

Heat flow due to Potential difference

**how many law of thermodynamics ..**

Zeroth law → Define temperature

1st law → Define energy  $\Delta Q = \Delta U + \Delta W$  "energy neither created nor destroyed but it can change from one form to another"

2nd law → Entropy

3rd law → Absolute zero

Ok, unattainable

Thermodynamics system is a place or space where energy transformation takes place. Heat or work observed at boundary. Universe consists of system and surrounding. Boundary of surrounding is hypothetical and depend upon the size of system.

**Insulated**

Thermo flask  
imperfect adiabatic system

I cannot  
exchange

heat  
but  
mass  
boundary

**Isolated**

Conn with  
universe

Perfectly adiabatic  
system

## Heat Transfer

close  
open  
insulated  
isolated

✓  
✓  
✗  
✗

## Mass Transfer

✓  
✓  
✗  
✗

**Steady** state has open system and has no change with respect to time.

**Unsteady** state has close system and has has change in Pressure/state with respect to time.

Thermodynamic Property can be measurable  
Temp, Pressure, V, K.E, P.E

Heat and work are not thermodynamic properties so they are not intensive or extensive

## Point function:

is a function which can measured at a point

e.g T, P, V, I.E

## Path function:

cannot measured at a point and depends upon the Path Difference  
e.g Heat, work.

$$Q_i = m c_p \Delta T$$

## intensive

independent on mass  
conductivity, Density

Temperature, Resistivity  
Pressure, Density

Specific energy =  $\frac{\text{energy}}{\text{Mass}}$ ,  $\frac{\text{extensive}}{\text{extensive}}$  = intensive

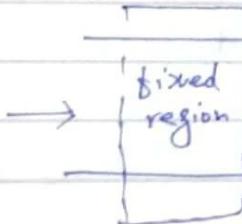
Specific Properties are intensive.

## extensive

Dependent on mass  
mass, volume, Resistance  
conductance, K.E, P.E

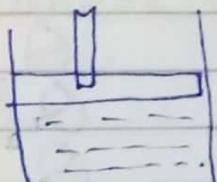
## Thermodynamic System

Fixed region / space system  
matter not fixed Open / flow system



system's approach  
closed system

matter fixed but  
not region or  
space fixed

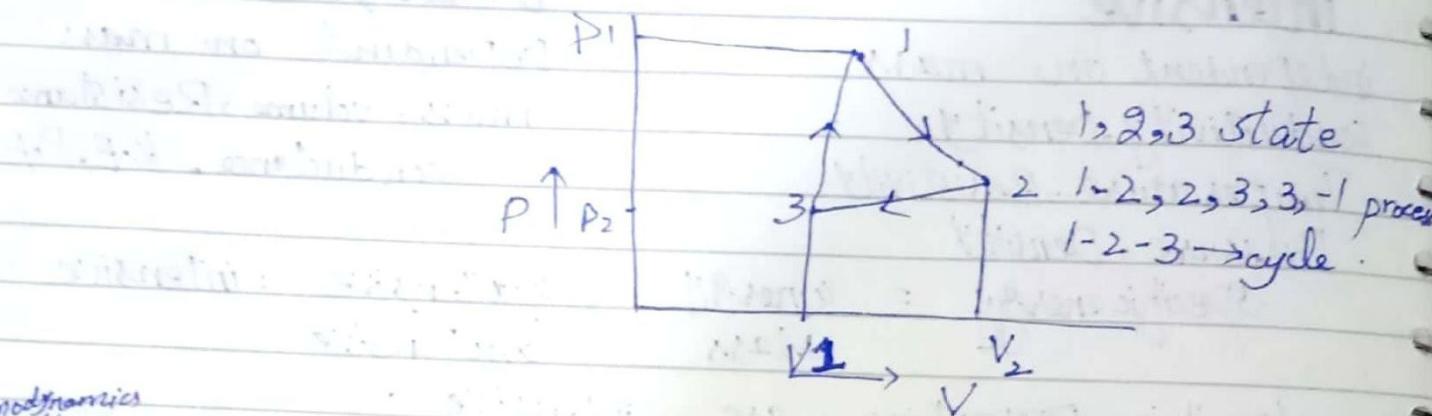


Thermodynamics  
state, Process, cycle can be  
explained by property diagram

P-V Diagram  
T-S

Steady flow process → Processes involving such devices can be represented reasonably well by somewhat idealized process, called steady flow process, which can be defined as process during which fluid flows through control volume steadily.

### Steady flow



### Thermodynamics

State can be measured by thermodynamics property at a particular thermodynamic equilibrium. Thermodynamic

The significance of thermodynamic process to help us work and heat.

### 1<sup>st</sup> law of thermodynamics

$$dQ = \Delta U + dW \quad \dots \text{①}$$

$$Q_{1-2} = U_2 - U_1 + W_{1-2} \quad \dots \text{②}$$

$$Q_{2-3} = U_3 - U_2 + W_{2-3} \quad \dots \text{③}$$

$$Q_{3-1} = U_1 - U_3 + W_{3-1} \quad \dots \text{④}$$

The significance is it tell us about the interaction of net heat and work.

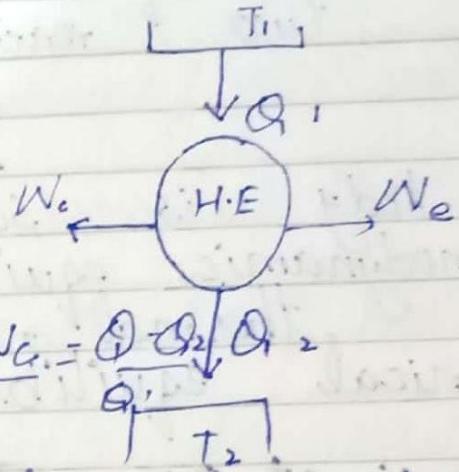
$$\oint dQ = 0 + \oint dW$$

cyclic integration of point function is always zero, so is a point function.

$$\text{Input} = Q_1 + Q_2 + Q_3 \\ \text{output} = W_e - W_c = W_{\text{net}}$$

$$\oint dQ = \oint dW$$

$$\eta = \frac{W_{\text{net}}}{Q} = \frac{W_e - W_c}{Q} = \frac{Q_1 - Q_2 - Q_3}{Q}$$



efficiency only for heat engine

For refrigeration we use COP

## ThermoDynamic equilibrium :-

When temperature becomes constant then it is called thermal equilibrium

$$T_1 = T_2$$

$$\Delta T = 0$$

When pressure becomes constant then it is called mechanical equilibrium

$$P_1 = P_2$$

$$\Delta P = 0$$

class 1 → Processes involving such changes are called

- A body is said to be in chemical equilibrium when concentration of two reactant becomes equal

$$C_1 = C_2$$

$$\Delta C = 0$$

A body is said to be in thermodynamic equilibrium if it is in thermal, mechanical and chemical equilibrium.

- Quasi static, Reversible, irreversible process

All process occur in nature are irreversible.

Quasi means almost  
static  $\rightarrow$  stationary

Evaporation process is in Quasi static

In Quasi static, phases are very close to each other.

