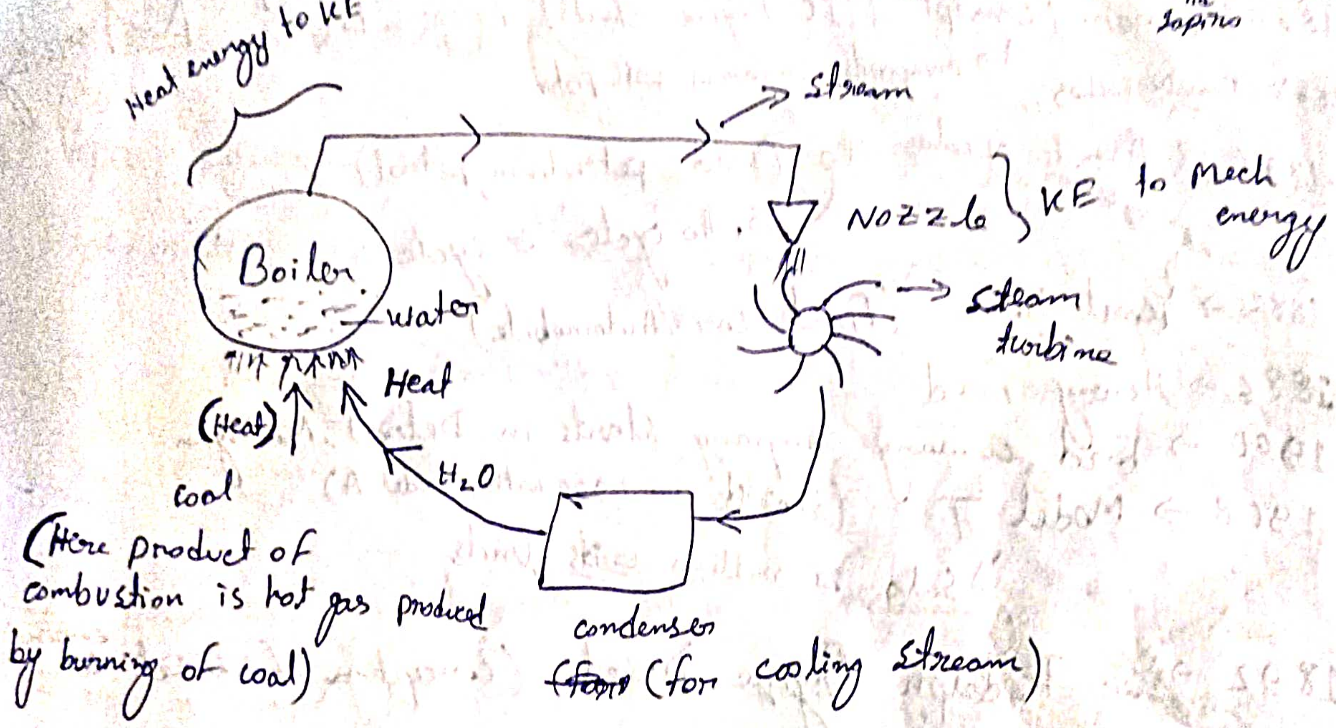
01/08/2022

Heat Engine

• Gas cycles

A mechanical device that converts heat energy into mechanical form of work

(Book → Nulkarni
P.K.Nair)
Moran and Shapiro



• Working fluid here is stream

Heat Engines → External combustion engine
Heat Engines → Internal combustion engine (IC ~~Engine~~ Engine)

If the product of combustion is used as working fluid then that is internal combustion engine

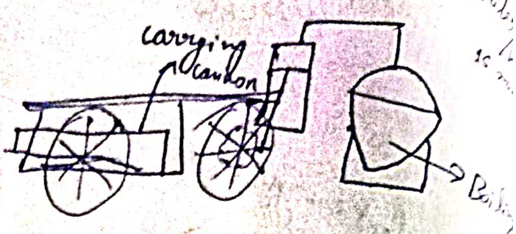
If " " " not used " " then that is external combustion engine

• Cycle is a repeated no. of operations taking place in a specific ~~org~~ order

• Ideal cycles or air standard ~~&~~ cycles (considering working fluid is air and is ~~ø~~ Ideal).

