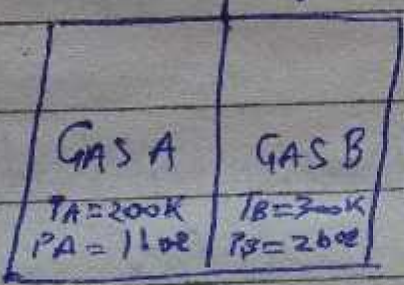
# Thermodynamic Equillibrium

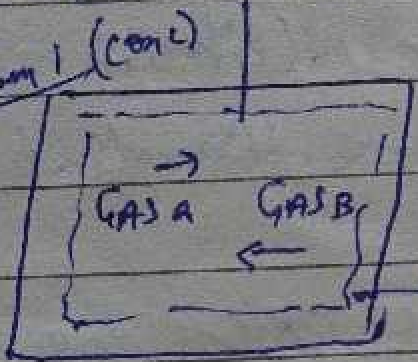
→ fixed Portition.




Now the Portition is removed & both gases are allowed to mix with each other.

Equillibrium 1 (conc)

diffusion

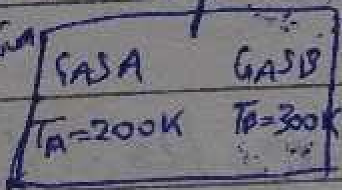



Portition removed.

→ new closed system.

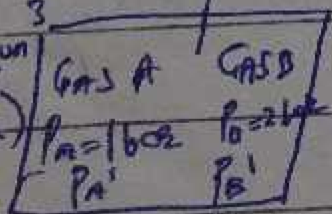
concentration gradient exist
forced to flow
homogeneous system.
system reaches dynamic equillibrium.

Equillibrium 2 (Temp)




$T_A' = T_B' = T_{mix}$ (final state)
thermal equillibrium.

3. Equillibrium (Pressure)




Mechanical equillibrium.

$P_A' \neq P_B'$ ← Partial Pressure.

$P_A' + P_B' = P_{mix}$

## Thermal Equillibrium

1) Temp is same at all points of entire system.
2) Temp does not change with time.

If both points are satisfied then we say that the system reaches thermal equillibrium

## Mechanical equillibrium → Pressure P.

1) The Pressure is same throughout the entire system.
2) The pressure inside the system does not change with time.
3) no $\Delta P$ between surrounding & system.
   unbalanced force → work will be done

## Chemical Equillibrium.

1) Chemical composition same throughout the system & do not change with time.

## Phase Equillibrium

Two Phases.

**Equillibrium :** all the properties of state
1) are same at all points of system
2) do not change with time.

no driving force in the system.
(temp diff
conc diff)

* Thermal equillibrium $dT/dt = \nabla T = 0$

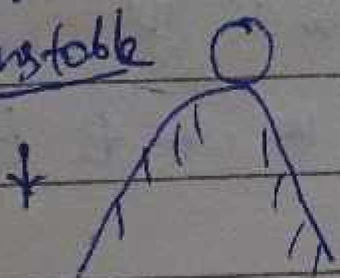
* Mechanical equillibrium

$$\frac{d\vec{v}}{dt} = \vec{a} = 0 \quad \text{(no acceleration)}$$

$$\Sigma F = 0$$

Thermodynamic state
using Thermodynamic properties.

