Date..................

Fundamentals of Mechanical Engineering (BME 101/BME 201)

Unit-1 Introduction to Mechanics.

Force moment and couple, principle of transmissibility, Varignon's theorem. Resultant of force system - concurrent and non-concurrent coplanner forces, Types of supports (Hinge, Roller) and loads (Point, UDL, VVL), free body diagram, equilibrium equations and Support Reactions.

Normal and shear stress, strain, Hockes' law, Poisson's ratio, elastic constants and their relationship, stress-strain diagram for ductile and brittle materials, factor of safety.

Unit-2 Introduction to IC Engines and Electric Vehicles

1- IC Engine
2- Electric vehicles and hybrid vehicles.

Unit-3 Introduction to Refrigeration

1- Refrigeration
2- Air Conditioning

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Unit-4

Introduction to fluid Mechanics and Application

~~1- Introduction to Measurment~~
~~2- Introduction to Mechatronic System~~

Introduction: Fluid properties, pressure, density, dynamic and kinematic viscosity, specific gravity, Newtonian and Non-Newtonian fluid, Pascal's Law and Continuity Equation.

Working Principles of hydraulic turbines (Pelton wheel and Francis) & pumps (Centrifugal and Reciprocating) and their classification and hydraulic lift.

Unit-5 :-

Introduction to Measurment and Mechatronics

1. Introduction to Measurment
2. Introduction to Mechatronic System.
3. Overview of Mechanical Actuation System.
4. Hydraulic and Pneumatic Actuatic System.

Introduction to Mechanics of Solid.

Bodies
- (Rigid)
- (deformable)

Solid Mechanics :- Branch of applied mechanics that deal with behaviour of solid bodies subjected to various types of loadings.

Mechanics of Rigid/Solid bodies :- Concerned with the static and dynamic behaviour under external forces of engineering components • infinitely strong. , deal with motion of solid.

Mechanics of deformable solids :- More concerned with internal forces and associated with change in geometry.

Properties of material :-

1) **Strength :-** It determine whether the component fail by breaking in service.

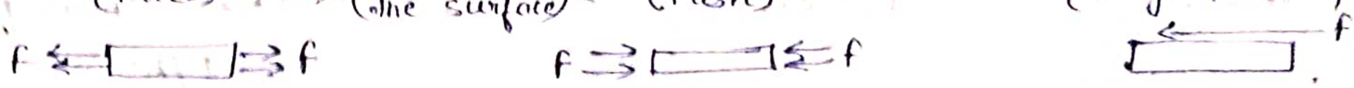
2) **Stiffness :-** It determine whether the amount of deformation they suffer is acceptable in service.

Simple Stress.

Stress. ~~Strength~~ :- The max. resistance offered by any material to the externally applied force/load.

load :- The external force which act on a rigid body.,

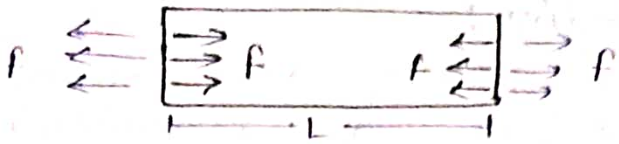
Load
- Tensile load (Pull) → (Normal to the surface) ← Compressive (Push)
- Shear (tangential or parallel)



Stress.

The resistance forces per unit area is called as stress.
When Fex is applied on the body, the body offers resistance force by developing internal opposite forces.

$$\sigma = \frac{\text{Internal Resistance force}}{\text{Normal area}}$$



$$\sigma = \frac{F_{int}}{A} \qquad \text{Unit} = N/m^2 = \text{Pascal (Pa)}$$

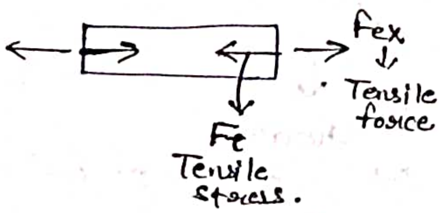
σ = direct stress.
A = normal area
F = internal resistance force = to the externally applied force

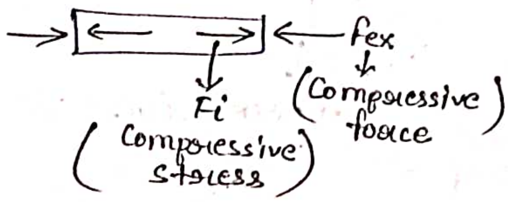
Types of Stress.