In reality, there is no process is reversible, but some processes are reversible

Polytropic process

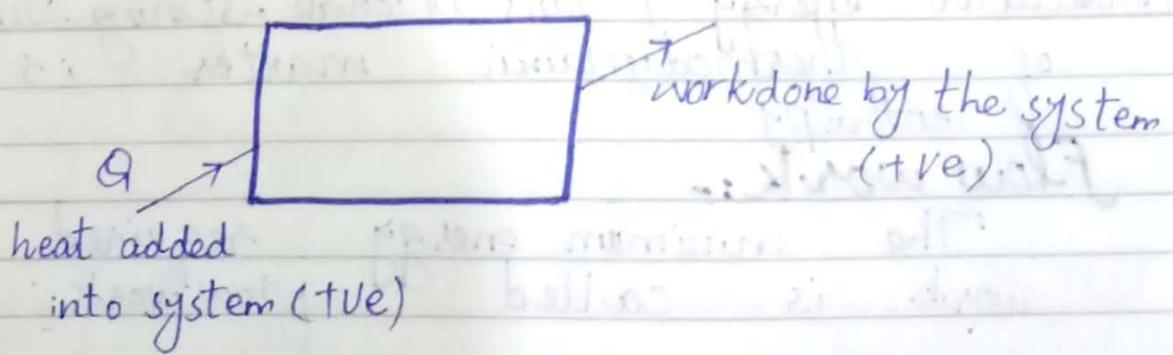
$$PV^n = C$$

- Isochoric process (constant volume)  $V = \text{const} + R\ln V$   $n = \infty$
- Isobaric process (constant pressure)  $P = C + R\ln V$   $n = 0$
- Isothermal process (same temperature)  $T = C + R\ln V$   $n = 1$
- Reversible Adiabatic process ( $dQ = 0 + R\ln V$ )  $n = r$

It is also called isentropic process  
(constant entropy)

All above processes are reversible.

Sign Convention :-



heat rejected by the system (+ve)   work done on the system (-ve)

$$dQ = \Delta U + dW$$

heat added into system (+ve)   work done on the system (-ve)

**Internal energy** :- Molecular energy of thermodynamic matter is called Internal energy.

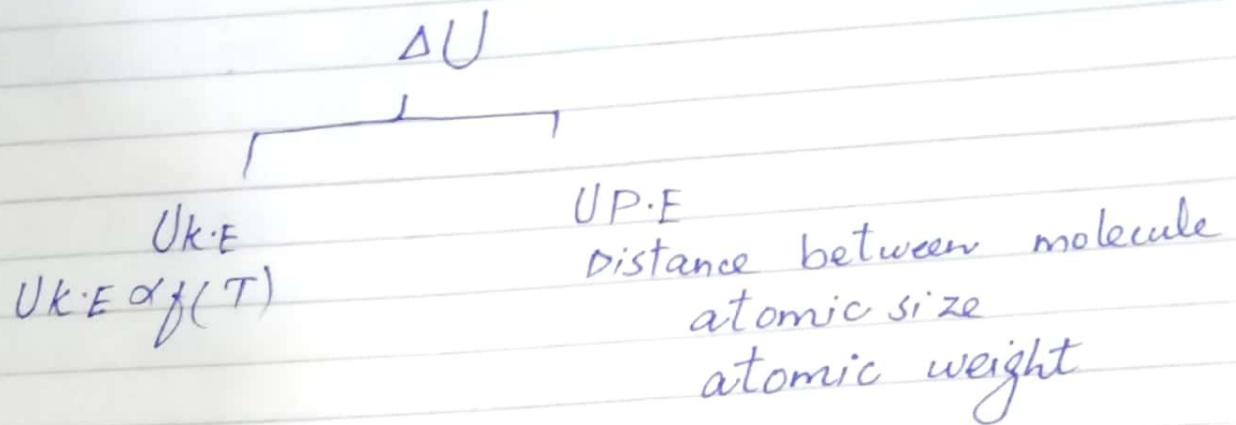
**Enthalpy** =

$$H = U + PV$$

Molecular energy (translational, spinning, vibratory) of thermodynamic matter is called enthalpy.

**Flow work** :-

The minimum energy required to do work is called flow work.



$$\Delta U = U.K.E + U.P.E$$

For ideal gases  $P.E = 0$

$$\Delta U = U.K.E + 0$$

$$\Delta U = U.K.E$$

For ideal gases

$$U = C_V \Delta T$$

Enthalpy, Internal energy, enthalphy

$$\Delta H = U + PV$$

$$\Delta H = C_p \Delta T$$

$$\Delta U = C_V \Delta T$$

$$\Delta S = C_p \left( \ln \left( \frac{T_2}{T_1} \right) \right)$$

d used for  
Path Junction  
Δ used for  
point Junction.

$C_p$ : Specific heat of liquid  
and solid

constant and same

water -  $C_p = 4.18 \text{ kJ K}^{-1}$   
 $C_p = C_V = 4.18 \text{ kJ K}^{-1}$

For solid and liquid  
 $C_p = C_v$

$$U = C_v \Delta T$$

$$U_2 - U_1 = C_v \Delta T$$

$$U_2 - 0 = C_v (T_2 - T_1)$$

$$U_2 = 4.18 (30 - 0)$$

$$U_2 =$$

$$\text{at } T_2 = 30^\circ \text{C}$$

$$S_2 - S_1 = C_p \ln \left( \frac{T_2}{T_1} \right) \quad \begin{array}{l} \text{- in case of entropy we} \\ \text{use kelvin scale} \end{array}$$
$$= 4.18 \ln \left( \frac{303}{273} \right)$$

## Differences

### Heat

- low grade energy because heat available in orderless form and in heat losses occurs.

Enthalpy

## Work

High grade energy because work available in order form and no loss occurs.

$$\Delta U = Q + W$$

## Similarities of work and heat :-

- Both are path function
- Both are form in transit form
- Both observe at boundary

1<sup>st</sup> law analysis depends upon the system

## Pressure and Temperature.

Absolute scale of pressure is pascal  
" " of Temp is kelvin

Concept of pressure is observed in liquid and gases

Intermolecular collision causes pressure of gas molecule

The manifestation of degree of hotness and coldness of body is called Temperature

0 Pa exist because intermolecular collision stop in gases if intermolecular distances between gas is very large.

0 K not exist The reason has to do with amount of work necessary to remove heat from substances which increases the colder you try to go To touch absolute zero

The actual pressure at given  
pos. is  $P_A + P_B$

$$P_{abs} = P_{guage} + P_{atm}$$

$$P_{atm} = 1.01 \text{ bar}$$

$$\text{Absolute } P_A = 0.6 \text{ bar}$$

$$P_B = 1.04 \text{ bar}$$

$$\text{Guage press } \mathbf{B} = -0.4 \text{ bar}$$

$$\text{Vacuum pressure } \mathbf{A} = -0.6 \text{ bar}$$

	1.01 bar	P <sub>B</sub> 1 Guage P
	10 <sup>5</sup> Pa	vacuum press.
	0.6 bar	
	0 Pa	

$$\text{Pvacuum} = P_{abs} - P_{atm} \rightarrow P_{abs} = \text{Pvacuum} + P_{atm}$$

$$P_{guage} = P_{abs} - P_{atm}$$

## Ideal Gases:-

• Intermolecular distances is large (no intermolecular attraction)  
• Size of individual molecule is negligible as compared to the size of container

$$PV = mRT$$

$$P = \rho RT$$

R is characteristic  
gas constant

$$\frac{PV}{m} = RT$$

fact

$V$   $PV = RT$   
is specific volume.