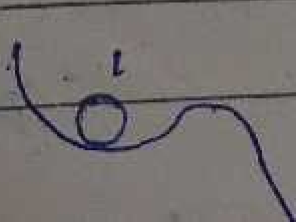
Mechanical equillibrium

unstable


neutral

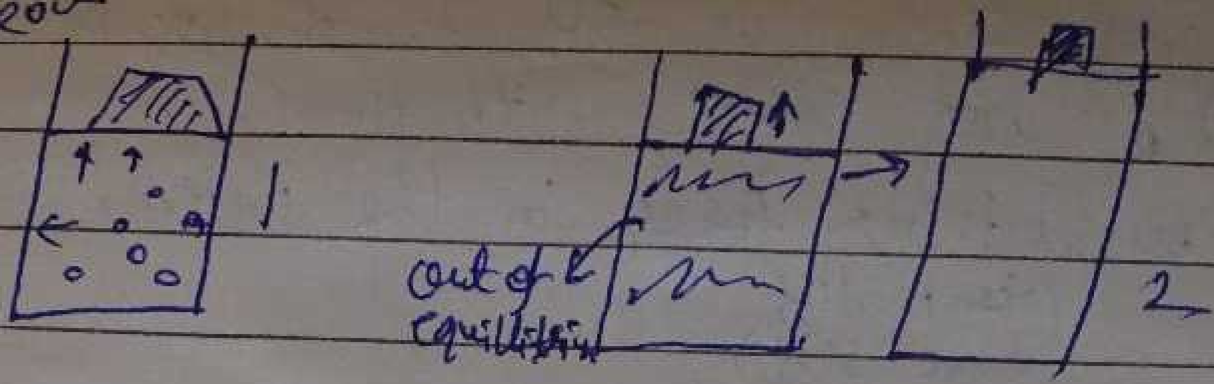
no change in P.E

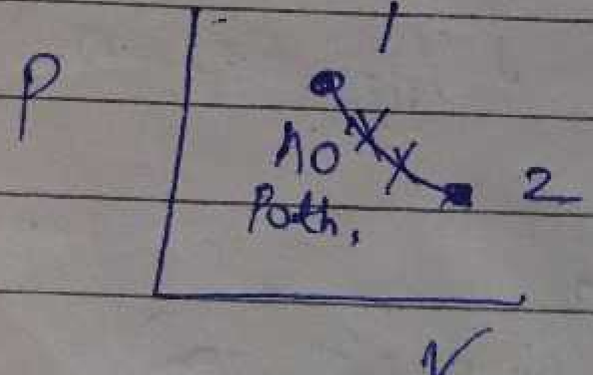
Stable


metastable


# Quasistatic Process

Place above half Rock



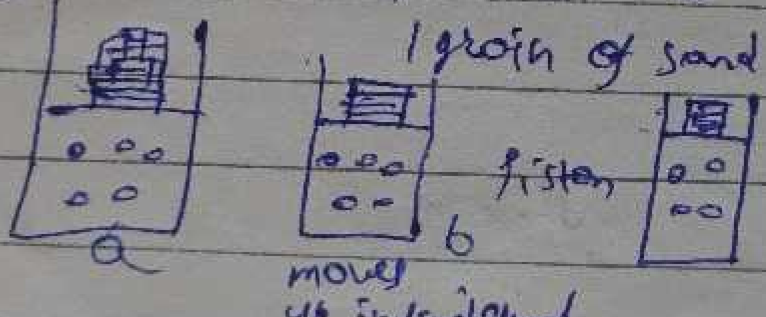



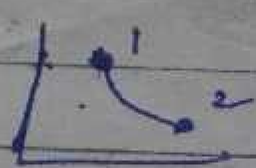

We cant define Path

different temperatures, different pressures Volumes. fluctuating.

(T, P)
Macrovariables not defined in between.

Perform same process [bunch of small pebbles]
1 grain of sand at a time.




Small increments.
system close to equillibrium in every step.
This is quasi-static Process.
almost static (equillibrium)
Theoretical allows us to describe a path.

[macrovariable defined only in equillibrium] crystry motion, wierd temp.

→ Key in thermodynamics, PV diagram,

Reversible no friction in Piston.

state a to state b.

In reality some energy or heat loss.

all ~~rev~~ reversible are quasistatic

but almost all quasistatic are reversible

some quasi-static are not reversible.

Allows to define macrovariable

for intermediate state.

Earlier we dont know what happens

in between.

# Exact Differential Equations - Intro.

Date 23.7.18.

## First order Exact Equations

A little partial differentiation in our ODE.

$$\frac{\partial}{\partial x}, \frac{\partial}{\partial y} \qquad z = f(x, y)$$

Chain rule from multi-variable calculus.

$$\partial z = \underset{M}{\frac{\partial f}{\partial x}} dx + \underset{N}{\frac{\partial f}{\partial y}} dy$$

$$\partial z = M dx + N dy$$

First order Exact equations.

$$dz = M dx + N dy$$

Exact differentials

$$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

Why? - Well behaved function, continuous.

$$\frac{\partial^2 f}{\partial y \, \partial x} = \frac{\partial^2 f}{\partial x \, \partial y}$$

$$\frac{\partial^2 f}{\partial y \partial x} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial M}{\partial y} \qquad \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial N}{\partial x}$$

First order equations.

