

Thermodynamics

PGT

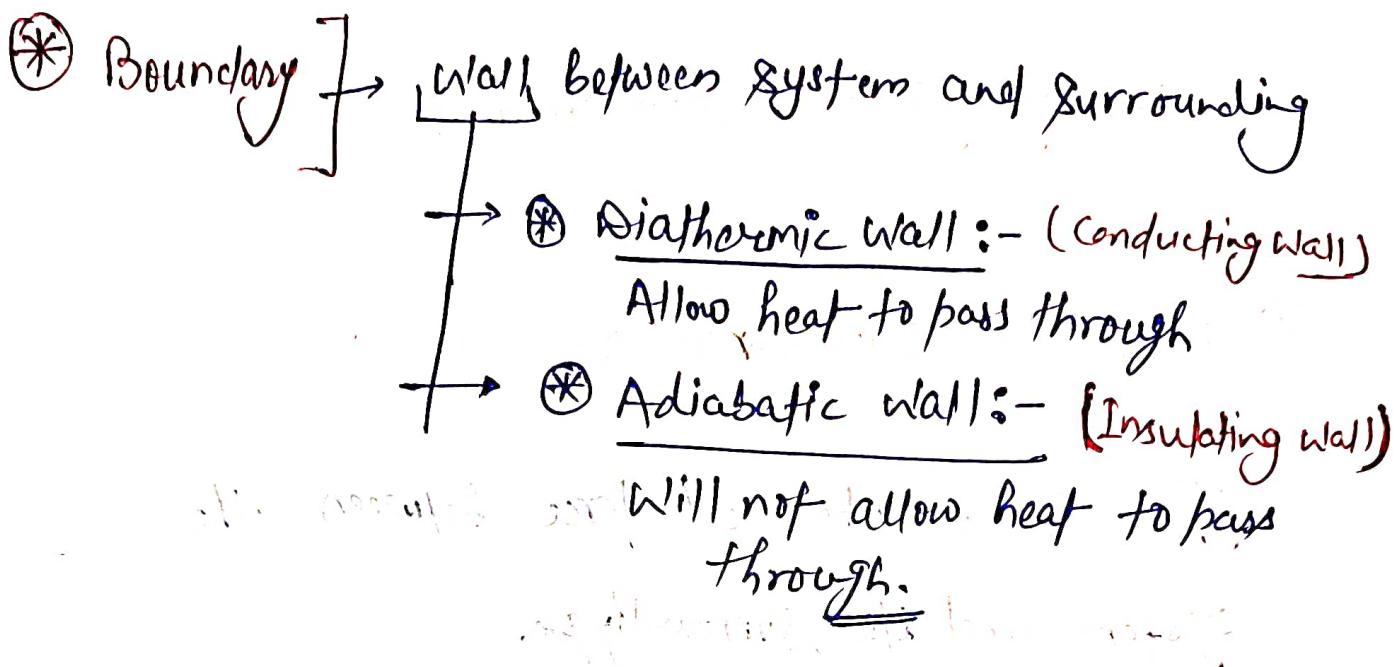
Thermodynamics :-

Thermodynamics is a branch of Science which deals with exchange of heat energy between bodies and conversion of heat energy into Mechanical Energy and vice-versa.

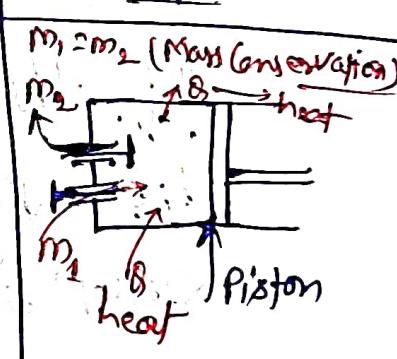
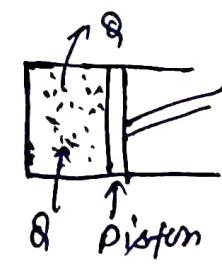
* Thermodynamic System:-

A system is defined as a quantity of matter or a region in space chosen for study.