$R$  = universal gas constant

$$R = 8.314 \text{ almdm}^3 \text{ K}^{-1} \text{ mol}^{-1}$$

$$R_i = \frac{R}{M} = \frac{8.314}{29} = 0.287$$

## Real gas equation:-

$$(P + \frac{n^2}{V^2}) (V - n b) = n R T$$

correction factor      correction factor  
for intermolecular      for size  $b$   
attraction

$P$  is increasing

$V$  is decreasing

## Heat

$$Q = mc_p \Delta T$$

$$C = \frac{Q}{m \Delta T}$$

The amount of heat required to raise the temperature of 1 kg substance through Kelvin is called specific heat.

In case of phase change we calculate heat by latent heat of vaporization.

$$Q = m \Delta H$$

$$\Delta H = 2257$$

In case of boiling we use

$$dQ = \Delta U + dW$$

## FREE Expansion / Throttling

Type Bolt / system is perfectly insulated from surrounding condition & or process of adiabatic the process is very fast.

In free expansion, contact area is not minimum.

$$dQ = \Delta U + dW$$

$$0 = \Delta U + dW$$

Exposed area has to be minimum.

Insulated / isolated

Free expansion process is a constant internal energy process and adiabatic process and irreversible process



$$U_1 = U_2$$

$$T_1 = T_2 \text{ for ideal gases}$$

in this case

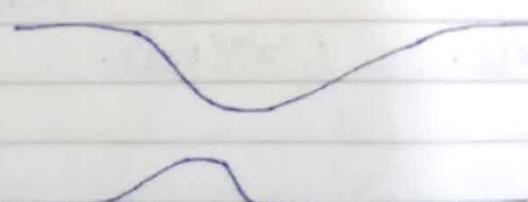
if expansion occurs then boundary remove

Free expansion process, no work is also isothermal done because process if process is no work is done on boundary reversible.



## Throttling --

In throttling contact area is minimum.



For closed system we

$$dQ = \delta U + dW$$

For Open system we use SFEE

$$Q + H_1 + \frac{V_1^2}{2} + g Z_1 = W + H_2 + V_2^2 + g Z_2 \quad \text{This}$$

equation is used for throttling

$$Q + H_1 = H_2 + W$$

In case throttling no boundary changes occur so no work.

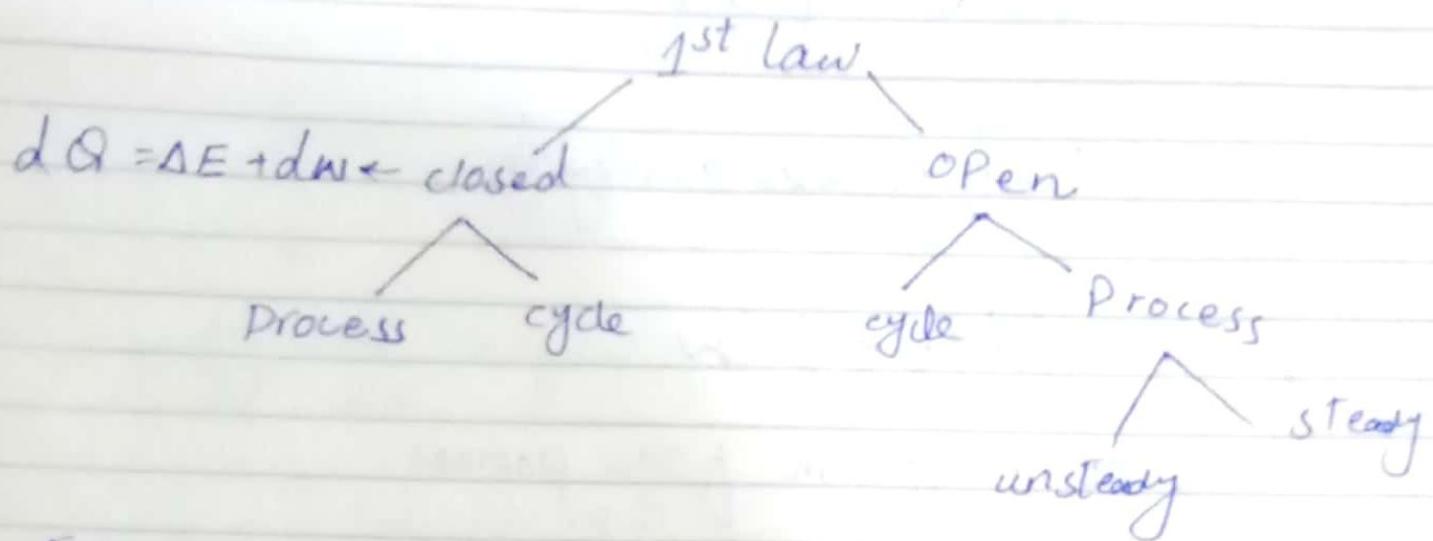
$$H_1 = H_2$$

Throttling is a constant entropy process.

It's a fast and irreversible process.

Throttling is a constant temperature process.

How to write 1<sup>st</sup> law of thermodynamics



For process

$$\int_1^2 dQ = E_2 - E_1 + \int_1^2 dw$$

$$\int_1^2 dQ = U_2 - U_1 + \int_1^2 dw$$

$$\{ Q_{1-2} = c_v(T_2 - T_1) + \int PdV \text{ for ideal gas}$$

$$U_2 - U_1 = c_v(T_2 - T_1)$$

$$\oint dQ = \oint dE + \oint dw$$

$$\oint dQ = \oint dw$$

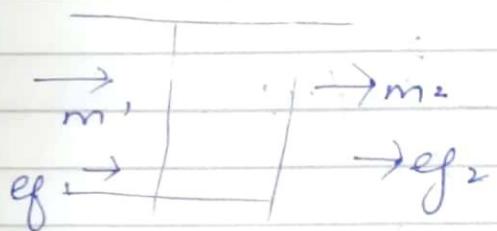
closed for cycle

$$\oint d\alpha = \oint dw$$

Open process for cycle

$$\oint d\alpha = \oint dw$$

open system for power



$$Q + m_1 ef_1 = \Delta E + m_2 ef_2 + W \text{ for unsteady system.}$$

$$ef = H_i + \frac{V^2}{2} + gz_i$$

Process  unsteady flow  
 steady flow

For Steady Flow we use:

SFEE  no mass accumulation  $m_1 = m_2$   
 no energy change  $\Delta E = 0$   
 $E_i = E_f$

15.3 Chap 4.3

2.2

2.3

2.6

2.4

2.5

$$\dot{Q}_{\text{inflow}} = \dot{m} e_{f2} + \dot{W}$$

$\dot{m}$  is mass flow rate  $\text{kg/s}$

$\dot{Q}$  is energy flow rate  $\text{kJ/s}$

$$\frac{\dot{Q}}{\dot{m}} + \frac{\dot{m} e_f}{\dot{m}} = \frac{\dot{m} e_{f2} + \dot{W}}{\dot{m}}$$

$$\therefore \frac{dQ}{dt} \cdot \frac{dt}{dm} + e_f = e_{f2} + \frac{\dot{W}}{\dot{m}}$$

$$\frac{dQ}{dt} = q, \frac{\dot{W}}{\dot{m}} = w$$

$$q + H_1 + \frac{V_1^2}{2} + g Z_1 = H_2 + \frac{V_2^2}{2} + g Z_2 + w \quad \text{for steady system}$$

$$q = H_2 - H_1 + \frac{V_2^2 - V_1^2}{2} + g(Z_2 - Z_1) + w$$

$$dq = dH + VdV + gdZ + dw$$

$$\int dq = \int dH + \int VdV + \int gdZ + \int dw \quad ] \begin{array}{l} \text{steady flow} \\ \text{System} \end{array}$$

{ 4.1

{ 4.2

{ 4.3

{ 4.4

{ 4.5

## 2<sup>nd</sup> law of Thermodynamics:

I tells us heat is low grade energy and work is high grade energy.