Checking for exactness – Examples.

1) $2xy\,dx + x^2\,dy = 0$ Exact

$M = 2xy \quad \frac{\partial M}{\partial y} = 2x, \quad N = x^2 \quad \frac{\partial N}{\partial x} = 2x$

2) $\underbrace{4x\sin y}_{M}\,dx + \underbrace{2x^2\cos y}_{N}\,dy = 0$ Exact

$\frac{\partial M}{\partial y} = 4x\cos y \qquad \frac{\partial N}{\partial x} = 4x\cos y$

3) $3x^2y\,dx + x^3y\,dy = 0$ Not exact

$\frac{\partial M}{\partial y} = 3x^2 \qquad \frac{\partial N}{\partial x} = 3x^2y$

If it is exact, how we solve it

$M = \frac{\partial f}{\partial x}$ (y constant) $\qquad N = \frac{\partial f}{\partial y}$ (x constant)

$\int M\,dx$ "C" $\leftarrow C_1(y) \qquad \int N\,dy$ "C" $\leftarrow C_2(x)$

Example: $(\underbrace{2x+4y-1}_{M})\,dx + (\underbrace{4x+6y+1}_{N})\,dy = 0$

Check ~~of~~ exactness:

$\frac{\partial M}{\partial y} = 4$ Exact $\frac{\partial N}{\partial x} = 4$

$\int M\,dx = \boxed{x^2 + 4xy - x} + C_1(y)$

$$\int N\,dy = \boxed{4xy + 3y^2 + y} + C_2(x)$$

Combine

$$x^2 + 4xy + 3y^2 - x + y = C$$

Solving Exact Equations - Example 1

$$(-3x^2 - y)\,dx + (3y^2 - x)\,dy = 0$$

$M = -3x^2 - y$ $\qquad\qquad$ $N = 3y^2 - x$

Check exactness.

$$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

$$\frac{\partial M}{\partial y} = -1 \qquad \frac{\partial N}{\partial x} = -1$$

Exact

$$\int M\,dx = \boxed{-x^3 - xy} + c_1(y)$$

$$\int N\,dy = \boxed{y^3 - xy} + c_2(x)$$

$$\boxed{-x^3 + y^3 - xy = c}$$

# Solving Exact Equations - Example 2.

$$(\cos x + x\cos y - y)\,dy = (y\sin x - \sin y)\,dx$$

$$(\underbrace{\sin y - y\sin x}_{M})\,dx + (\underbrace{\cos x + x\cos y - y}_{N})\,dy = 0$$

03 06 2019

Check exactness

$$\frac{\partial M}{\partial y} = \cos y - \sin x \qquad \frac{\partial N}{\partial x} = -\sin x + \cos y$$

Exact

$$\int M\,dx = x\sin y + y\cos x + c_1(y)$$

$$\int N\,dy = y\cos x + x\sin y - \frac{y^2}{2} + c_2(x)$$

$$\boxed{x\sin y + y\cos x - \frac{y^2}{2} = C}$$

System, Surrounding, Boundary and Control Volume.

<u>System</u> - Area of interest, focus, study.
Colony road → system. (repair)
Living, non-living.
Sachin is a good friends system is Sachin
<u>Surrounding</u>: Outside the system, which affects the system.
eg Railway track — parallel highway
Engine runs on track. Car driven by A on highway
= move parallel.
Engine not affecting the ~~car~~ - hence not surrounding ~~the~~ for the car
bus driven after car. then chances of collision
Car system, bus affects. hence surrounding.

<u>Boundary</u>: Separates, differentiates, system & surroundings.
Rigid, flexible, imaginary, Real
balloon. boundary can expand. hence flexible

<u>Control Volume</u>: Mass flows. eg Air compressor, turbine (water)
Mass in & out.

Boundary shape not
changed. fixed boundary.

Type of system = Open, Closed, isolated
[Adiabatic, homogeneous, heterogeneous]

Open system + surrounding exchange mass / energy
fuel in bike. → eg Motor engine.
Mass finished hence exchange.
Work exchange / heat transfer. → open system.