• 1769 – Cugnot (First concept of engine working on stream)

1780 → James watt



1860 → Lenoir (concept of IC Engine starts)
↳ Gunpowder in cannon with piston

1869 → Beau De Rochas

• 1876 → August Nicolas Otto (Used petrolium/petrol)
↳ Otto ~~gyte~~ ~~ø~~ cycle

1883 → Karl Benz (First car/Automobile)

1886 → Henry ford

1900 → Ford ~~comany~~ company starts in Detroit, Michigan

1908 → Model T (started in 1900 with model A)
↳ Sold 20 million ~~units~~ Units

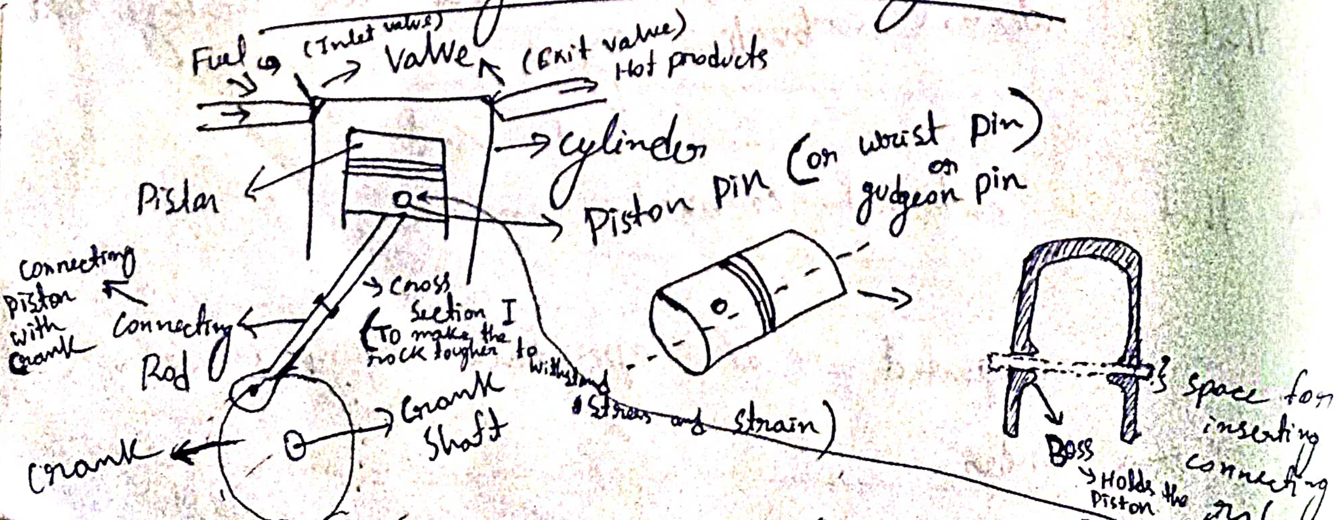
1892 → Sir Rudolph ~~Engine~~ Disel (concept of Disel engine)

• 1946 → Hind motors Started (Ambassador) → First Indian Automobile company

• 1954 → ~~Tata~~ Tata Motors

• 1981 → Maruti
year??

Terminologies related to engine



Write → Inlet valve as Inlet manifold
Exit valve as Exit manifold

02/08/2022

Engineering Thermodynamics
Sujit Karmakar Sir's portion

(I) Properties of pure substance : Steam table, Mollier Diagram, p-h chart

(II) Vapour power cycle : Rankine cycle, Reheat cycle, Regenerative cycle, Binary vapour cycle

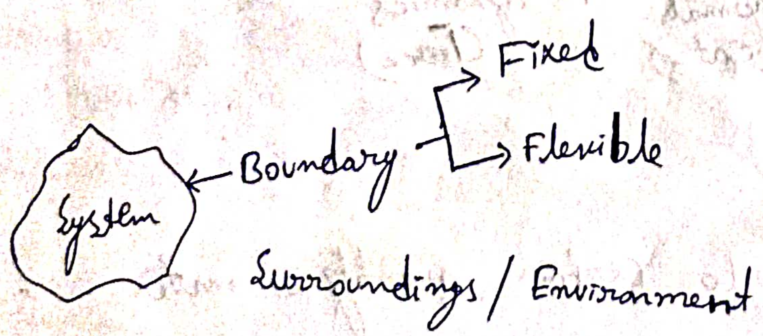
- 3Es → Energy, ~~Enthalpy~~ Entropy, Equillibrium

$\underbrace{\text{Heat transfer}}_{\text{Heat in transit due to temp. difference}}$

Whereas in Thermodynamics the system should be in equillibrium

When ~~I~~ answer required for a certain time, thermodynamics cannot be applied unless equillibrium is achieved

