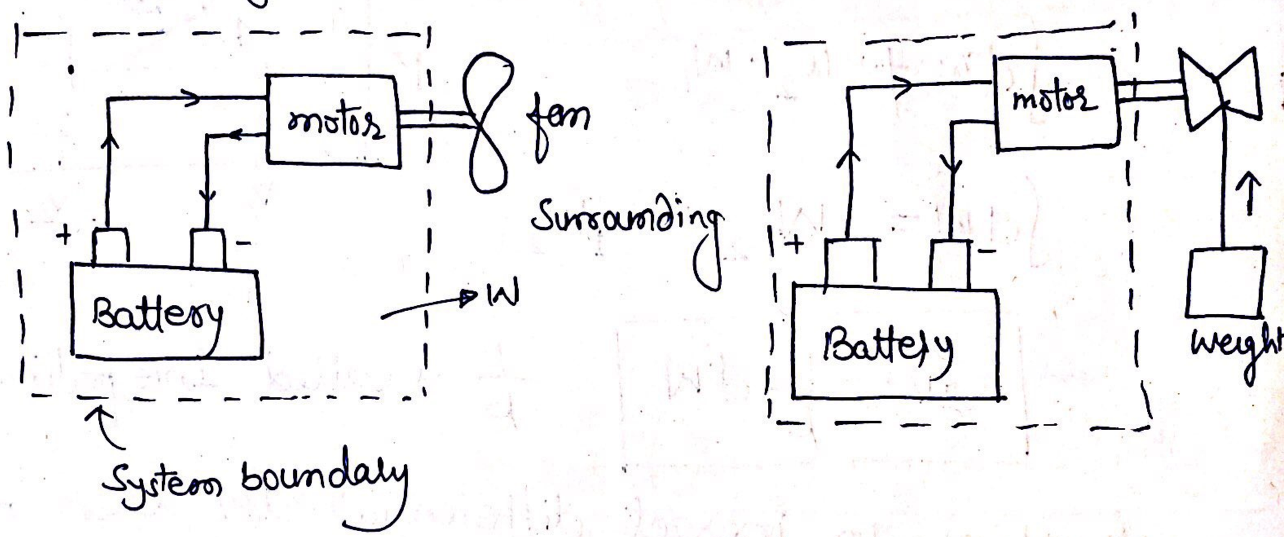
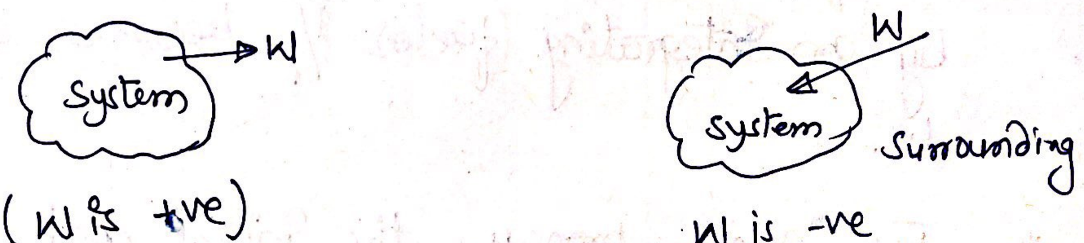
3.

WORK AND HEAT TRANSFER

WORK TRANSFER :- "Work is said to be done by a system if the sole effect on things external to the system can be reduced to the raising of a weight."

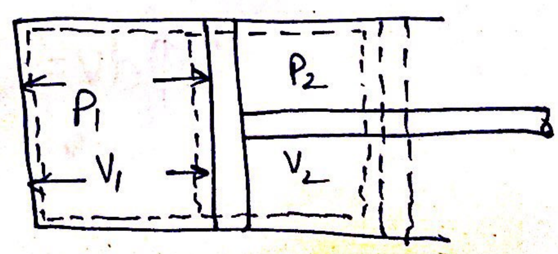
The weight may not actually be raised, but the net effect external to the system would be the raising of a weight.