Dam - turbine rotated with water.
hence mass transfer.
Energy formed as electricity by Generator.

Closed System: No mass transfer.
Eg Tea Cup.
Tea cools hence energy exchange but no mass
transfer.

Isolated system: No mass / energy.
Thermo flask.
Tea hot for 24 hrs - insulated
No mass / energy transfer [limited time]

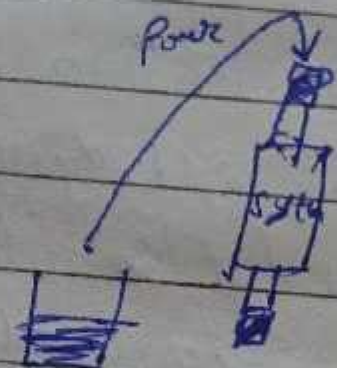
Adiabatic System - No heat exchange
~~Aag~~ अंगीठी - wooden handles
iron handles.
wood can ~~be~~ move easily. wood is adiabatic.
fire fighters wear asbestos uniform

Interested study

System - Part of Universe

system → system boundary (Real / imaginary)

surrounding




diffrent interactions.

into the system

Out of the system.

into the system

drained out hence out of system.

Lecture 2 Interactions between system/surr
↓
exchange

Mass, Energy.

Mass Interaction:

Mass into the system

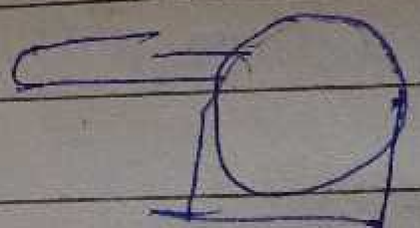
Mass out of system.


Mass into the system

open lid

Mass out of the system.

Energy into the system
Energy out of the system.



heat the Pan. [into the system]

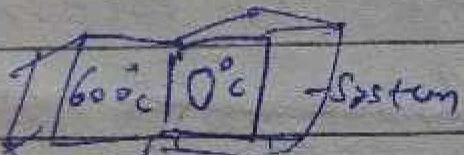
heated Pan will dissipate energy. [out of system]

One may happen [in/out].

Type of energy interactions → heat / work.

1) heat — into the system / heat added. [+ive]
out of the system.

due to temperature difference [high temp to low temp]




heat will flow from 600 to 0°C.

Our system temp will increase
thermal equillibrium.

$\boxed{300}\boxed{300}$ (same material & same mass)

System Gain heat

← $\boxed{300°C}$ system.
↓ heat out

heat Rejected from System. [Q is −ive]

$\boxed{300}\boxed{0°C}$ After some time $\boxed{150}\boxed{150}$ [same material & mass]

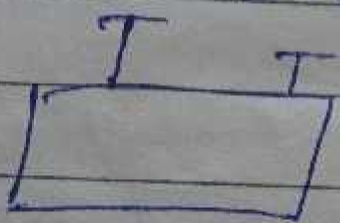
# Energy Transfer - II

## Work of Transfer

Any other transfer other than heat

Work into the system [Work given to system -ive]

Work out of system [work output from the system -ive]



vehicle cleaning

Pascal's law

Some force on left Piston [F x d]

Work into the system left

Right Piston Moves up or rises.

System does Work on right

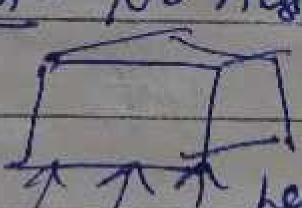
Types of System :

open system - boiler

Water boils.

boiler - open system.


Closed System : No mass transfer.

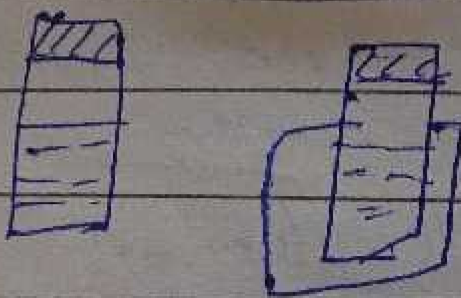



emits radiation. [heat out of system]

heat in & out. Mass is constant.

