{1-2} = \Delta E + W_{1-2}$$

$$Q_{1-2} = E_2 - E_1 + W_{1-2}$$

$$Q_{1-2} = (U_2 + \cancel{KE_2} + \cancel{PE_2}) - (U_1 + \cancel{KE_1} + \cancel{PE_1}) + W_{1-2}$$

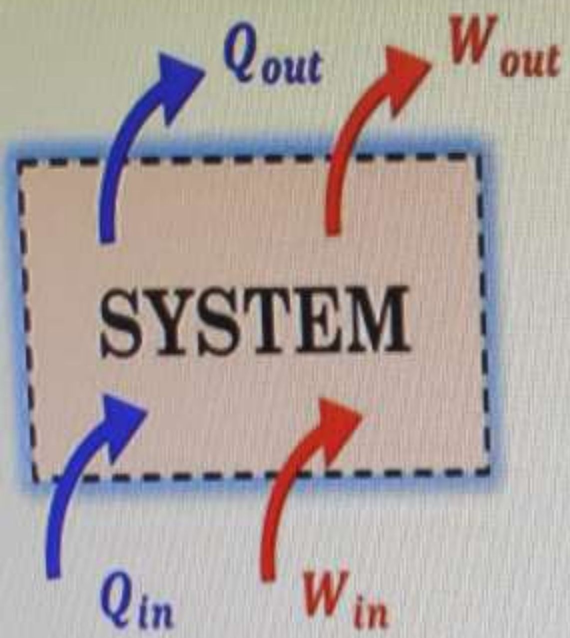
$$Q_{1-2} = U_2 - U_1 + W_{1-2}$$

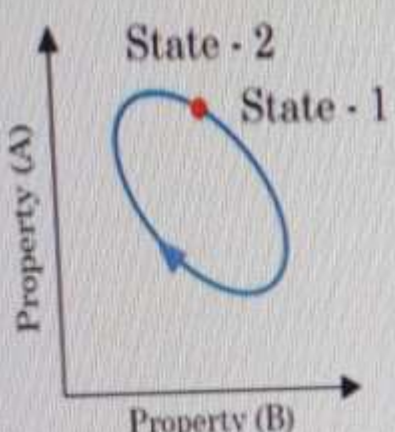
$$\boxed{Q_{1-2} = \Delta U + W_{1-2}}$$

→ Applicable for Stationary Closed System undergoing any Process

Theater mode (t)

