I^{st} law of Thermodynamics :-

Cyclic Process :-

According to joules Experiment of first law "Net amount of work done is proportional to the total amount of heat transfer."

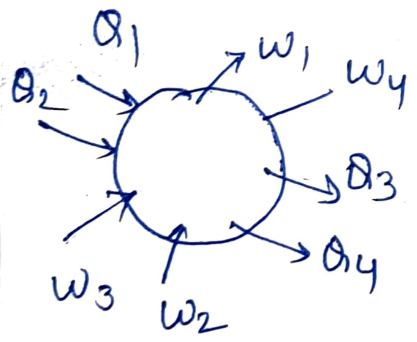
$\oint$ = Cyclic Integration

$$\boxed{dW \propto dQ}$$

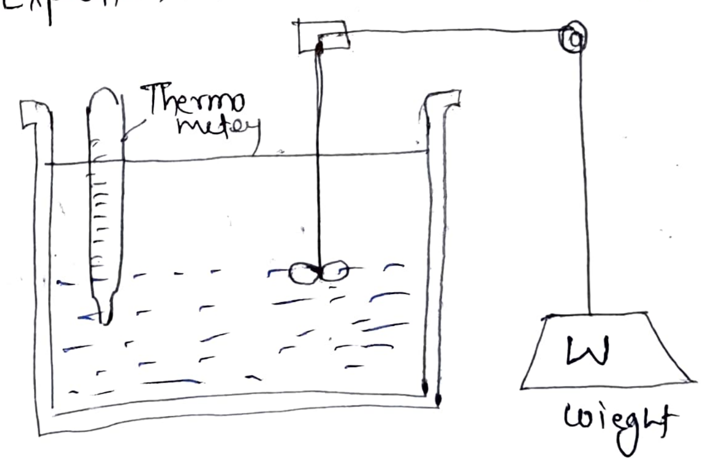
$$\oint \Sigma (dW) = \underline{J \oint \Sigma (dQ)}$$

where J = Joules Constant

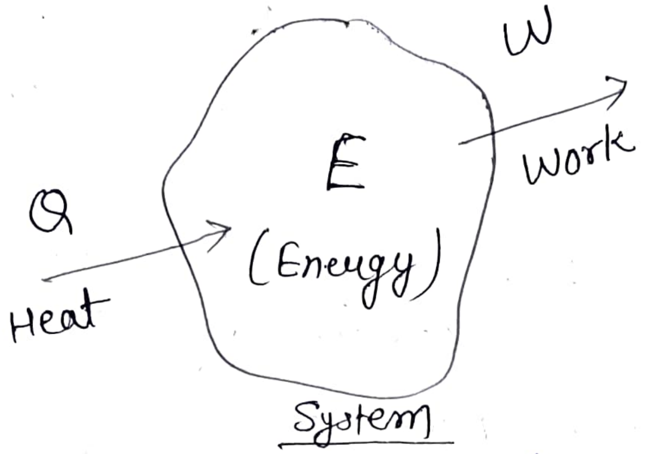
$$\boxed{Q_1 + Q_2 - Q_3 - Q_4 = W_1 - W_2 - W_3 + W_4}$$



Joules Experiment



Undergoing a change of State :-



If a system undergo a change of state the "Net energy transfer will be accumulated within the system i.e "Net energy transfer is equal amount energy stored in system."

$$dQ - dW = E$$

$$dQ - dW = \cancel{K.E.}^{\,0} + \cancel{P.E.}^{\,0} + dU \quad \text{(Internal Energy)}$$

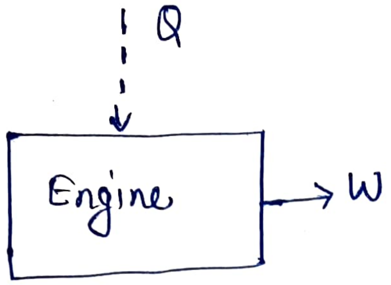
$$dQ - dW = 0 + 0 + dU$$

$$dQ - dW = dU$$

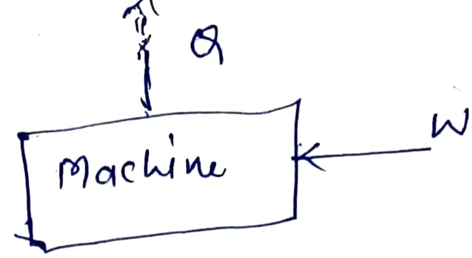
$$\boxed{dQ = dU + dW} \quad \text{———} \quad \text{m.Imp}$$

PMM1 :→ Perpectual ~~motion~~ motion machine of the first kind

There can be no machine which would continuously supply mechanical work without some other from of Energy disappearing simultaneously. Such a fictitious machine is called a perpetual motion machine of the first kind PMM1. It is emposssible.