Fixed Mass Analysis (Closed System) :→

$$dW = F \cdot dl = p\,a\,dl$$
$$= p\,dV$$
$$W_{1-2} = \int_{V_1}^{V_2} p\,dV$$



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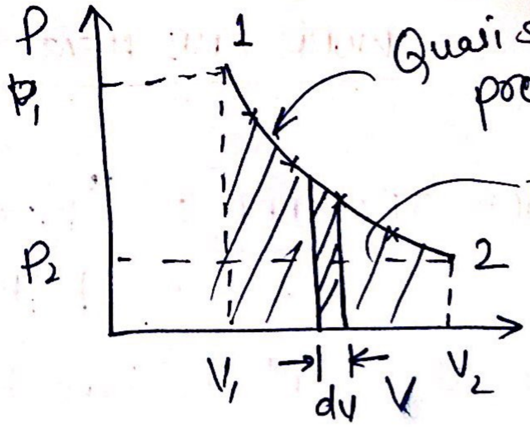
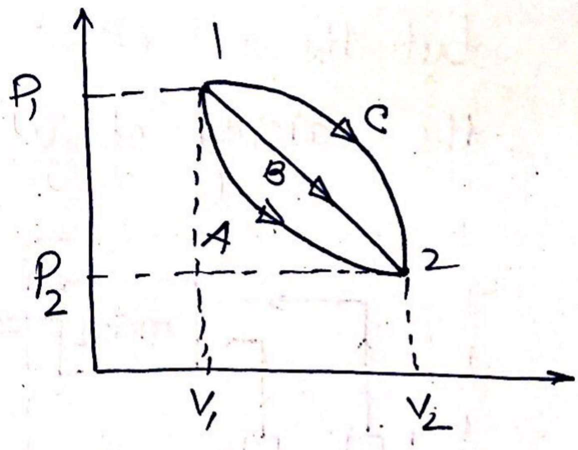
* $\int p\,dV$ can be performed only on a Quasi-static path.



* <u>Path function and Point function :</u>

work = (Area under P-V curve)



$$W_A \neq W_B \neq W_C$$

$$\int dW \neq W_2 - W_1$$

$$\int dW = W_{1-2} \text{ or } {}_1W_2$$

$$\boxed{dV = \frac{1}{p}\,dW}$$

$\frac{1}{p}$ is called Integration factor.

Therefore, an inexact differential dW when multiplied by an integrating factor $1/p$ becomes an exact differential dV.

* For cyclic process, the initial and final states of the system are the same and hence, the change in property is zero. i.e.

$$\oint dV = 0 \qquad \oint dP = 0 \qquad \oint dT = 0$$

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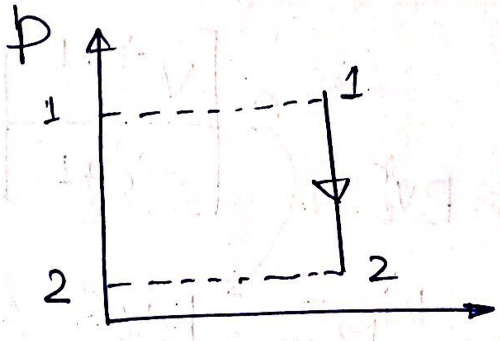
→ Work is a path function and dW is an inexact or imperfect differential.

→ Thermodynamic properties are point function. The differentials of point functions are exact or perfect differential.

→ **pdV work in Different processes :-**

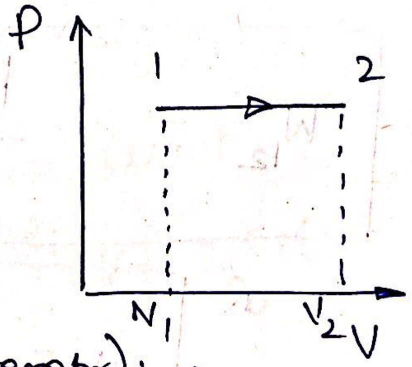
1. **Constt. volume Process (Isochoric or Isometric) :-**