(अन्यथा एक सिर्फ़ गाँथीं वाली क्षेत्र को नहीं बर्तावा जाता)



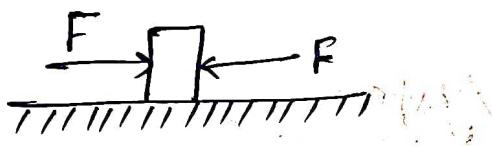
* Thermodynamic Systems

Systems	Mass	Energy	Example :-
(1) Open systems :- It exchanges both heat (or Energy) and matter (mass) with its surroundings.	(✓) (in or out)	(✓) (in or out)	$m_1 = m_2$ (Mass conservation) 
(2) Closed systems :- It exchanges only heat (or Energy) but no matter with its surroundings.	(X) (No in or out)	(✓) (in or out)	
(3) Isolated systems :- It exchanges neither heat (or Energy) nor matter with its surroundings.	(X) (No in or out)	(X) No heat in or out	④ Thermoflask ④ Universe

* Thermodynamic Equilibrium

(*) Mechanical Equilibrium:-

There is no unbalanced force between the system and its surroundings.



(*) Thermal Equilibrium:-

If the temperature is the same throughout the entire system. (T_f nicht T_0 System ist nicht T_f)



* Chemical Equilibrium -

If its chemical composition does not change with time, that is, no chemical reactions occur.

(अदि रहती

परी रहती

रासायनिक रिक्वेन्ट रहती है)

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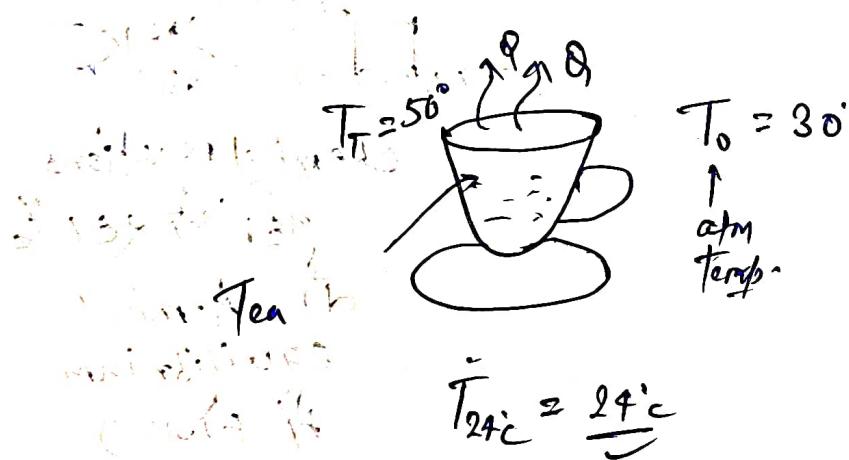
* Heat, Internal Energy and Work :-

Heat :-

Heat is nothing but energy in transit.

→ Heat is a form of Energy.

→ Heat flows from the body at a higher temperature to the one at lower temperature.



→ Heat is a scalar quantity.

→ Unit: Joule (S.I unit)

Calories (Practical unit)

$$1 \text{ Calorie} = 4.2 \text{ J}$$

→ It is denoted by (Q)

✳ Heat \rightarrow Path dependent quantity.

Matter

* Internal Energy :- Intensity of system (U)

Internal Energy of a system is the energy possessed by the system due to molecular motion and molecular configuration.

① The Energy due to molecular motion is called internal Kinetic Energy (U_k)

② The energy due to molecular configuration is called internal Potential Energy (U_p).

Internal Energy (U) = Kinetic Energy + Potential Energy of these molecules.

$$I.E(U) = U_k + U_p$$



* Work done :-

Small work done.

$$dW = Fdx$$

$$dW = PA dx$$

per unit piston

small change
in volume (dv)

$$dW = PA dx$$

$$dW = Pdv$$

Integrating both sides

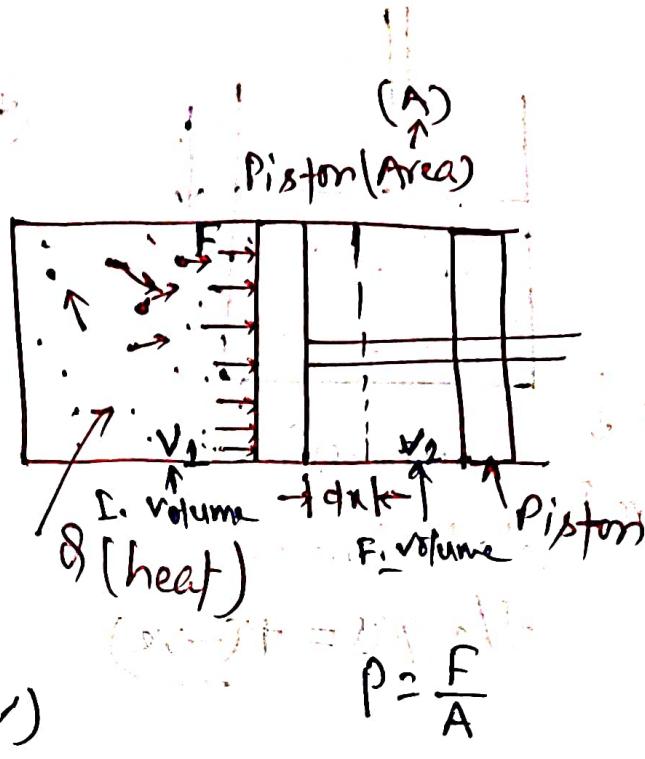
$$\int dW = \int Pdv \quad \text{(for constant pressure)}$$