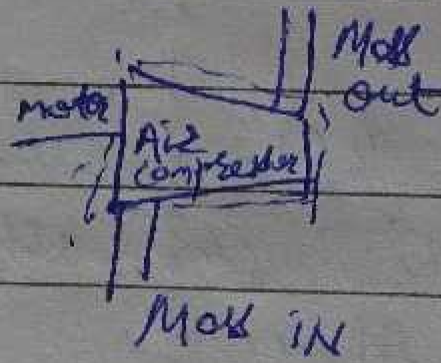
practicalls very less.

→ ~~2ther~~ thermoflask → theoretical
insulated



insulation.

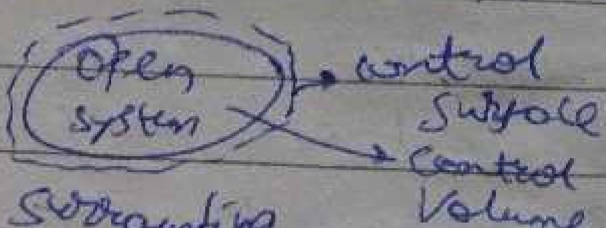
Control volume & Control surface




Large to Ligh

Open system.
Energy/Mass.

Rotary device
Motors gives work into system
May get heated hence heat may go out
Analysing open system:
dotted line → control surface
Control volume is open system. [Mass interaction has to be there / - open
Engine, Compressor, turbine, Pump.

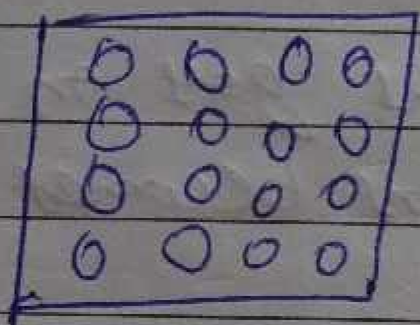



→ Explain properties, state, path, process, cycle ots]
with the help of piston cylinder and graph.

## CONTINUUM

Date 27/7/18.

It is a phenomenon by which we can understand about Macroscopic and microscopic point of view.

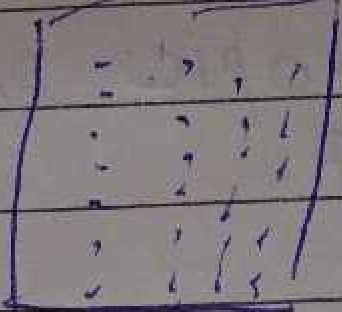


Any object is made up of number of discrete particles or atoms.

If the particle or atom is large enough as compared to the air space between adjacent particles or atom, then the property of system is the average of properties of individual particles.

In this condition, we can consider the object is continous and homogheous.

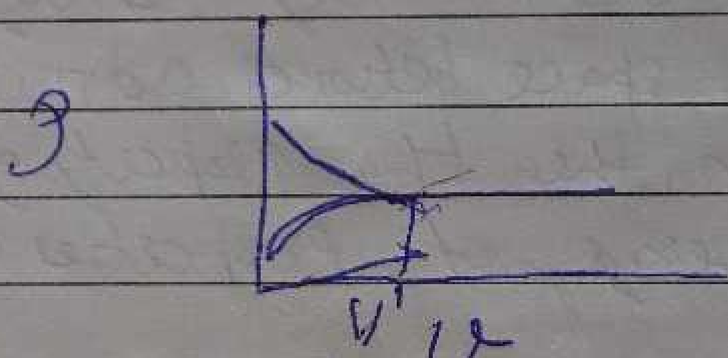
This entire phenomenon is called concept of continuum.



If the particles or atoms goes on decreasing then the particle or atoms becomes unstable.



It means the properties of particle & atoms become discontinous and the object becomes non-homogeneous.




Macroscopic point of view :

In this point of view, we dont consider events which occur at molecular level.
It means we consider the object with large enough particles or atoms.
By this we can easily study the behaviour of the object by analysing the properties at large atom level which can be continous.

## Microscopic point of view

Date ..........

In this point of view we consider the events which occur at molecular level. It means we need to consider the properties variation at molecular level. By this it becomes hard to study the behaviour of the object by analysing the properties at molecular level which are discontinous.