PMM1



Converse of PMM1

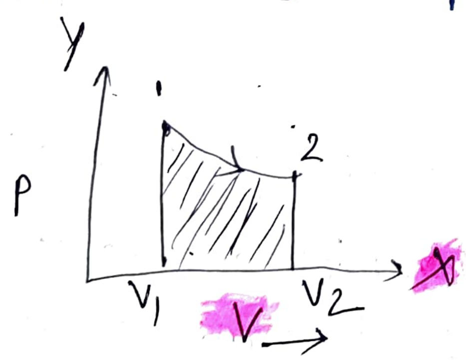
Converse of PMM1 is also true there can be no M/c which work continously consume work without some other form of energy appearing Simultaneously.

TYPES OF WORK

There are two types of work
1. closed system work
2. open system work

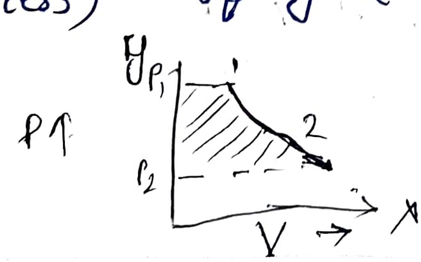
Closed system work :- (Non-Flow Process) In case of closed system we project on X-axis or Volume axis.

$[\because W = P.dV]$



M.Imp NOTE - In PV diagram area under the curve show work done by the system

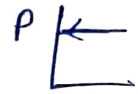
Open system :- (Flow Process) In Open system we project an area of y-axis or pressure axis.

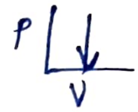


Application of first law :-

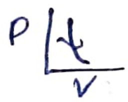
App^n to Non flow Process closed System:

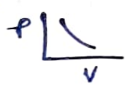
Work done $\underbrace{W = \int P . dv}$

① Isobaric Process [Constant P] 

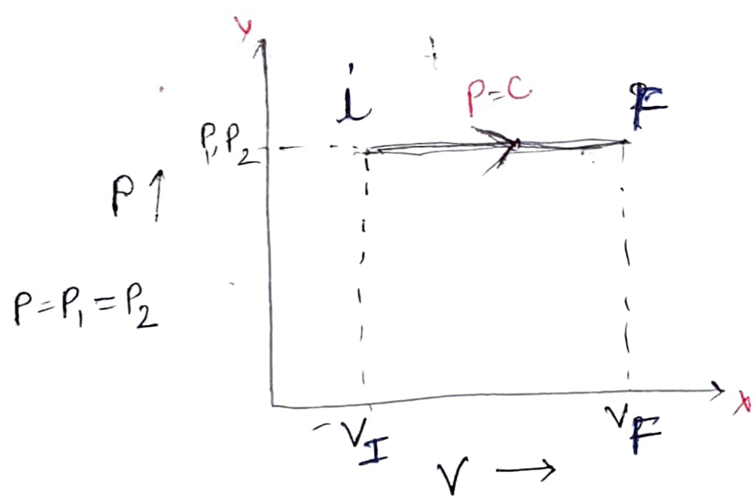
② Isochoric Process [constant V] 

③ Isothermal Process [constant T] 

④ Adiabatic Process [dQ = 0] 

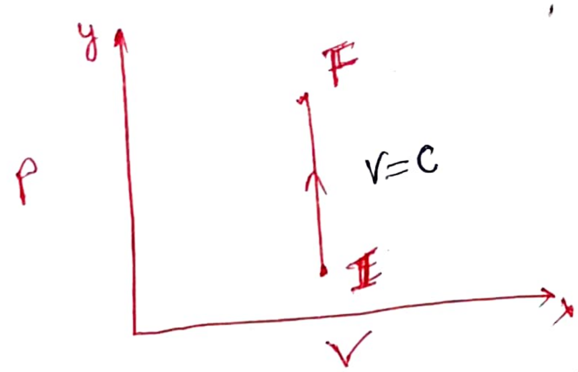
⑤ Polytropic Process [$n = 1.1 - 1.39$] 

① Isobaric Process :- (constant pressure process)



$$W = \int P . dv$$
$$= P \int_{i}^{F} dv$$
$$= P [V]_I^F$$
$$= P (V_F - V_I)$$
$$\boxed{W_{1-2} = P . (V_F - V_I)}$$

② Isochoric Process :- [Constant Volume Process]