$Q = ms\Delta T$



- Working Substance / ~~Fluid~~ working fluid

~~There is a need~~ In thermodynamic devices a fluid has a medium of energy transport between the system and the surroundings, the fluid is known as the working substance or the working ~~f~~ fluid

Ex → In power plant → water
In IC engine and Gas turbine → Air
Refrigerator → Refrigerant (CFCs, R22, R1, ~~etc~~ etc)

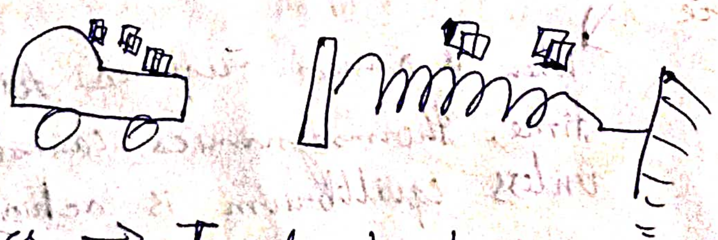
- Heat to work conversion is less (∴ heat is low graded energy)
Work to heat conversion is more (∴ work is high graded energy)

∴ 1^{st} law of thermodynamics talks about quantity whereas the 2^{nd} law talks about quality

The quality is based on the ΔT term (from $q = ms\Delta T$)

05/08/2022

1^{st} law of thermodynamics: Energy of the entire universe is constant
↓
cannot tell about time
(Only tells that heat will flow but doesn't tell in which direction heat will flow)



- Thermodynamics → Thermal (heat) + dynamics (Force)

- Macroscopic view
↓
We fix our attention to certain quantity of matter

Microscopic view
↓
" " " " single molecules

System

Controlled mass system (closed system)

I) Mass is fixed but there may be energy transfer

II) Identity of the System is fixed

Controlled volume system (open system)

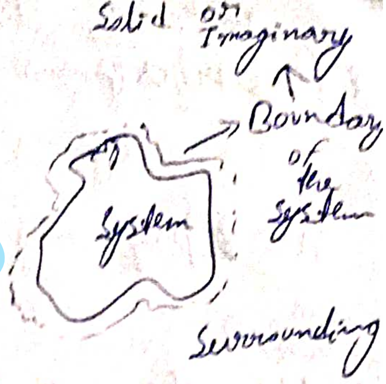
I) Volume is fixed

II) Identity may change

Isolated System

I) ~~#~~ No mass transfer

II) No energy transfer



Thermodynamic Properties

(Egg → open system → Flow of CO_2 and O_2)

Extensive Properties (Depends on mass of the System)

Ex → volume

Intensive properties (Independent of mass)

Ex → ~~T~~ Temperature, density

$m \to 0$ } Represents a point

cannot ~~measure~~ define extensive property here as extensive properties $\neq 0$

• We can easily characterize ~~to~~ the system by [illegible]
$\#$ Properties

$n \to \#$ properties $\quad m \to$ $\underbrace{\text{Independent properties}}_{\text{to have to find this}}$

Gribbs phase Rule

$$f = c - \phi + 2$$

c → no. of components

ϕ → no. of phases

Ex: (Water), (liquid)

$$\Rightarrow f = 1 - 1 + 2$$
$$= 2$$

So we can use the x-y coordinate we can locate the state of a system

For 3 properties we use x, y, z coordinate.

$f = 1$ (Like H_2O at $200\,^\circ c$.

For $c = 1$, $\phi = 2$ we don't need temperature we only need atmospheric pressure)

$$c = 1, \ \phi = 3$$

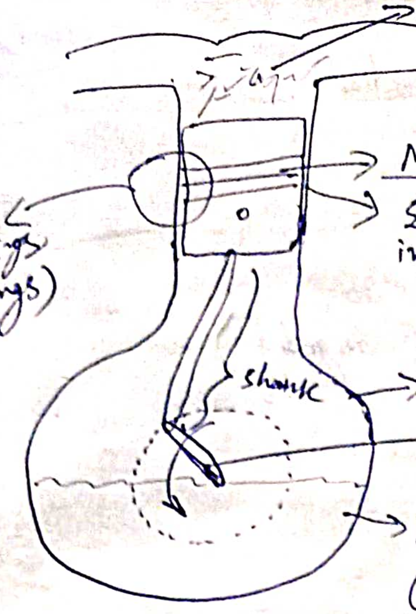
$f = 0$ Ex → Triple point of water

08/08/2022

• Aluminium alloy used for piston (pure Al has low melting point)