It can be discussed by Clausius inequality

### 2<sup>nd</sup> law

cycle:

4.9

$$\oint \frac{dQ}{T} \leq 0$$

$$\oint \frac{dQ}{T} = 0$$

$$\oint \frac{dQ}{T} \leq 0$$

$$\left( \oint \frac{dQ}{T} \right)_{\text{Reversible}} = 0$$

For reversible case

$$\left( \frac{dQ}{T} \right)_{\text{reversible}} = ds$$

$$\left( \oint \frac{dQ}{T} \right)_{\text{Irreversible}} < 0$$

$$ds > 0 \quad \left( \frac{dQ}{T} \right)_{\text{Irreversible}} + \text{sg} < ds$$

$$dQ = Tds \text{ for reversible}$$

$$\left. \begin{array}{l} \frac{dQ}{T} > 0 \\ \frac{dQ}{T} < 0 \end{array} \right\} \text{not possible}$$

PV diagram gives us work  
 Tds diagram gives us heat

2nd law tells about possibility

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PMMPMM<sub>1</sub>

PMM<sub>1</sub> violates first law of thermodynamics.

$$dQ = \Delta E + dW$$

$$dQ = 0$$

$$0 = \Delta E + dW$$

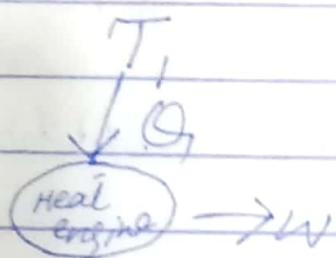
$$dW = -\Delta E$$

$$dW = E_1 - E_2$$

$$\eta = \frac{W}{Q} = \frac{W}{0} = \infty$$

PMM<sub>2</sub>

PMM<sub>2</sub> violates 2<sup>nd</sup> law of thermodynamics



$$\eta = \frac{W}{Q} = \frac{W}{W} = 1$$

$$\eta = \frac{W}{W} = 1$$

$$\eta = 100\%$$

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Kashmir Notes

es

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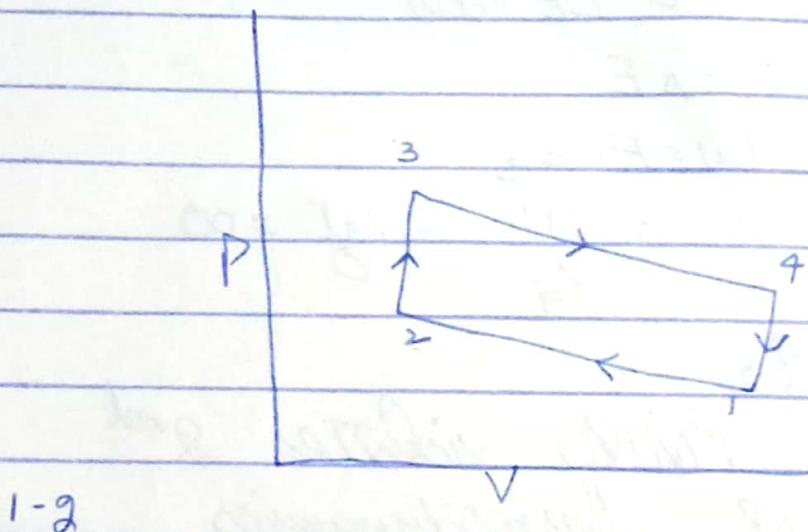


M T W T F S

Carnot cycle never violate  
the law of thermodynamics

$$\eta = 1 - \frac{T_2}{T_1}$$

PV-Diagram of otto cycle



isentropic compression

2-3

(isochoric heat addition)

(3-4)

isentropic expansion

4-1

isochoric heat rejection

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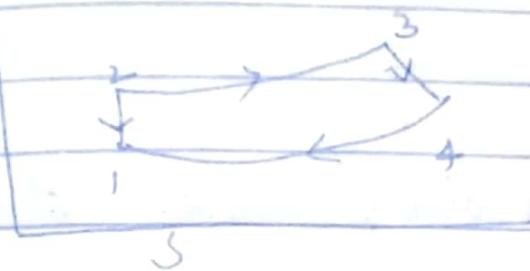
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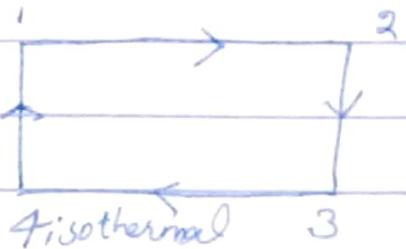
Same processes  
as P-V  
Diagram?



## Carnot cycle

Carnot cycle  
tells us it  
is an  
externally  
reversible

that's why not  
possible  
in reality



isentropic  
Process

$$dS = \frac{dQ}{T} + dS_g$$

if  $dS_g = 0$  adiabatic process

$dS_g = 0$  for reversible process

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Adiabatic

Process

Fast process  
contact space  
small

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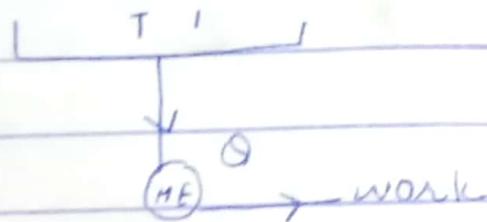
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isentropic process is a reversible adiabatic process but reversible adiabatic process is not. isentropic

## Kelvin Planck Statement:-

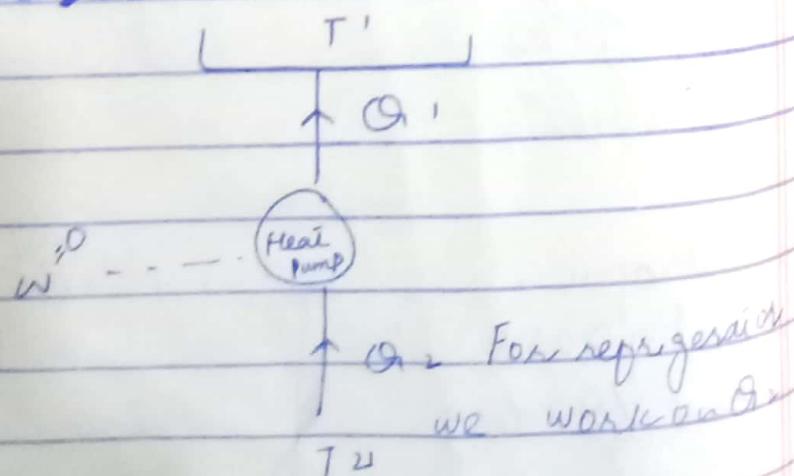
By PMM,



$$q = \frac{w}{\eta} = 1$$

$$\Omega \eta < 1$$

## Clausius



$$1 > \eta > \infty$$

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In case of heat pump we use COP<sub>R</sub>