Normal

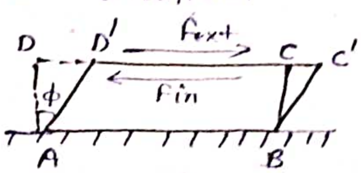
Tensile
- elongate the body
- force resist the elongation is called Tensile stress.

Compressive
- compress the body
- force resist the compression is called compressive stress





Shear. (τ) (Tau)
- Force // to object.
- equal and opp.
- slide its one part over another.



(Fin = shear stress)
(Fext = shear force)

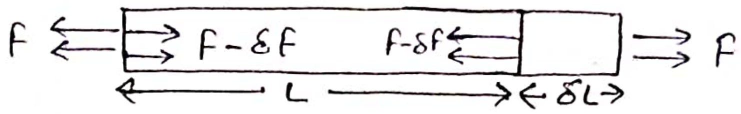
$\tau = F/A$
(Unit = N/m^2)
= Pascal

Strain.

The deformation produced per unit length of the body is called strain.

Reason for strain:-

$F_{in} < F_{ex}$ (deformation stress)



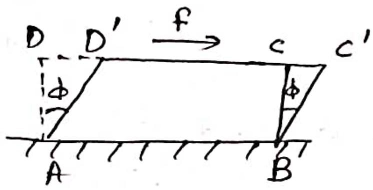
$$\varepsilon = \frac{\text{increase in dimension}}{\text{original dimension}} = \frac{\delta L}{L}$$

Strain.

- **Normal** (Force ⊥ to surface)
  - **Tensile**: Elongation ∥ to F_{ext} or F_{app}

    $$\varepsilon_t = \frac{\delta L_{in}}{L}$$
  - **Compressive**: compression ∥ to F_{ext} or F_{app}

    $$\varepsilon_c = \frac{\delta L_{de}}{L}$$
- **Shear** (Force ∥ to surface)

  $$\varepsilon_s = \frac{CC'}{BC} = \tan\phi = \phi \text{ radian.}$$
- **Volumetric**: The ratio b/w the change in volume and original volum is known as volumetric strain

  $$\varepsilon_v = \frac{\text{change in volu}}{\text{original volu}}$$

  $$\varepsilon_v = \frac{\Delta V}{V}$$

Various Elastic Constant.

Hook's law:- Acc. to this law, within elastic limit, strain is proportional to stress.

$$\frac{\text{Stress}}{\text{Strain}} = \text{Constant.}$$

1) Modulus of Elasticity (E)

$$E = \frac{\text{Normal Stress } (\sigma)}{\text{Normal strain } (\varepsilon_o)}$$

$$E = \frac{F/A}{\Delta L/L} = \frac{F}{A} \times \frac{L}{\Delta L}.$$

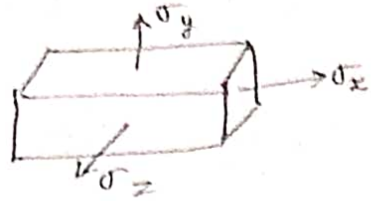
2) **Modulus of Rigidity :-** (within elastic limit)

$G = \frac{\text{Shear stress}}{\text{Shear strain}}$

3) **Bulk Modulus :-**

$$K = \frac{\text{Average stress intensity } (\sigma_{avg})}{\text{volumetric strain } (\varepsilon_v)}$$

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y + \sigma_z}{3}$$



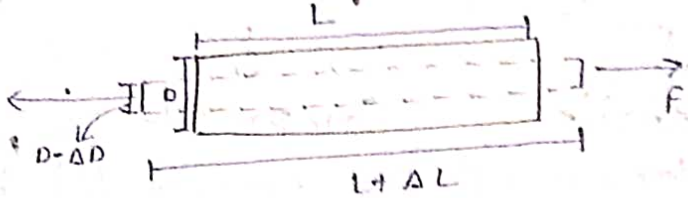
Unit :- N/m^2 or Pascal.

4) **Poisson's Ratio :-**

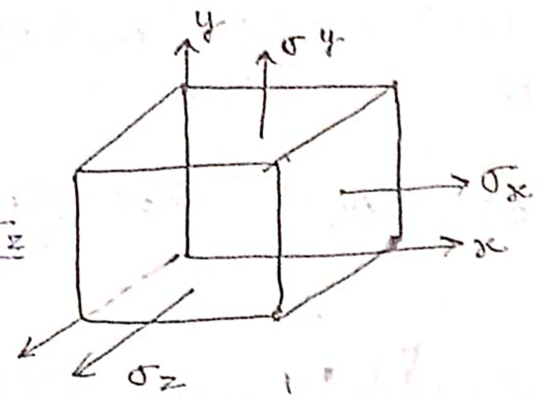
When an object is deformed in longitudinal direction then simultaneously the lateral dimensions also change.