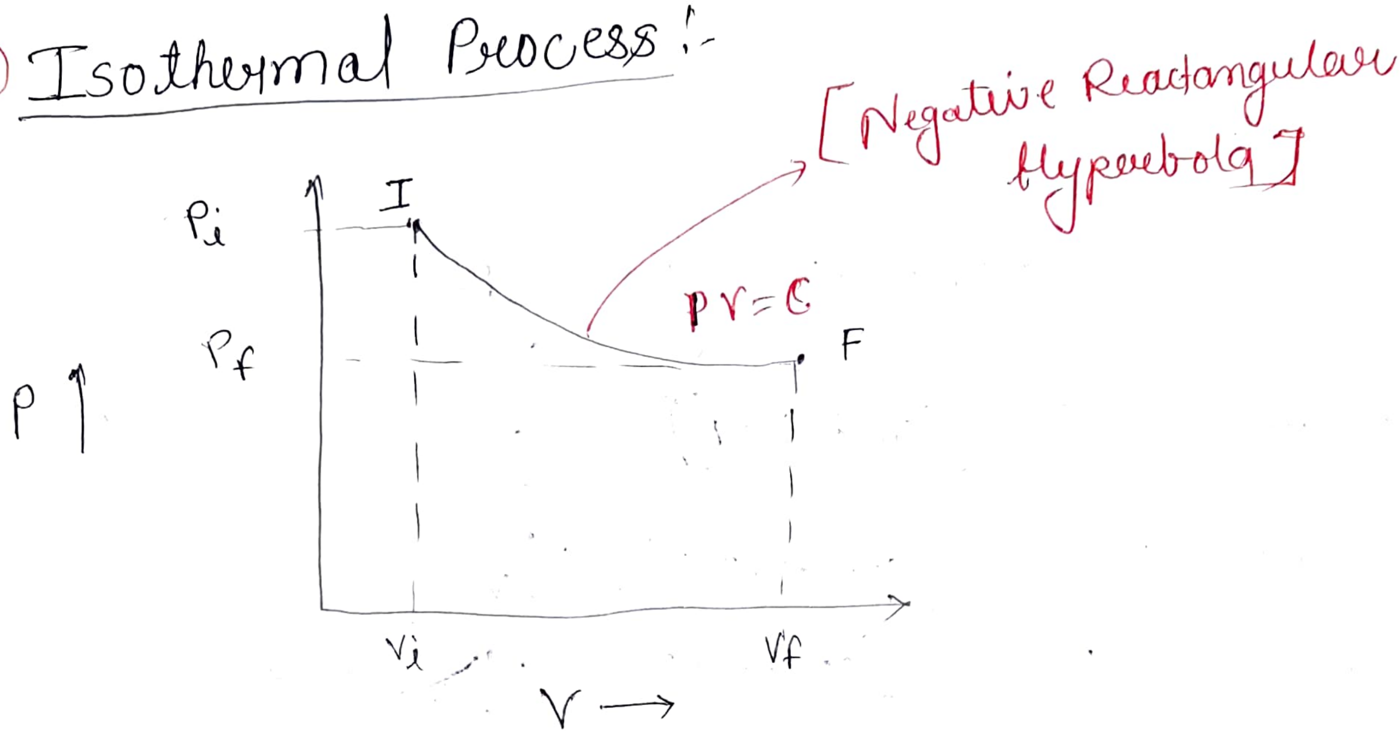


$$W = \int_I^F P . dv$$
$$= P \int_I^F dv$$
$$= P [v]_I^F, \quad = P [V_F - V_I]$$

$V_F = V_I = V$

$$= P [0], \quad \boxed{W = 0}$$

③ Isothermal Process :-



$PV = C, \quad P_I V_I = P_F \cdot V_F = C$ (Isothermal $T_I = T_F = T$]

$P_i V_i = mRT$

$P_i V_i = RT$

$P_f \cdot V_f = RT, \quad \underline{T_1 = T_2 = T}$

$${}_iW_f = \int_i^f P \cdot dV \qquad \left[\because PV = C \quad P = \frac{C}{V}\right]$$

$$= \int_i^f \frac{C}{V} \cdot dV$$

$$= C\int_i^f \frac{1}{V} \cdot dV$$

$$= C\left[\log V\right]_i^f$$

$$= C\left[\log V_f - \log V_i\right)$$

$$= C \log \frac{V_F}{V_i}$$

$$\boxed{{}_iW_f = P_i V_i \log \frac{V_F}{V_i} = P_F \cdot V_F \cdot \log \frac{V_F}{V_i}}$$