$$= \frac{Q_2}{W}$$

$$= \frac{Q_2}{Q_1 - Q_2}$$

$$\text{COP}_{\text{of refrigeration}} = \frac{Q_2 - 0}{Q_1 - Q_{20}}$$

In COP of heat pump

$$\text{COP}_{\text{HP}} = \frac{Q_1 - Q_{20}}{Q_2}$$

$$\text{COP} = \text{COP}_{\text{HP}} + \text{COP}_{\text{Refrigeration}}$$

$$0 < \text{COP}_R < \infty$$

$$1 < \text{COP}_{\text{HP}} < \infty$$

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1<sup>st</sup> law relate with 2<sup>nd</sup> Law

$$dQ = \Delta U + dW$$

$$dQ = CV\Delta T + dW$$

$$dQ = CV\Delta T + PdV$$

2<sup>nd</sup> law

$$dQ = TdS \text{ for reversible process}$$

$$TdS = CV\Delta T + PdV$$

$$H = U + PV$$

$$dH = dU + PDV + VdP$$

$$dH = dQ + VdP$$

$$dQ = dH - VdP$$

$$dH = CP\Delta T$$

$$dQ = CP\Delta T - VdP$$

$$TdS = CP\Delta T - VdP$$

$$TdS = CP\Delta T - VdP$$

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## TOPICS

1.1 → only definitions

1.2 → Unit and dimension

1.3 → System

1.4 → properties

1.5 Density

1.6 State and equilibrium

1.7

## Chap # 2

Energy

Mechanical energy

energy transfer by heat

energy transfer by work

electrical work

Mechanical form of Work

example 207 12.822.9

2.5

2.6

energy conversion efficiencies

2.1-2.7 Problems

2.15-2.22 Prob

2.34-2.36

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Chap # 4

4.1 moving boundary work.

4.1 example

Polytropic process

Energy balanced for closed system

Specific heat

4.3, 4.4

Chap # 05

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efficiency - always less than 1  
 when we discuss conversion of energy we tell about efficiency  
 → Heat engine

When discuss about transformation of energy we told about COP  
 COP can be greater than 1  
 refrigeration

## Work-

$$dQ = dW + \Delta U$$

$$dQ = \Delta U + PdV$$

If A boundary of system is being displaced (compressed) or expand ) is called thermodynamics work.

control system approach:-

$$W = F \cdot d$$

$$= PAd$$

$$W = PdV \text{ only for}$$

closed system

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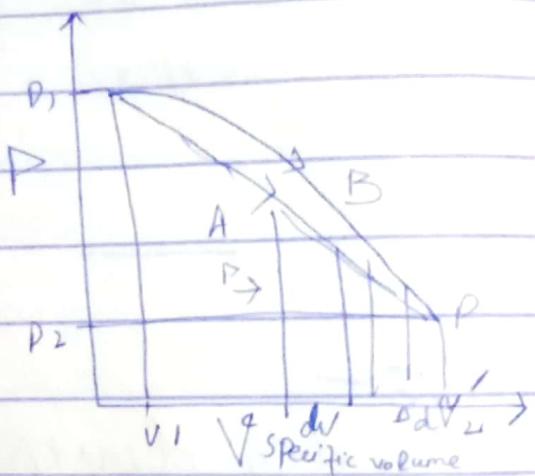
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It is also called displacement work, PdV work, boundary work  
In case of nozzle no boundary work done, and output is zero because it is free expansion.



$$\text{Path A} \quad \int_1^2 dw = \int_1^2 P dV$$

$$\text{Path B} = \int_1^2 dw = \int_1^2 P' dV$$

PdV also used to calculate reversible work, static work

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## Polytropic process

$$P V^n = C$$

$$0 \leq n \leq \infty$$

## Isochoric process

$$n = \infty$$

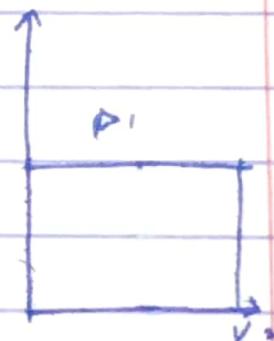
$$P V^\infty = C$$

$$P^\infty V^{\infty \times \frac{1}{\infty}} = C$$

$$V = C$$

$$dW = \int_1^2 P dV$$

$$dW = 0$$



## Isobaric process.

$$P V^n = C$$

$$n = 0$$

$$P = C$$

For close system we calculate area under the curve.

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Isothermal process:-

$$PV^n = C \quad n=1$$

$$PV = C$$

$$PV = mRT$$

$$\frac{PV}{m} = RT$$

$$PV = RT$$

$$R = \frac{\bar{R}}{M}$$

$$PV = RT - \text{constant}$$

$$P_1V_1 = P_2V_2$$

$$PV = P_1V_1 = P_2V_2$$

$$PV = P_1V_1$$

$$P = \frac{P_1V_1}{V}$$

$$dW = \int P dV$$

$$dW = \int_1^2 \frac{P_1V_1}{V} dV$$

$$= P_1V_1 \ln \frac{V_2}{V_1}$$

$$dW = P_1V_1 \ln \frac{P_1}{P_2}$$

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Reversible adiabatic process..

Isentropic process

$$PV^n = C$$

$n$  depends upon the type of Gas

$$\text{air} = n = 1.4$$

$$P_1 V_1^n = P_2 V_2^n$$

$$P_1 V_1^n = P_2 V_2^n = P V^n$$

$$P_1 V_1^n = P V^n$$

$$P = \frac{P_1 V_1}{V^n}$$

$$\int dW = \int_{V_1}^{V_2} P dV$$

$$P = \frac{P_1 V_1}{V^n}$$

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

$$P V^n = C$$

$$P_1 V_1^n = P_2 V_2^n = P V^n$$

$$P = \frac{P_1 V_1}{V^n}$$

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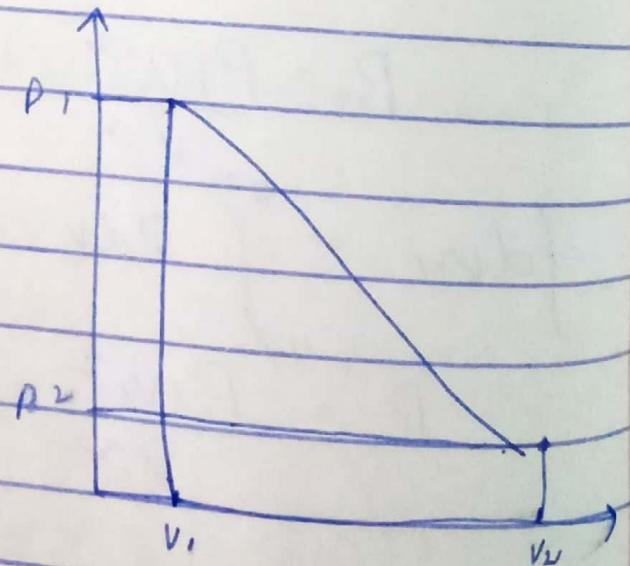
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$$dW = \int_{V_1}^{V_2} P dV$$

$$= \int_{V_1}^{V_2} \frac{P_1 V_1^n}{V^n} dV$$

$$= P_1 V_1^n \int_{V_1}^{V_2} \frac{dV}{V^n}$$

$$dW = \frac{P_1 V_1 - P_2 V_2}{n-1}$$



Laws of thermodynamics.  
 Second law tells us direction of heat flow, whether reaction is reversible or irreversible.