FIRST LAW OF THERMODYNAMICS





Heat added to the system = Q_{in}

Work done on the system = W_{in}

Heat removed from the system = Q_{out}

Work done by the system = W_{out}

During a Cycle 1-2,

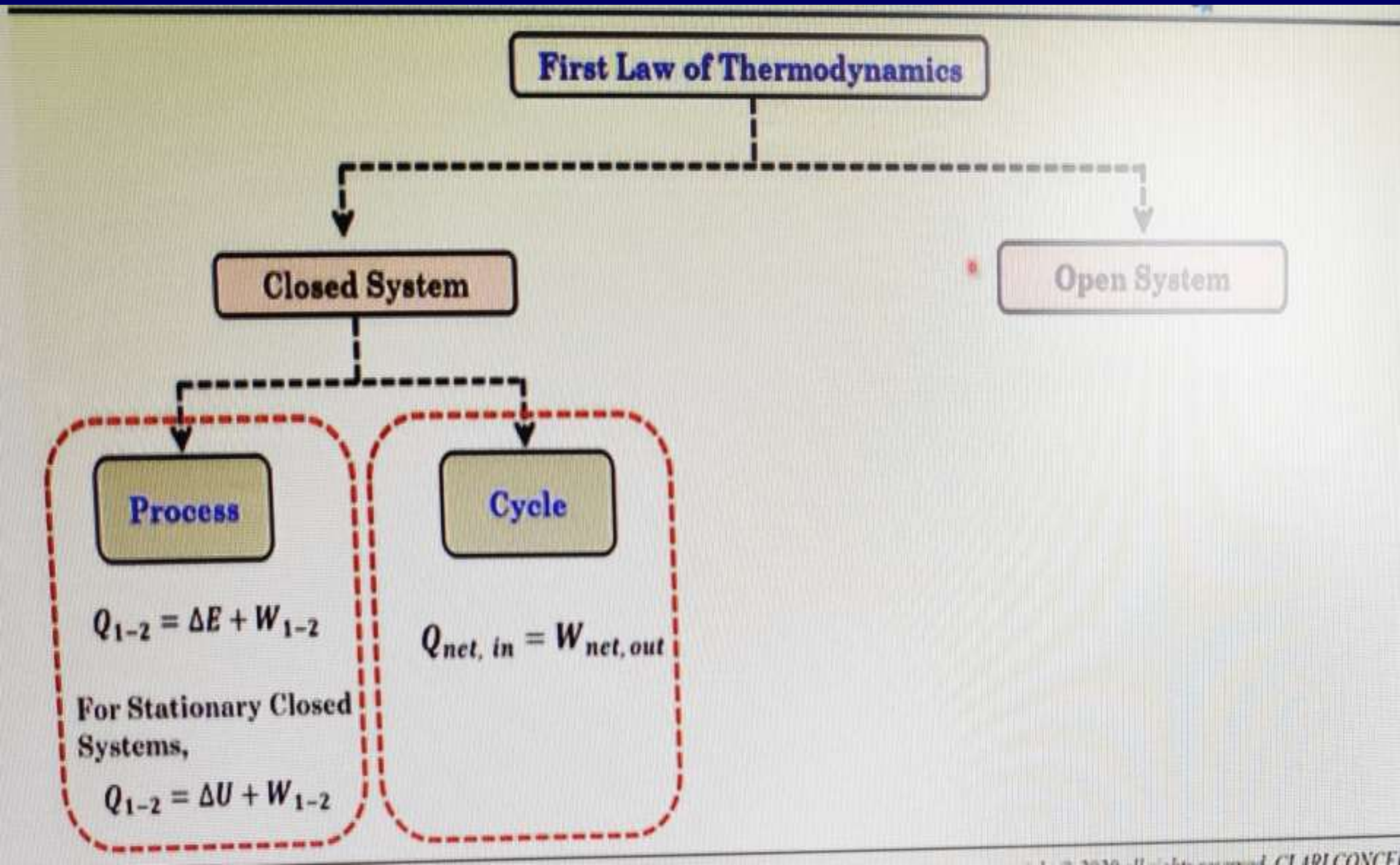
$$\cancel{E_1} + Q_{in} + W_{in} - Q_{out} - W_{out} = \cancel{E_2}$$

$$Q_{in} - Q_{out} = W_{out} - W_{in}$$

$$Q_{net,\,in} = W_{net,\,out}$$

→ Applicable for Closed System undergoing any Cycle

FIRST LAW OF THERMODYNAMICS



Steady Flow Energy Equation

- Consider flow of fluid through a generalized open system as shown in Fig.
- The working fluid enter the system at section 1 and leave the system at section 2 and passing at a steady rate.
- Let,