$$\mu = \frac{\text{lateral strain } (\varepsilon_{lat})}{\text{longitudinal straing } (\varepsilon_{long})}$$

$$\boxed{\varepsilon_{lat.} = \frac{\Delta D}{D} \qquad \varepsilon_{long.} = \frac{\Delta L}{L}}$$



Relation b/w E, K, and μ :-



for x - axis :-

$$\text{longitudinal strain} = \frac{\sigma_x}{E} - \frac{\mu\sigma_y}{E} - \frac{\mu\sigma_z}{E}$$

$$= \frac{1}{E}(\sigma_x - \mu\sigma_y - \mu z_z)$$

if $\sigma_x = \sigma_y = \sigma_z$ then,

$$\text{long. strain} = \frac{1}{E}(\sigma - 2\mu\sigma)$$

$$\varepsilon_x = \frac{\sigma}{E}(1-2\mu)$$

Hence, volumetric strain $= \varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$

$$\boxed{\varepsilon_v = \frac{3\sigma}{E}(1-2\mu)} \quad \text{——} \ (1)$$

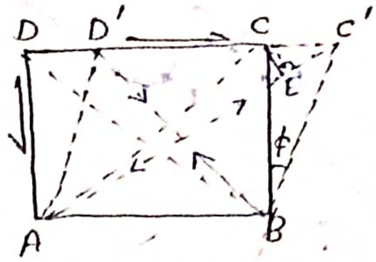
$$K = \frac{\sigma}{\varepsilon_v}$$

putting value of ε_v from eq (i) —

$$K = \frac{\sigma \times E}{3\sigma} \frac{1}{(1-2\mu)}$$

$$\boxed{E = 3K(1-2\mu)}$$

Relation b/w E, G, μ :-



longitudinal strain in diagonal AC =

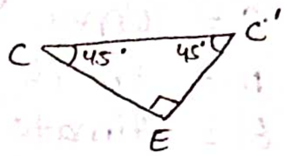
$$\frac{AC' - AC}{AC}$$

As, $AC = AE$

$$\frac{AC' - AE}{AC} = \frac{EC'}{AC}$$

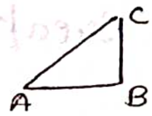
If $CC' \approx$ very small, $\angle ACB = \angle AC'B \approx 45°$

In $\Delta ECC'$,



$$EC' = CC' \cos 45°$$

$$EC' = \frac{CC'}{\sqrt{2}}$$



In ΔACB, $AC = \sqrt{2}\, BC$

so $$\varepsilon_{AC} = \frac{EC'}{AC} = \frac{CC'}{\sqrt{2}(\sqrt{2}BC)} = \frac{CC'}{2BC}$$

$$\tan\phi = \frac{CC'}{BC} \approx \phi$$

$$\varepsilon_{AC} = \frac{\phi}{2}$$

$$G = \frac{\tau}{\phi}.$$

long. strain in AC = $\frac{\tau}{2G}$ — (i)

longitudinal strain in diagonal AC = $\frac{\tau}{E} + \mu\frac{\tau}{E}$

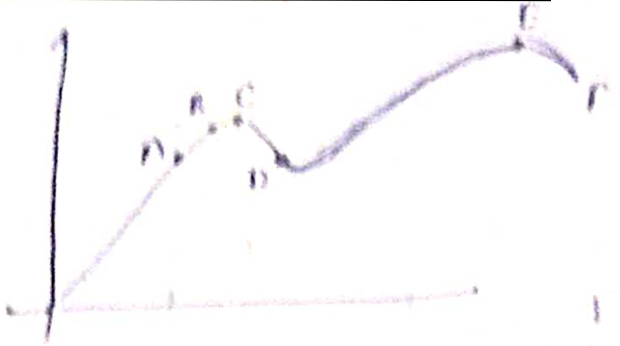
$$\varepsilon_{AC} = \frac{\tau}{E}(1+\mu) \quad \text{— (ii)}$$

From eq (i) and eq (ii) —

$$\frac{T}{2G} = \frac{T}{E}(1+\mu)$$

$$\boxed{E = 2G(1+\mu)}$$

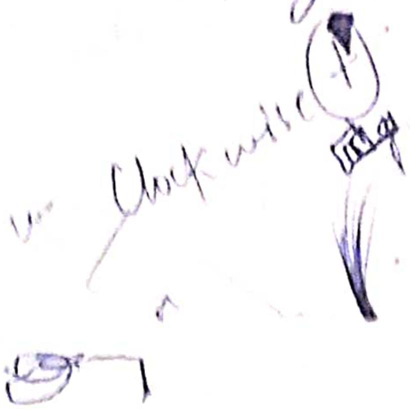
Stress - Strain Curve :-



A = Proportional limit
B = Elastic limit
C = Upper yield point
D = Lower " "
E = Ultimate stress point
F = Breaking point

$\mu = \frac{\epsilon_{lat}}{\epsilon_{long}}$ | $G = \frac{\tau}{\phi}$

$E = \frac{\sigma}{\epsilon}$ | $K = \frac{\sigma}{\epsilon_v}$



Beam

A beam is a structural member used to support loads applied at various points along its length.