Isothermal Expansion

Also, $P_i V_i = P_f \cdot V_f$

$$\left| \frac{P_i}{P_f} = \frac{V_f}{V_i} \right|$$

So,

$$\boxed{({}_iW_f)_{iso.} = P_i V_i \log \frac{P_i}{P_F} = P_f \cdot V_f \log \frac{P_i}{P_f}}$$

Isothermal Compression

Adiabatic Process :-

Notes:-

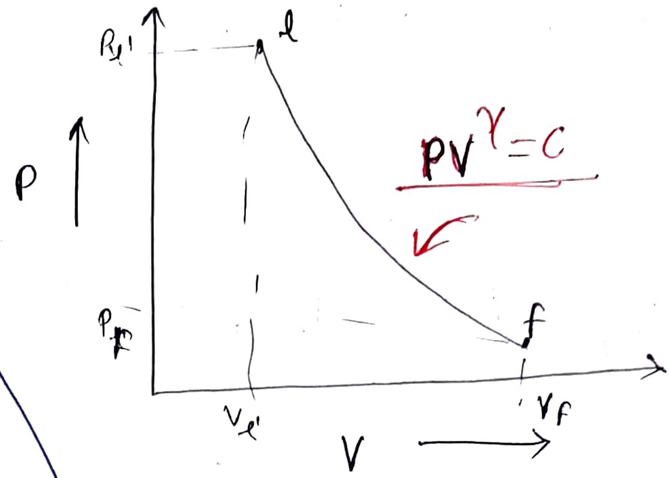
$Q = mC\Delta t$

$Q = mC_p \Delta t$ $P = C$

$Q = mC_v \Delta t$ $V = C$

$C_p = 1.005$ kJ/kg , $C_v = 0.728$ kJ/kg

$\boxed{C_p - C_v = R}$, $\boxed{\frac{C_p}{C_v} = 1.4 = \gamma}$



$PV^\gamma = \text{Constant}$

$P_i V_i^\gamma = C$ $[P_i V_i^\gamma = P_f V_f^\gamma = C]$

$P_f \cdot V_f^\gamma = C$ $\because P = \frac{C}{V^\gamma}$

Work done

$${}_iW_f = \int_i^f P \cdot dV$$

$$= \int_i^f \frac{c}{V^\gamma} \cdot dV$$

$$= c \int_i^f \frac{1}{V^\gamma} \cdot dV$$

$$= c \int_i^f V^{-\gamma} \cdot dV$$

$$= c \left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_i^f$$

$${}_iW_f = \left[\frac{C \cdot V^{-\gamma+1}}{-\gamma+1}\right]_i^f$$

$$= \left[\frac{P \cdot V^\gamma \cdot V^{-\gamma+1}}{-\gamma+1}\right]_i^f$$

$$= \left[\frac{P \cdot V^{\cancel{\gamma}\,\cancel{-\gamma}+1}}{-\gamma+1}\right]_i^f$$

$$= \left[\frac{P \cdot V}{-\gamma+1}\right]_i^f$$

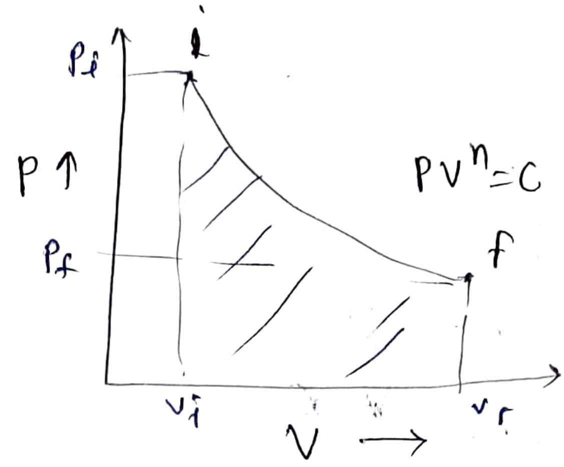
$$= \left[\frac{P_f \cdot V_f - P_i V_i}{-\gamma+1}\right]$$

$$= \left(\frac{P_i V_i - P_f \cdot V_f}{1-\gamma}\right)$$

$$\boxed{{}_iW_f = \frac{P_i V_i - P_f \cdot V_f}{1-\gamma}}$$

Work done for Adiabatic process.

Polytropic Process :→



$$\boxed{{}_iW_f = \frac{P_iV_i - P_f.V_f}{n-1}}$$

$\frac{C_p}{C_v}$ = is 1 to 1.4 then all real time process are polytropic process.

$$\boxed{1 < n < 1.4}$$

Process in which PV^n = constant