Gas → Splash Lubrication System
(oil splashes)

1000 to 1500 °C



3 rings (piston rings)

→ Makes the piston-cylinder interface gas tight

→ Stops the gas from coming in contact with the lubricating oil (as the lubricating oil may catch fire)

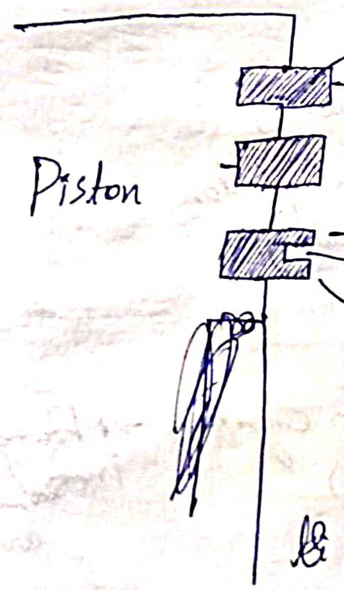
shank

→ Crank case → To protect the bearing from dust, water and rusting

→ Crank shaft

→ Lubricating oil
(Mobil is Trademark of Indian oil organization)
(boiling point / Ignition temperature → higher than that of petrol, diesel)

- Torsional and bending load on the shaft
- Blacksmithing → Forging (by hammering)
  Casting → Brittle
  } Material → Forged Steel



Piston

→ Spring steel / fine grain cast Iron

→ Gas ring (Makes the piston-cylinder interface gas tight)

→ Helps in the oiling process i.e. in lubricating the cylinder surface

→ (Oil ring)

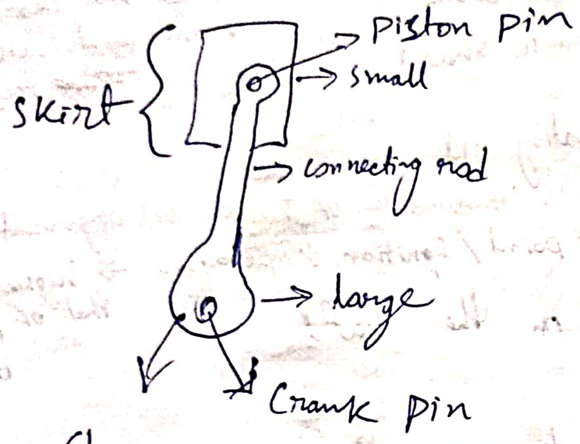
Oil gets stuck here and helps in lubrication

Piston ring

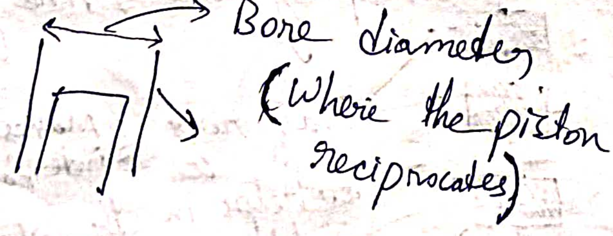
Gap in the range of 0·4 mm
(180° apart between the first two rings)

→ Gaps 180° apart

• strength to mass ratio (modulus of rigidity)



Shear stress $= \frac{F}{A}$ → more area less shear stress so less shear stress and less chances of failure



• Air cooling system → For small duty engines → Fringes for increased surface area
(Ex → bike)

liquid cooling system
→ Ex → car
→ 4 pistons
→ coolant passing between cylinder and jacket
→ liquid cooling system in case of car

• cylinder → Cast Iron → For low duty engines
cast steel → For heavy duty engine

cast Aluminium → For light weight engines

12/08/2022

Introduction to thermodynamics

For a system to be a state

- Thermodynamic properties should be invarient with time
- The ~~property~~ properties should be uniform within the system

For this

There should be no exchange of energy ~~&~~ ~~or~~ or mass between the system ~~a~~ and the surrounding → Isolated system

Also if we stop all flow of mass and energy between the system and the surroundings then the system reaches ~~a~~ the dead state so there is no interaction between the system and the surroundings