Types of support :-

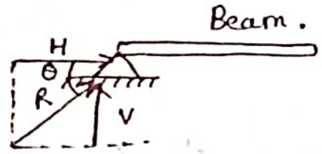
1) Simple Support.
If both ends of the beam rest on a simple support the support is known as simple support.

2) Roller Support.
Here one end of the beam is supported on a roller (Eg. skaters)

3) Hinged Support.
The beam does not move either along or normal to the ~~length~~ hinge but it can rotate. (Eg. door)

4) Fixed Support.
The beam is not free to rotate or slide along the length of beam or in the direction normal to the beam. Therefore the reaction components can be observed. Also known as build-in support.

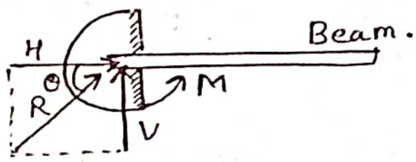
5) Cantilever beam.
A cantilever beam is a rigid structural element that is supported at one end and free at the other.



Reaction = R
Its components in vertical and horizonal dirx^n are V and H, respectively.

$$\theta = \tan^{-1}\left(\frac{V}{H}\right)$$

c) Hinged Support



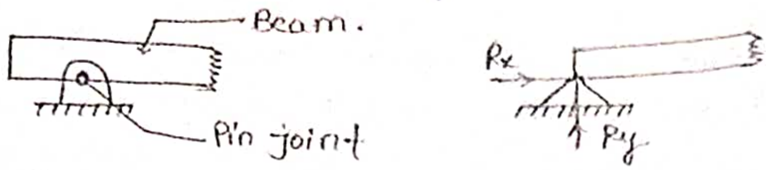
H = Horizontal Reaction component.
V = Vertical " "
R = Resultant reaction.
M = moment reaction.
$\theta = \tan^{-1}(V/H)$

d) Fixed support or built-in support.

Types of Beams :-

1) Simply supported Beam :-

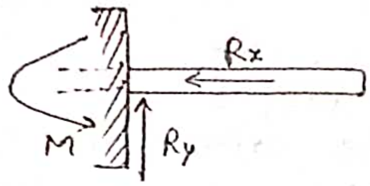
If supports creats only the translational constraints of beam. then, it is called simply supported Beam.



1) Actual 2) Diagramatic.

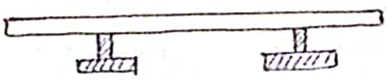
2) Cantilever Beam :-

A cantilever Beam is a rigid structural element that is supported at one end and force at other end.



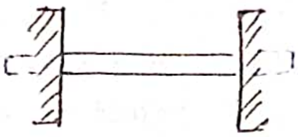
3) Overhanging Beam :-

If the end portion of a beam extends beyond the support, then the beam is known as overhanging beam.



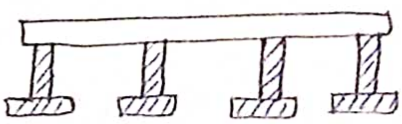
4) Fixed Beam :-

When both ends of the beam are fixed then the beam is known as Fixed Beam.



5) Continous Beam :-

If beam is supported by more than 2 supports at equal distances then, it is called Continuous Beam.



Beams.

(Statically Determinate)	(Statically Indeterminate)
If all the external forces and moments acting on a beam can be determined from the equilibrium cond^n alone.	If in these types of beams one has to consider deformation i.e, deflections to solve the problems