$$W_{1-2} = \int p\,dV = 0$$



2. **Constt Pressure Process (Isobaric or Isopiestic) :-**

$$W_{1-2} = \int_1^2 p\,dV = p(V_2 - V_1)$$

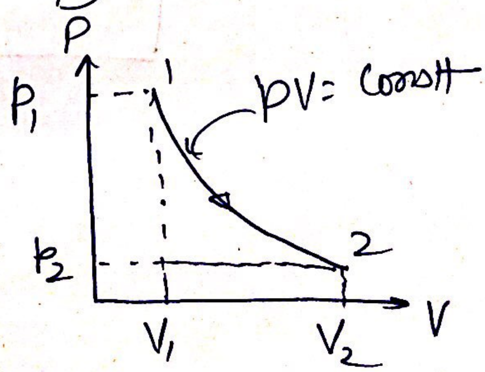


3. **Isothermal Process (Constt tempr) :-**

$$W_{1-2} = \int_1^2 p\,dV$$

$$pV = mRT = C$$

$$p = \frac{C}{V}$$



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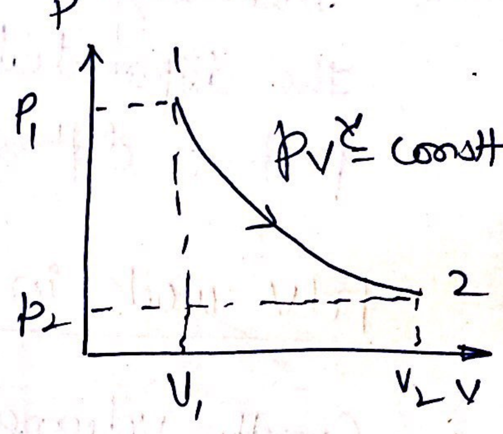
$$W_{1-2} = \int_1^2 \frac{C}{V}\, dV = C \ln\left(\frac{V_2}{V_1}\right)$$

$$\boxed{W_{1-2} = C \ln \frac{P_1}{P_2}}$$

$$\boxed{C = mRT = P_1V_1 = P_2V_2}$$

4. Adiabatic Process



$$W_{1-2} = \int p\, dV$$

$$= \int_1^2 \frac{C}{V^{\gamma}}\, dV$$

$$= C \left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_1^2 = \frac{C}{-\gamma+1}\left(V_2^{-\gamma+1} - V_1^{-\gamma+1}\right)$$

$C = P_1V_1^{\gamma} = P_2V_2^{\gamma}$.

$$W_{1-2} = \frac{P_1V_1^{\gamma}}{-\gamma+1}\left(V_2^{-\gamma+1} - V_1^{-\gamma+1}\right)$$

$$\boxed{W_{12} = \frac{P_2V_2 - P_1V_1}{1-\gamma}}$$

$$\boxed{\gamma = \frac{C_p}{C_v}}$$

OR.

$$\boxed{W_{1-2} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$$

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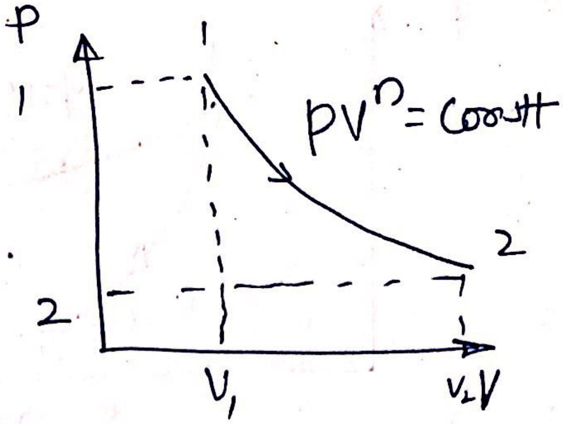
5. <u>Polytropic process :</u>



$$W_{1-2} = \int p\,dV$$

$$= \int_1^2 \frac{C}{V^n}\,dV$$

$$= C\left[\frac{V^{-n+1}}{-n+1}\right]_1^2 = \frac{C}{-n+1}\left[V_2^{-n+1} - V_1^{-n+1}\right]$$

$$\boxed{W_{1-2} = \frac{P_1V_1 - P_2V_2}{n-1}}$$

$$\boxed{-\infty < n < \infty}$$

$\underline{n \neq 1}$

* <u>Slope of Adiabatic and Isothermal curve on p-V diagram for an ideal gas :-</u>