$$\boxed{\int dW = \int_{V_1}^{V_2} Pdv}$$

$$W = P [v]_{V_1}^{V_2}$$

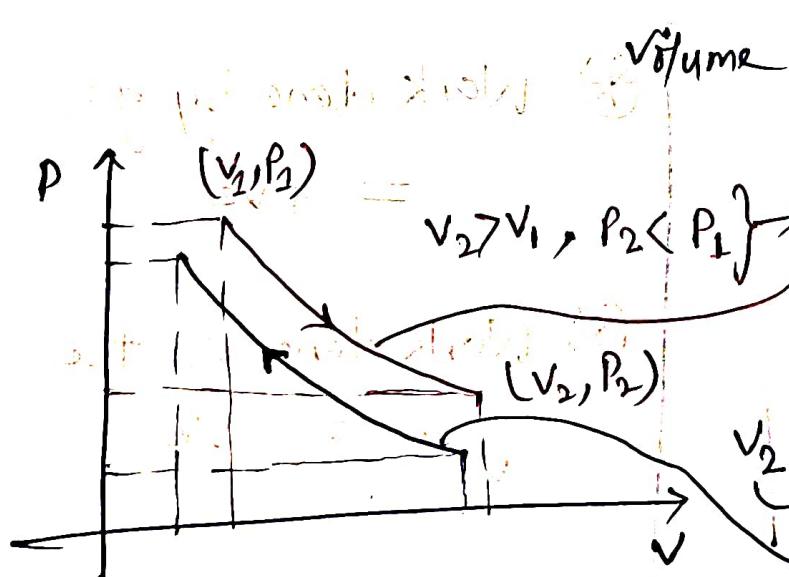
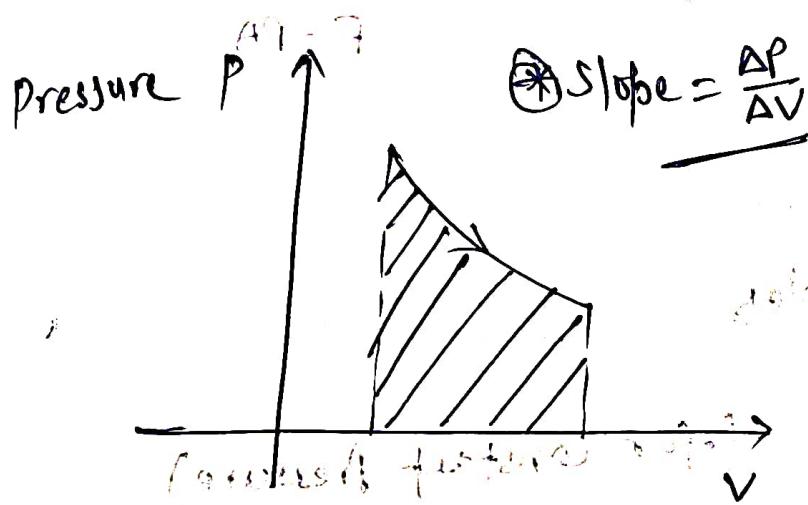
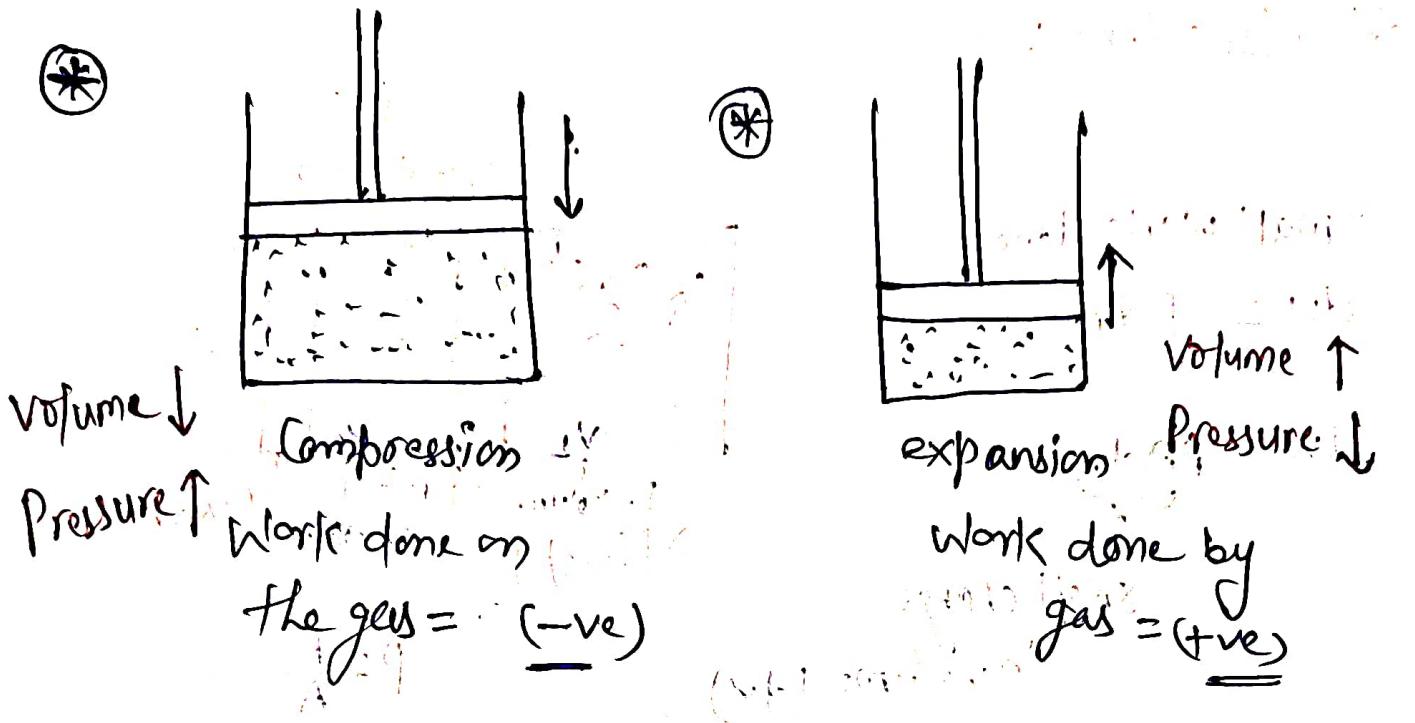
$$\boxed{W = P_i [V_2 - V_1]}$$