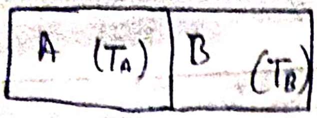
Heat flows due to temp difference

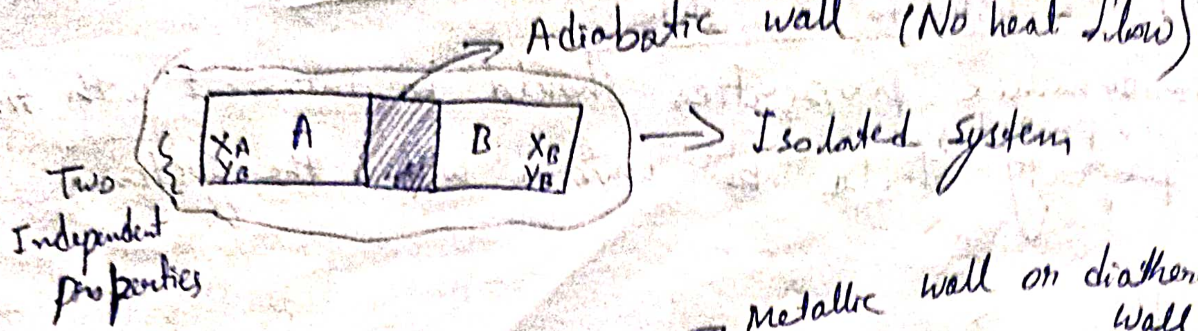
Thermodynamic State
↓
Thermodynamic Equillibrium

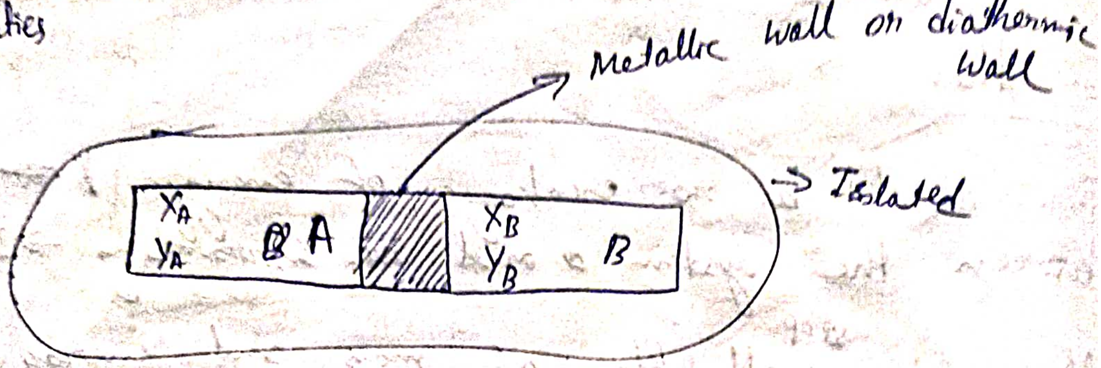
↓ Thermal Equillibrium
- → Zeroth law
- → concept of temperature
  ↓
  A thermodynamic property by virtue of difference of which heat flows ~~to~~ from one place to another

↓ Mechanical Equillibrium

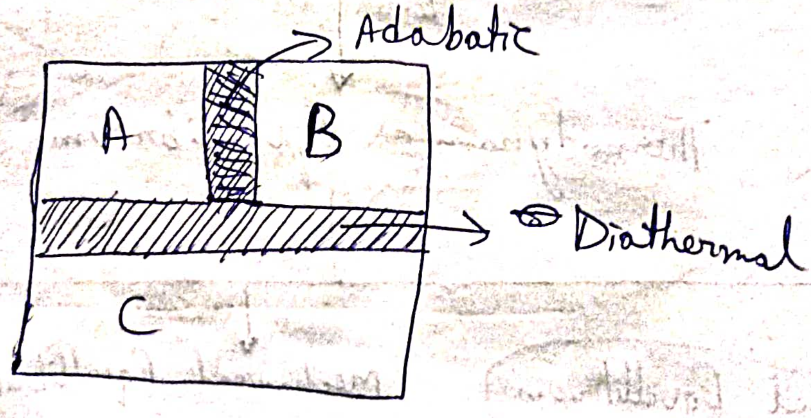
↓ Chemical equillibrium







After some time there will be a single Independent property Instead of two which will be same for both If that property is temperature then this is in thermal equillibrium



Temperature gradient is zero

- When two bodies or systems are in thermal equillibrium with a third one then they are in thermal eq with each other. → Zeroth law of thermodynamics
- The equillibrium state achieved by two (or more) system characterised by restricted b values of the th...

properties of the system after they have ~~boo~~ ~~to~~ been in ~~commo~~ communication with each other through a diathermic wall.