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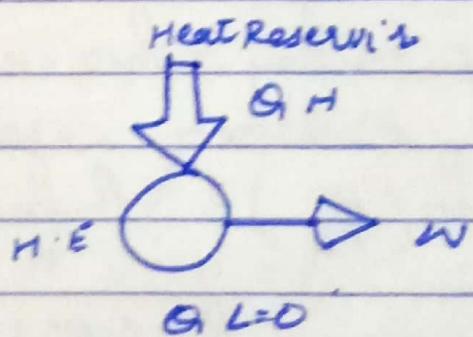
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## Analysis of 2<sup>nd</sup> law of thermodynamics.

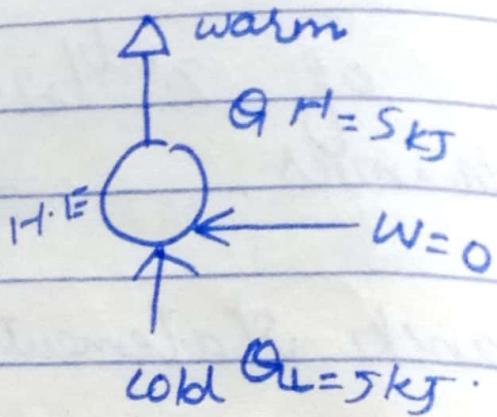
kelvin planck statement:

It is impossible for any device that operates on a cycle to receive heat from a single reservoir and produce net amount of work.



Clausius statement:

It is impossible to construct a device that operates in a cycle and produce no effect other than transfer of heat from low-temp body to high-temp body.



How to calculate polytropic index: ?

$$PV^n = C$$

$$P_1 V_1^n = P_2 V_2^n$$

$$\ln P_1 V_1^n = \ln P_2 V_2^n$$

$$\ln P_1 + n \ln V_1 = \ln P_2 + n \ln V_2$$

$$\ln \left( \frac{P_1}{P_2} \right) = n \ln \left( \frac{V_2}{V_1} \right)$$

$$n = \frac{\ln \left( \frac{P_1}{P_2} \right)}{\ln \left( \frac{V_2}{V_1} \right)}$$

$$PV^n = C$$

$$P_1 V_1^n = P_2 V_2^n = C$$

$$PV^n = P_1 V_1^n = P_2 V_2^n$$

$$\left( \frac{P_1}{P_2} \right)^{\frac{1}{n}} \times \left( \frac{V_1}{V_2} \right)^{n \times \frac{1}{n}} = C$$

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The physical pendulum  
phasor

$$\left(\frac{P_1}{P_2}\right)^{\frac{1}{n}} \times \frac{V_1}{V_2} = 1$$

For isochoric process  
 $n = \infty$

$$\left(\frac{P_1}{P_2}\right)^{\frac{1}{\infty}} \times \frac{V_1}{V_2} = 1$$

$$1 \times V_1 = V_2$$

$$V_1 = V_2$$

For isobaric process

$$\left(\frac{P_1}{P_2}\right)^{\frac{1}{n}} \times \frac{V_1}{V_2} = C$$

$$\frac{P_1}{P_2} \left(\frac{V_1}{V_2}\right)^n = C \quad n=0$$

$$P_1 = P_2$$

Ideal Gas:-

$$PV = mRT$$

$$PV^{\gamma} = R T$$

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

$$W = R T_1 \frac{V_1}{\ln \frac{V_2}{V_1}}$$

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A state is said to be at equilibrium when body is in thermodynamics equilibrium and in this case no work possible.

$$\text{Prove } \left(\frac{\partial P}{\partial V}\right)_{\text{adiabatic}} = \left(\frac{\partial P}{\partial V}\right)_{\text{isothermal}}$$

$$PV = C$$

$$PdV + VdP = 0$$

$$PdV = -VdP$$

$$\left(\frac{\partial P}{\partial V}\right)_{\text{isothermal}} = -\frac{P}{V}$$

$$PV^\gamma = C$$

$$PdV^\gamma + V^\gamma dP = 0$$

$$PdV^{\gamma-1} + V^\gamma dP = 0$$

$$PdV (V^{\gamma-1}) = -V^\gamma dP$$

Comments:

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Kashmir Now

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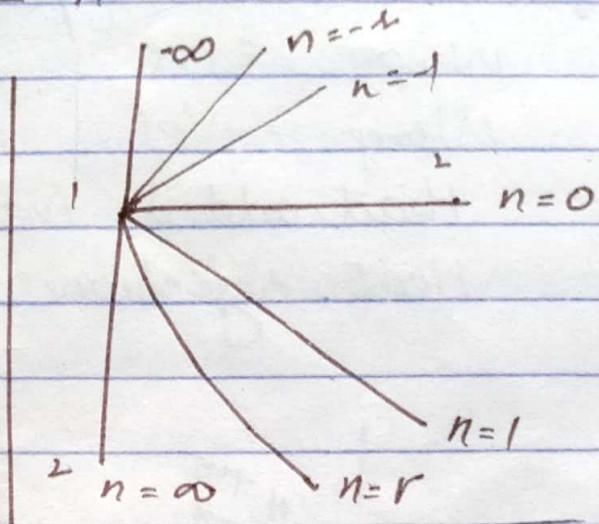
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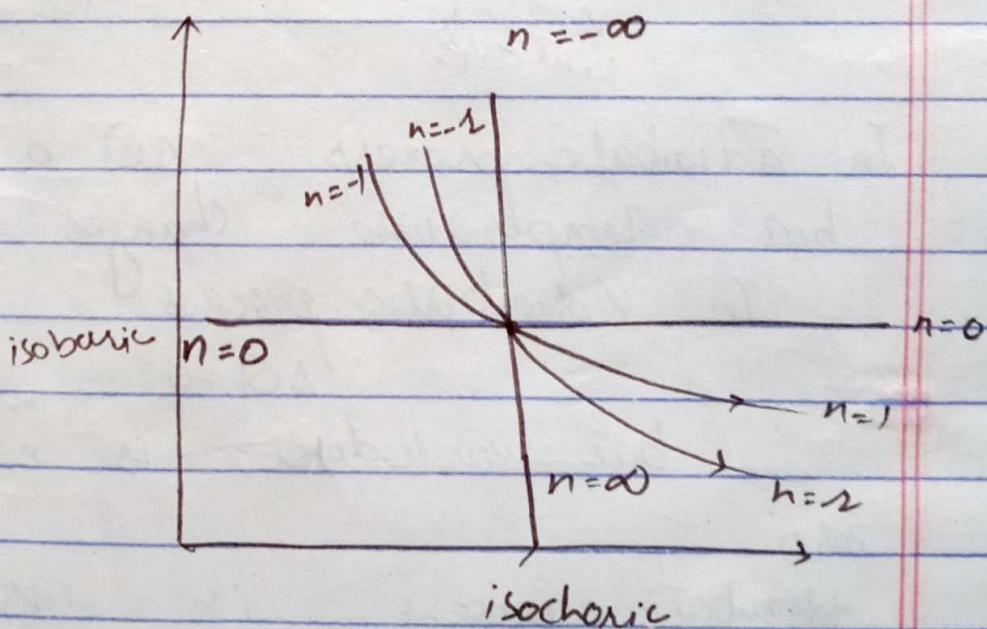
Ranges of polytropic  $n$ :-