(Work done
by gas)



* Work done by gas
= +ve

* Work done on the
gas = -ve



area under
P-V diagram

* Thermodynamics State Variables :-

Thermodynamics State Variables
(प्रकाशित करने वाले वर्ष 1971)

Pressure, Volume, Temperature, Internal Energy.

① Intensive Variable :-

These are the variable which are independent of the size.

Ex:- Pressure, density and Temperature

② Extensive Variable :-

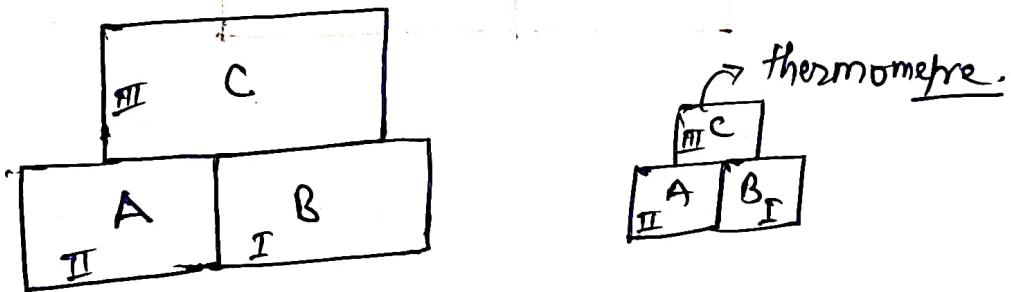
These are the variable which depend on the size of the system.

Ex:- Volume, Mass, internal Energy.