<u>Thermal Equillibrium +</u>

Zeroth law = Concept of ~~tem~~ temperature

Temperature → A thermodynamic property that ~~to~~ determines whether two system are in thermal equillibrium with each other.

• Mechanical Equillibrium → No Mechanical equillibrium work done between system and surrounding

→ No pressure difference ⇒ Pressure gradient is zero

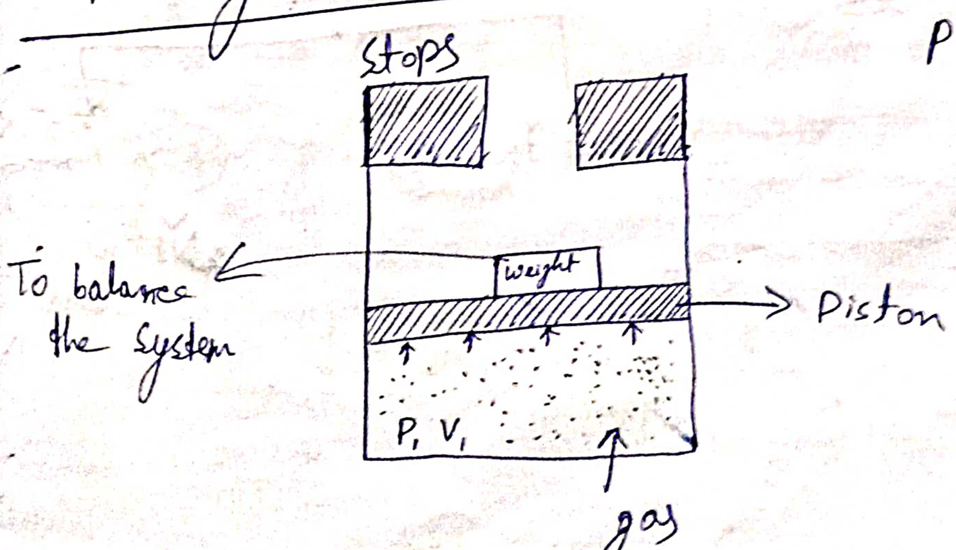
• chemical equillibrium → Concentration gradient is zero

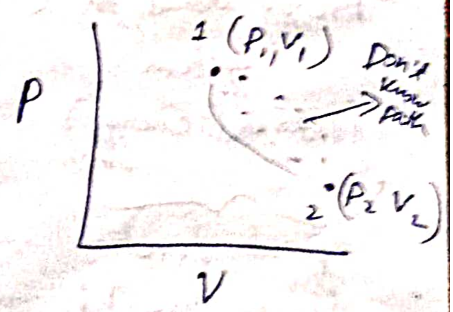
→ No mass transfer

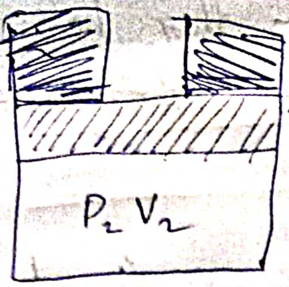
When all 3 equillibrium are achieved then the system is in thermodynamic equillibrium

~~Not the~~
Irreversible process
(A thermodynamic process)

<u>Thermodynamic Process</u>

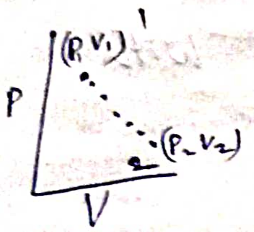


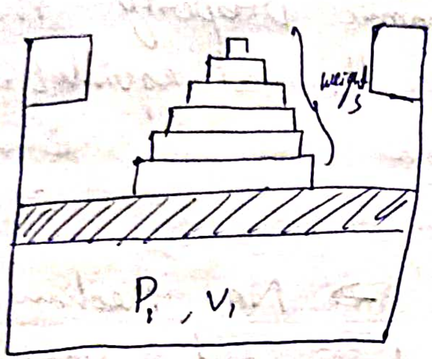




→ After removing weight

In order to find out the path between P_1V_1 and P_2V_2 we make the change Infinitesimally & slowly.





***
Quasi Equillibrium process
Quasi Static Process
Reversible process

$P_1' = P_1 - dp$

& $V_1' = V_1 + dV$

We take off 1 weight, allow the system to be in equillibrium and ~~not~~ mark the point on the graph to get the path taken

Thermodynamic concept of energy

Energy

- Energy stored in a System (Internal energy)
  - Point function, State Variable
- Energy in transfer
  - Heat transfer
  - Work transfer
    - Next class