$$0 \leq n \leq \infty$$

$$-\infty \leq n \leq \infty$$

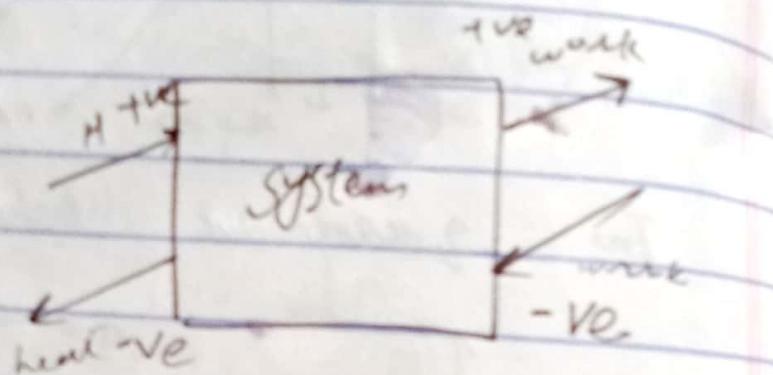


In quadrant behaviour



## Page (60-61) Work done / Heat Transfer

Work = +ve	
W <sub>comp</sub> = -ve	63 Page
Heat added = +ve	
Heat rejection = -ve	



In adiabatic process  $\Delta Q = 0$

but temperature changes.

In Adiabatic process

$$\Delta Q = 0$$

but workdone is not zero.

Adiabatic process is insulated

When body is in thermal equilibrium process also adiabatic.

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## Origin of heat

1- kinetic theory of gases

It tells us about heat.

2- Calorie theory  $\rightarrow$  page 62

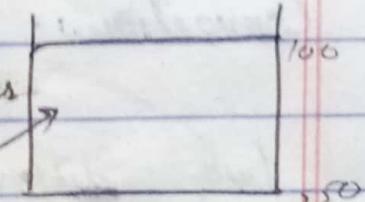
mass

It tells us about Saturated vapour, and unsaturated vapour.

calorie is a massless

quantity which can <sup>water</sup>  
added into system

but condition of system  
donot changes.



## Modes of heat transfer - 62 pg

① Conduction  $Q = -kAdT/dx$

② Convection  $Q = -hAST$

③ Radiation  $Q = \epsilon T$

Conduction follow the Fourier's law

Comments

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### Conduction:-

Conduction is physical phenomenon which require direct contact. It takes place in same medium.

e.g. Solid - solid

Gas - Gas

liquid - liquid

### Convection:-

It happens in two different medium. It is a interfacial phenomenon.

Solid - liquid

Gas - Solid

Solid - Gas

### Radiation:-

It requires no medium.

Major radiation

UV - Visible - IR

In these regions, heat transfer by radiation.

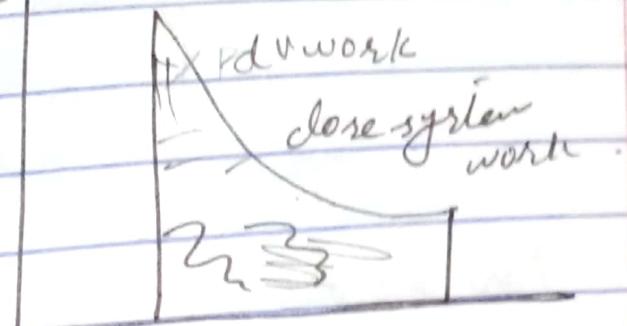
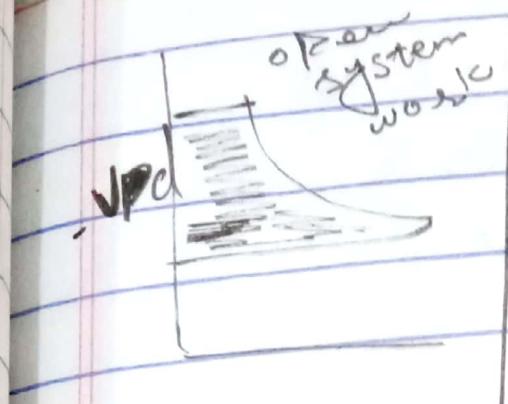
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difference b/w entropy and  
several heat

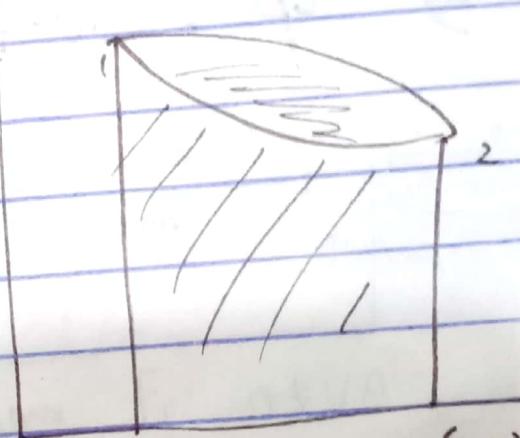
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$$dQ_A = T dS$$

work<sub>B</sub> > A



$$\begin{aligned} S &\rightarrow 10 \text{ J/K} \\ &= \frac{\text{kJ}}{10^3 \text{ K}} \end{aligned}$$

63 page

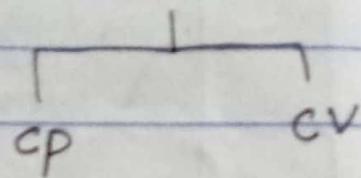
Work and heat are inexact  
differentials denoted by  $(\delta)$ ,  $(\delta)$

$dW$  is particular elemental work.

Integration gives work of  
total system.

Comments

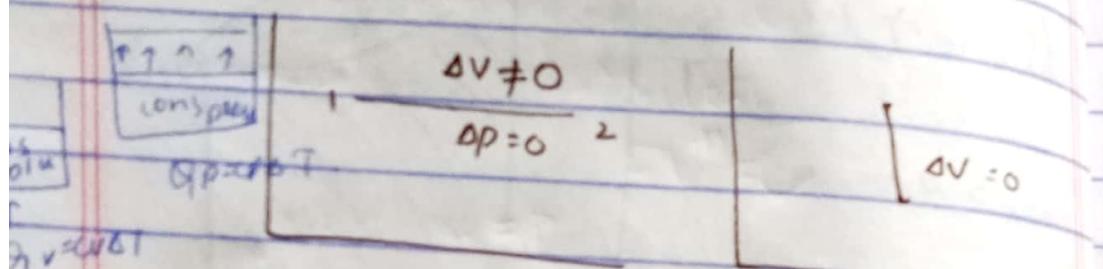
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For gases  $C_p > C_v$

For incompressible fluid  $C_p = C_v$

Why  $C_p > C_v$ ?