(प्रकाशित करने वाले वर्ष 1973)

* Zeroth Law of Thermodynamics :-

The zeroth law of thermodynamics states that, if two systems A and B are separately in thermal equilibrium with a third system C, then A and B are in thermal equilibrium with each other.



$$T_A = T_C$$

$$\text{and } T_B = T_C$$

$$\text{then } T_A = \underline{T_B}$$

The property which is same for all the bodies is temperature.

$$^{\circ}\text{C} = \frac{5}{9} (\text{ }^{\circ}\text{F} - 32)$$

→ thermometry
(temp. measurement)

* First Law of Thermodynamics :-

The general Principle of Conservation of Energy implies that

$$\Delta Q = \Delta U + \Delta W$$

i.e., the energy (ΔQ) supplied to the system goes in partly to increase the internal energy of the system (ΔU) and the rest in work (ΔW).

$$\Delta Q = \Delta U + \Delta W$$

$$dQ = dU + dW$$

$$dU = dQ - dW$$

* Heat Transfer in various Closed Systems Process:-

(*) Constant Volume Process:-

From first law of Thermodynamics:

$$\Delta Q = \Delta U + (\Delta W)$$

$$\Delta Q = \Delta U + P\Delta V$$

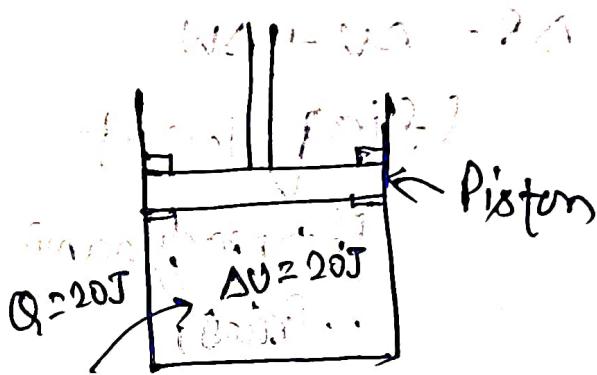
$$\Delta Q = \Delta U + 0$$

(*) $\boxed{\Delta Q = \Delta U}$

$$\Delta Q = \Delta U = mC_v\Delta T$$

(Isochoric process)

P_0 and T_0 are \cancel{W}



* Constant Pressure Process :-

(Isobaric Process)

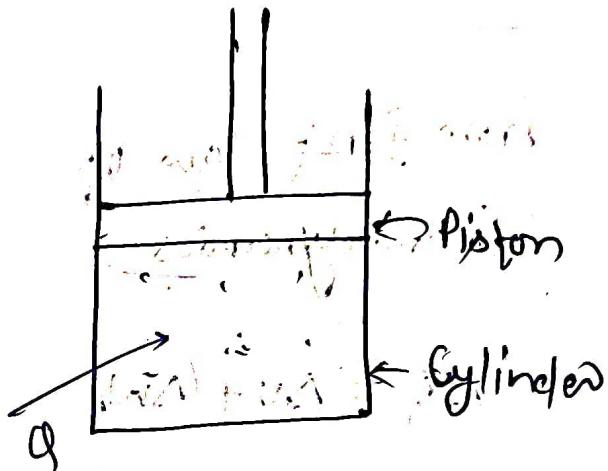
$$\Delta Q = \Delta U + \Delta W$$

(First Law of Thermodynamic Process)

Thermodynamic Process

$$W_{P=C} = P(V_2 - V_1)$$

Work done at const. pressure = $P\Delta V$



$$\boxed{\Delta Q = \Delta U + P\Delta V}$$

- * When heat is supplied at constant pressure it increases the Enthalpy of the system

$$\Delta Q = mC_p\Delta T$$

[↑ Specific heat at constant pressure]

* Constant Temperature Process :-

(Isothermal Process) (Temp \rightarrow const.)

$$\Delta Q = \Delta U + \Delta W$$

(first law of thermodynamics)

Internal Energy is function of Temperature.

