Systems & Energy

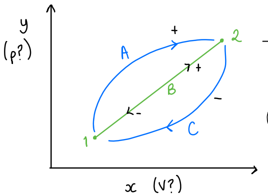
Closed System : NFEE $\Delta U = mc_v \Delta T$

Open System : SFEE $\Delta U = mc_p \Delta T$

1st Law of Thermo.

'Work from state 1 to 2'

$$Q_{12} + W_{12} = \Delta U$$



Outward path 1 to 2
+ return 2 to 1 via any route = 0
→ Independent of path

$(\Sigma\delta Q + \Sigma\delta W)_A + (\Sigma\delta Q + \Sigma\delta W)_C = 0$

$(\Sigma\delta Q + \Sigma\delta W)_B + (\Sigma\delta Q + \Sigma\delta W)_C = 0$

$(\Sigma\delta Q + \Sigma\delta W)_A = (\Sigma\delta Q + \Sigma\delta W)_B$

o - cyclic

$$\oint \delta Q - \oint \delta W = 0$$

δ - very small amount

When a system taken through cycle, net work done by systems on surroundings equal to net heat supplied to system by surroundings (cons. of energy)

Axiom :
- Cannot be proved, but has never been contradicted

Corollaries :

1: exists property such that a change in its value is equal to difference between heat supplied and work done during any change in state
→ called internal energy, U

2: internal energy of system remains unchanged if isolated from surroundings

3: perpetual machine of 1st kind is impossible
→ 100% efficiency impossible

Work and Heat

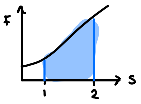
Transient Property :
only appears at boundary
→ not system property

For Piston Cylinder
$W = p\delta V$
↳ $F = pA$
$W = pAs \leftarrow V$

If restraining force changes :
$W = \int_1^2 p\, dv$

For constant force
$W = \pm Fs$

$$W = \pm \int_1^2 F(s)\, ds$$



Sur ⟶ Sys. = +ve
Sys ⟶ Sur. = -ve

Work and heat describe process not state

Transferred by conduction, convection and radiation.

$Q = m_f\ q_{cal}$
kg ↗ ↖ $\frac{kJ}{kg}$

Transmit energy - not system properties

Boundaries

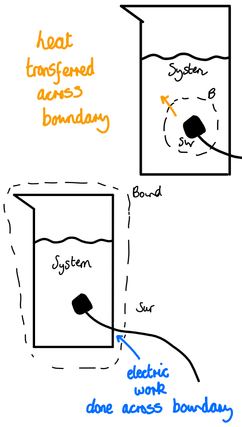
Work and heat transferred across boundary therefore defining boundary is essential

Doesn't have to be fixed

Separates quantity of matter and surroundings

external to system but affected by changes occuring in system

Different boundary will represent different process :



Closed System

mass conserved but energy freely transferred in and out of system
→ e.g coffee cup with lid

Non-flow Energy Equation
$\Delta U = Q + W$

System must be stationary
any change in KE or PE is small

Open System

Matter and energy flow
→ e.g turbine

Equalibrium

- Constant properties with space over time

Quasi Equalibrium Process

System deviates from equalibrium by infinitesimal amount
↳ reversible
↳ state 1 → 2 → 1 without change of surroundings

Isotropic :
equal in all directions
→ e.g stresses on fluids all the same

Each unit of mass will have the same internal energy
→ same Specific internal energy

State Postulate

- if 2 independent properties are known, you can fully determine state (calculate all others)

For system change of state value of property independent of process undergone
e.g cyclist going up hill
→ first and last position important : route irrelevant

$$\int_1^2 dP = P_2 - P_1$$

For work, process is important :

$$\int_1^2 dx \neq X_2 - X_1$$

Pressure (p)

$\frac{F}{A}$

Absolute - relative to vacuum

Gauge - relative to standard atmosphere

Temperature (T)

Thermodynamic scale - no dependence on particular substance
- has absolute zero

Two-point scale - defined by properties of substance
e.g. water freezing point = 0°C