$\Delta V \neq 0$  it means work is done. When heat is added at constant pressure then  $\Delta V \neq 0$  it means work is done so a part of heat is used to do work on piston and rest of heat is used to increase the temperature of 1K. But when heat is added at constant volume no work is done all heat absorbed is used to increase Temp through 1K.

$C_p - C_v = R \rightarrow$  Mayer's equation.

$$\frac{C_p}{C_v} = n$$

$$C_v(\frac{C_p}{C_v} - 1) = R$$

$$C_v(n-1) = R$$

$$\boxed{\frac{C_v = R}{(n-1)}}$$

$$\frac{C_p}{C_v} = n$$

$$C_p = n C_v$$

$$\boxed{\frac{C_p = n (R)}{(n-1)}}$$

Examples 9.1 ← 4.11  
Assignments.

Chp # 1 Short Q

1.1 c, 1.4, c, 1.5c, 1.7,

**1.18, 1.19, 1.20, 1.21**

1.22, 1.23, 1.24, 1.26, 1.27

1.34,

Chp # 2 :-

Examples 2.10, 2.16, 2.17

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ste:

2.1-2.7

2.15-2.23

2.34, 2.36, 2.89-2.99

Short Questions

Q. 6.

A mass of gas is compressed in a quasi static process from 80 kPa and 0.1 m<sup>3</sup> to 0.4 MPa and 0.03 m<sup>3</sup> assumed pressure and volume  $PV^n = C$

Work done = ?

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

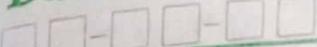
$$n = \frac{\ln \frac{P_1}{P_2}}{\ln \frac{V_2}{V_1}}$$

$$n = \ln \frac{80 \times 10^3}{0.4 \times 10^6} = \frac{0.03}{0.1}$$

$$\ln 0.2 = -1.39$$

$$= -1.20$$

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$$n = 1.3$$

$$W = \frac{(80 \times 10^3 \times 0.1 - 0.4 \times 10^6 \times 0.03)}{1.3 - 1}$$

$$\frac{1800 - 12000}{1.3 - 1}$$

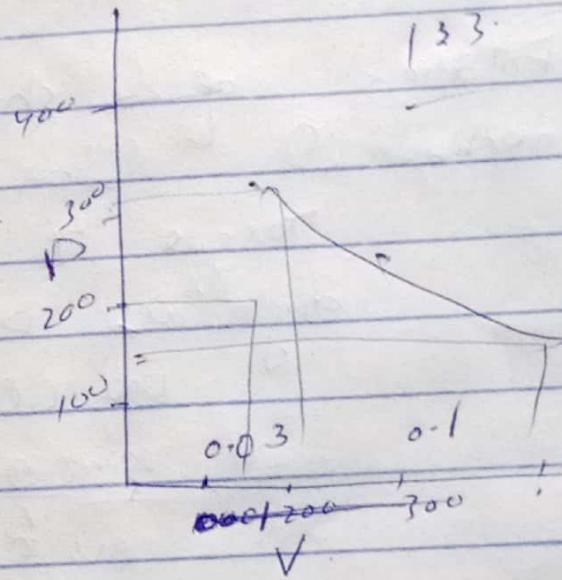
$$1.3 - 1$$

$$W = -13333.3$$

$$-13333 \times 10^3$$

$$133$$

$$400 \times 10^3$$



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## Thermodynamics

### Electric work

$$W_e = VI$$

### Shaft work / Displacement work

Rotation of shaft gives mechanical work.

Torque  $\tau$   
angular displacement  
 $\theta$

$$W = \tau\theta$$

$$W = CO$$

$$W = C \cdot \theta$$

$$W = T \cdot \theta$$

A fluid in a horizontal cylinder fitted in a frictionless leaky roof pulley, is continuously agitated by means of stirrers passing through cylinder over. The cylinder diameter

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0.4m. During the stirring process lasting 10 mins. The piston slowly moves a distance of 0.485m. against the atmospheric pressure. The net work done by the fluid during the process is 2 kJ. The speed of electric motor is 840 RPM.

Determine the torque of shaft and power of motor

$$0.485 - 0.4$$

$$\begin{array}{r} 0.485 \\ - 0.4 \\ \hline \end{array}$$

Find  $\tau$  and power

Given Data

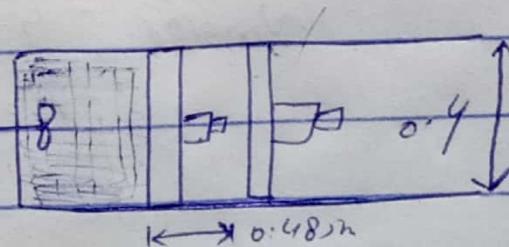
$$d = 0.4\text{m}$$

$$s = 0.485$$

$$t = 10\text{min}$$

$$W_{\text{fluid}} = 2\text{ kJ}$$

$$\text{speed} = 840 \text{ RPM}$$



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Water + fluid = Displacement  
~~= 0.085~~

$$V = AdL$$

$$V = 0.085 \times (0.085)$$

$$\therefore PdV$$

$$= 10^3 \times 0.085$$

$$= 0.007325$$

$$0.085 \times 0.085^2$$

$$V = AdL$$

$$V = \pi d^2$$

$$\frac{4}{4}$$

$$V = \frac{3.14}{\pi} (0.4)^2 \times 0.485$$

$$\frac{V}{4} = \frac{0.314}{4} \times 0.16$$

$$\frac{4}{4} = \frac{0.16}{100}$$

$$\text{Displacement} = 6.17 \text{ kJ}$$

$$W_{motor} = 6.17 - 2$$

$$W_{motor} = 4.17$$

$$P_0 = \frac{W}{t}$$

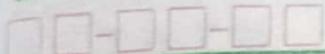
$$= \frac{4.17}{10 \times 60}$$

$$= \frac{4.17}{600}$$

$$= 0.068$$

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$$P = 6.95 \text{ N}$$

$$T' =$$

$$\omega = \frac{2\pi N}{60}$$

$$\omega = \frac{2 \times 3.14 \times 8.90}{60}$$

$$\omega =$$

$$\Delta \varphi = \omega t$$

$$\omega = \frac{\Delta \varphi}{t} = 6.95$$

$$T = 87.92$$

$$\boxed{\approx 0.08 \text{ N/m}}$$

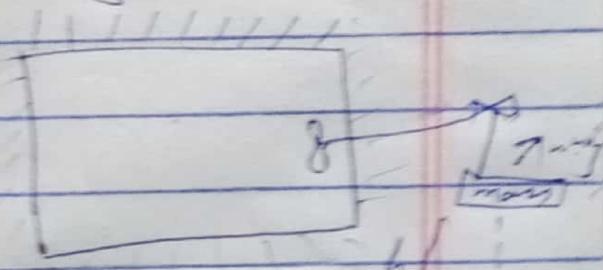
examples

2.7
2.8
2.9
2
1

Problem:

$$2.04 - 2.33$$

String work



Rigid  
adiabatic  
Container

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D

$$W = mgh$$

irreversible process

Displacement work = 0

$$W_{displ} = 0$$

$$mgh = 0$$

Stress increase - the ~~intended~~  
energy of system.

Non-mechanical form of  
work.

Electric work

Stirring work

shaft work.