$$U = f(T)$$

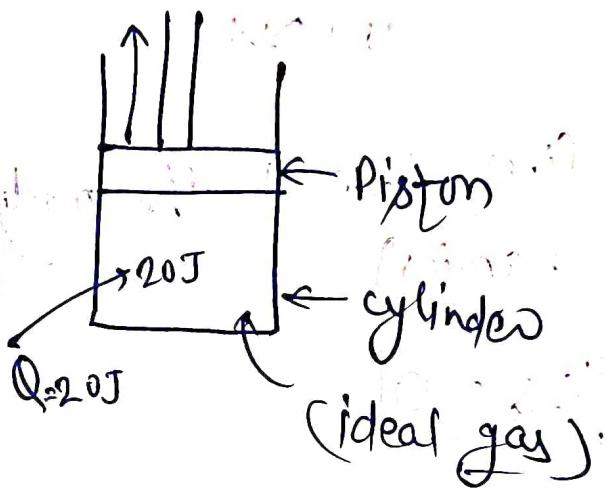
$$\Delta T = 0$$

(Temperature = Constant).

$$\Rightarrow \Delta U = 0$$

$$\therefore \Delta Q = \Delta W$$

$$W = 20J$$



$$W = P_1 V_1 \ln \frac{V_2}{V_1}$$

(*) Adiabatic Process :-

$$\Delta Q = \Delta U + \Delta W$$

(first law of thermodynamics)

$$|\Delta Q = 0|$$

$$\Delta Q^0 = \Delta U + \Delta W$$

$$\Delta W = -\Delta U$$

Work is performed by gas at the cost of its internal Energy.

$$|\Delta W| = |- \Delta U|$$

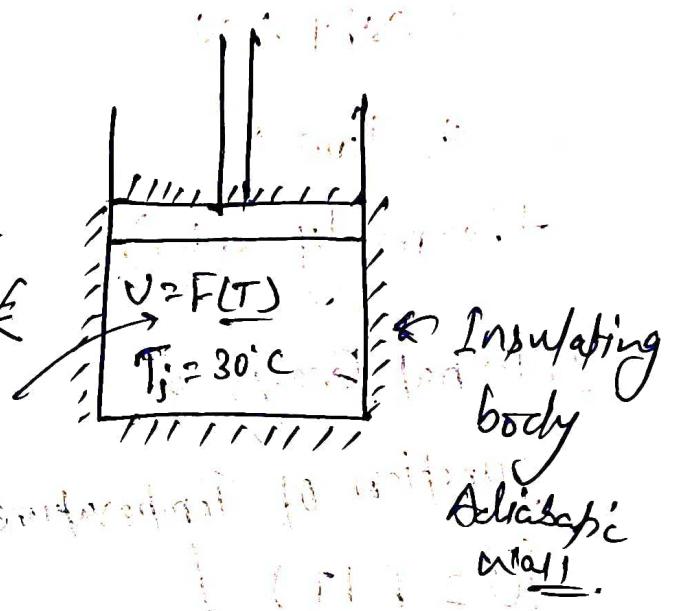
Work done is path function

Change in Internal Energy is Point function

$$PV^\gamma = C$$

$$W = \frac{P_2 V_2 - P_1 V_1}{1-\gamma}$$

$$W = nR \frac{(T_2 - T_1)}{1-\gamma}$$



* Polytropic Process :-

many changes.

$$PV^n = C$$

where $0 < n < \infty$ (theoretically)

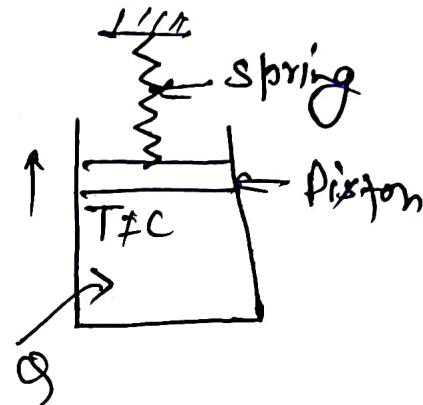
$n \rightarrow$ Polytropic Index

$1 < n < r$ (practically)

$$\Delta Q = \left(\frac{r-n}{r-1} \right) W_{\text{Polytropic process.}}$$

$$\boxed{\text{Work done} = \frac{P_1 V_1 - P_2 V_2}{n-1}}$$

$$\Delta Q = \left(\frac{r-n}{r-1} \right) \frac{P_1 V_1 - P_2 V_2}{n-1}$$



$T \neq \text{const.}$

$V \neq \text{const.}$

$P \neq \text{const.}$

Work done $\neq 0$

* Ideal gas:-

$$\boxed{U = F(T)}$$

$$\boxed{C_p > C_v}$$

* $C_p - C_v = R$ (Mayer's Equation)

$$C_v = \frac{R}{r-1} \quad | \quad C_p = \underline{\frac{rR}{r-1}}$$