m = mass flowing through the control volume, kg/s

Q = heat entering the control volume, kJ

W = work transferred from control volume, kJ

C_1, C_2, = velocity of fluid at entrance and exit, m/s

p_1, p_2= pressure of fluid at entrance and exit, N/m^2

u_1, u_2 = internal energy per kg of fluid at entrance and exit, kJ/kg

v_1, v_2 = specific volume of fluid at entrance and exit, m^3/kg

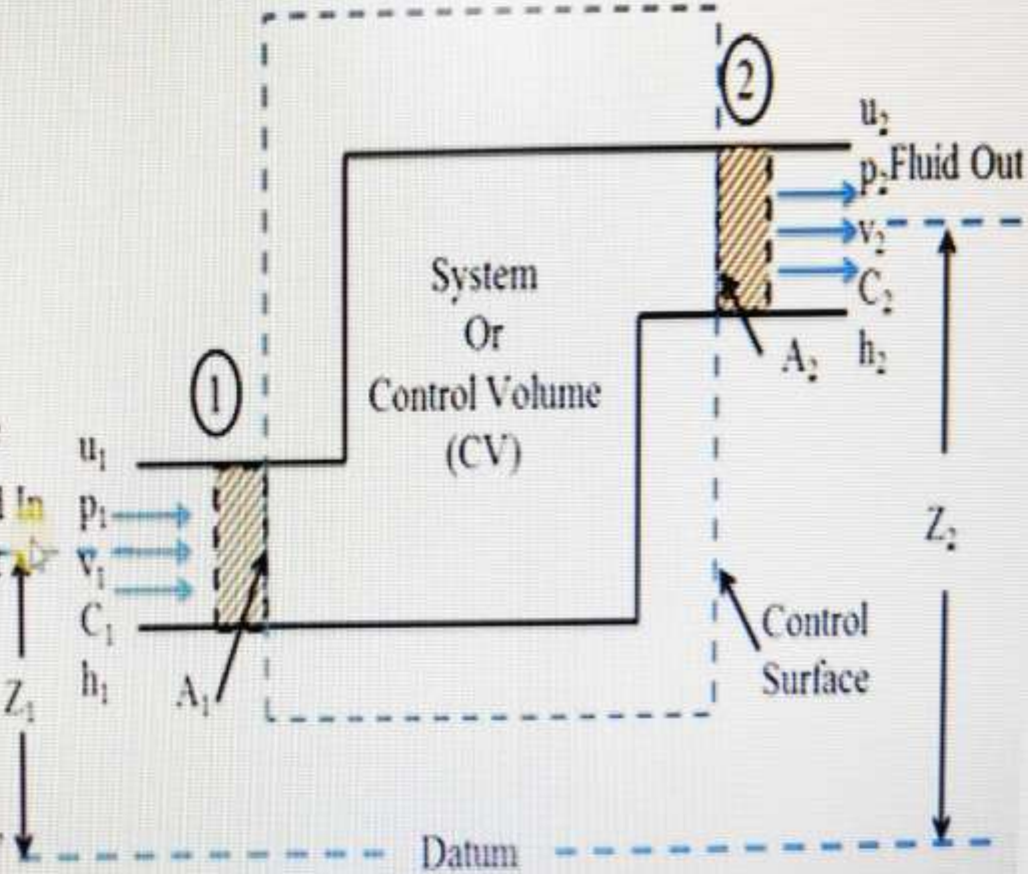
h_1, h_2= enthalpy of fluid at entrance and exit, kJ/kg.

CV =control volume

q = heat entering the control volume per kg of fluid, kJ/kg

w = work transferred from the control volume per kg of fluid, kJ/kg.

z_1, z_2= elevation of entrance section and exit section,



Steady flow energy equation:

- The energy balance required in open system for flow process may be written as follows

Energy entering to the C.V	+	Heat entering to the C.V	=	Energy leaving to the C.V	+	Work transferred From the C.V	+	Increase of stored energy within the C.V

For steady flow process, increase of stored energy within control volume is zero

Energy entering to the C.V	+	Heat entering to the C.V	=	Energy leaving to the C.V	+	Work transferred From the C.V

(Internal energy at sec 1) + (Flow work at sec 1) + (Kinetic energy at sec 1) +(Potential energy at sec 1)	+	Heat entering to the C.V	=	(Internal energy at sec 2) + (Flow work at sec 2) + (Kinetic energy at sec 2) +(Potential energy at sec 2)	+	Work transferred From the C.V

- $[m_1 (u_1 + p_1v_1 + \frac{C_1^2}{2} + z_1g)] + [Q] = [m_2 (u_2 + p_2v_2 + \frac{C_2^2}{2} + z_2g)] + [W]$ ....(1)
- Equation 1 is the general energy equation. It is applicable to compressible and incompressible fluids, liquids and gases, ideal and real fluids.
- Applying steady state process condition as mass of working fluid entering to the control valve is equal to leaving from the control volume. $= m_1 = m_2 = m$

Steady flow energy equation:

$$[m_1 (u_1 + p_1v_1 + \frac{C_1^2}{2} + z_1g)] + [Q] = [m_2 (u_2 + p_2v_2 + \frac{C_2^2}{2} + z_2g)] + [W] \text{ ....(1)}$$

- Equation 1 is the general energy equation. It is applicable to compressible and incompressible fluids, liquids and gases, ideal and real fluids.
- Applying steady state process condition as mass of working fluid entering to the control valve is equal to leaving from the control volume. $= m_1 = m_2 = m$
- $m (u_1 + p_1v_1 + \frac{C_1^2}{2} + z_1g) + Q = m (u_2 + p_2v_2 + \frac{C_2^2}{2} + z_2g) + W$
- $m (h_1 + \frac{C_1^2}{2} + z_1g) + Q = m (h_2 + \frac{C_2^2}{2} + z_2g) + W$ ......(2) $(h_1 = u_1 + p_1v_1 \text{ and } h_1 = u_2 + p_2v_2)$

Equation (2) is called the **steady flow energy equation (SFEE)**. This is also the first law of thermodynamics applied to open system for steady flow process.

SFEE for unit mass

$$h_1 + \frac{C_1^2}{2} + z_1g + \frac{Q}{m} = h_2 + \frac{C_2^2}{2} + z_2g + \frac{W}{m}$$

$$h_1 + \frac{C_1^2}{2} + z_1g + q = h_2 + \frac{C_2^2}{2} + z_2g + w$$

JAI HIND