Isothermal	Adiabatic
Ideal gas	Ideal gas
$PV = mRT = \text{constt.}$	$PV^{\gamma} = \text{constt}$
$p\,dV + V \cdot dp = 0$	$p \cdot \gamma \cdot V^{\gamma-1} dV + V^{\gamma} dp = 0$
$\frac{dp}{dV} = -\frac{p}{V}$	$\frac{dp}{dV} = \frac{-\gamma p}{V}$

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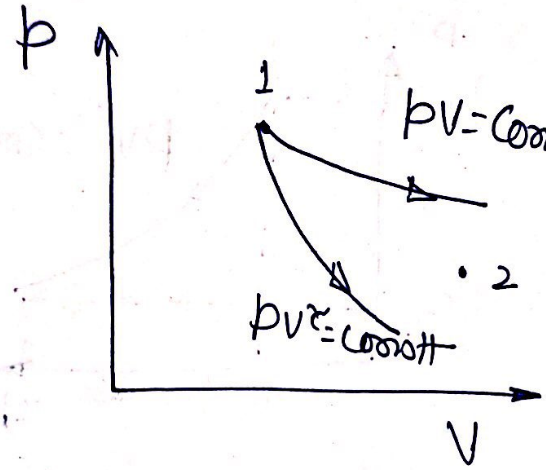
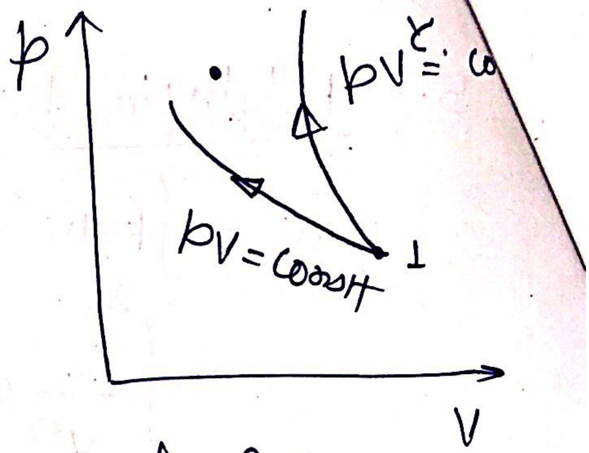
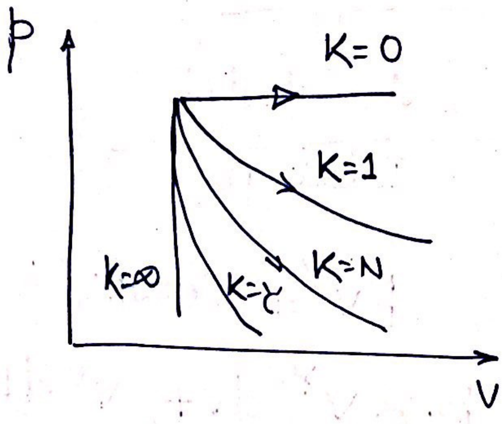
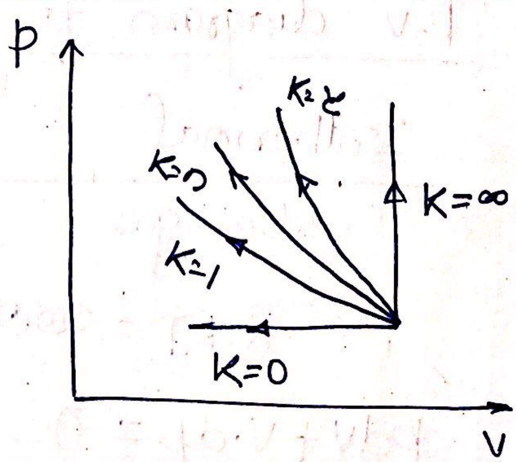




* Adiabatic curve is more vertical than Isothermal curve...
* The slope of Adiabatic curve is γ- times the isothermal curve on p-V diagram.
* Adiabatic curve more steeper than isothermal curve.

Representation of different processes on PV diagram





$$pV^K = \text{Constt}$$

K=0 Constt pressure
K=1 Isothermal
K=n polytropic
K=γ Adiabatic
K=∞ Constt volume.

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