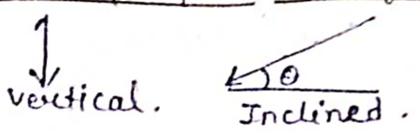
$\Sigma F_x = 0$

$\Sigma F_y = 0$

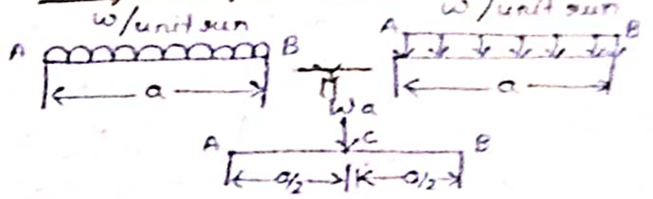
$\Sigma M = 0$

Types of loads :-

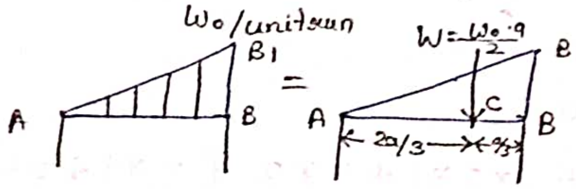
a) Concentrated or point load.



b) Uniformly distributed load.



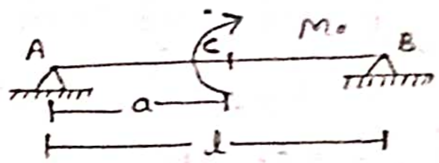
c) Uniformly varying load.



Total load $\bar{x}_A = \frac{2a}{3}$ $\quad W = \triangle ABB_1 = \frac{W_o \times a}{2}$

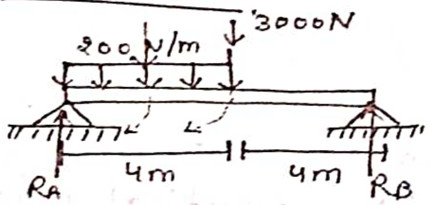
$\bar{x}_B = \frac{a}{3}$

d) Pure moment.



Numericals.

1)



Find R_A and R_B = ? $W_o = 200 \times 4$
$= 800$

Equilibrium eq-

$\Sigma M_A = 0$

Taking clockwise dir^n → +ve

$-(200\times4)\frac{a}{2} - 3000 \times 4 + R_B \times 8 = 0$

$-1600 - 12000 + R_B \times 8 = 0$

$\boxed{R_B = 1700\,N}$

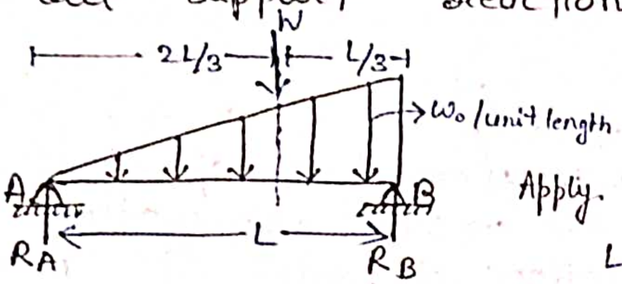
$R_A + R_B = 200\times4 + 3000$

$R_A = 800 + 3000 - R_B$

$= 3800 - 1700$

$\boxed{R_A = 2100\,N}$

Find out support reactions at supports.



$$W = \frac{w_o L}{2}$$

Apply. $\Sigma M = 0$ at B,

$$L(R_A) - \frac{w_o L}{2}\left(\frac{L}{3}\right) = 0$$

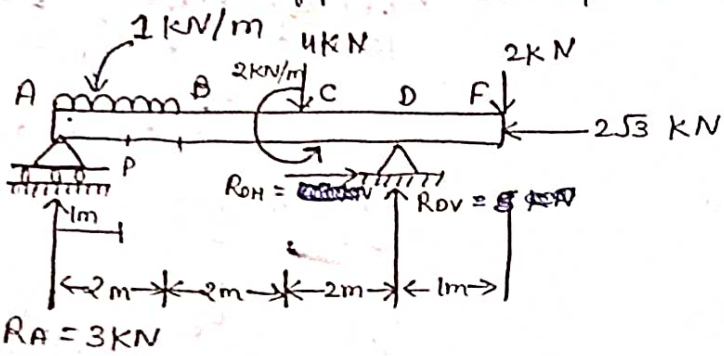
$$\boxed{R_A = \frac{w_o L}{6}}$$

Apply $\Sigma M = 0$ at A,

$$L(R_B) - \frac{w_o L}{\cancel{2}}\left(\frac{\cancel{2}L}{3}\right) = 0$$

$$\boxed{R_B = \frac{w_o L}{3}}$$

Ques. Find out support reactions at supports.



R_A = ?
R_{DV} = ?
R_{DH} = ?

$\Sigma M_D = 0$

$-R_A \times 6 + 1\times 2\times 1 + 4\times 2 \mp 2\times 1 + 2 = 0$

$$\boxed{R_A = 3KN}$$

$\Sigma f_x = 0,$

$R_{DH} = 2\sqrt{3}$ kN

$\Sigma f_y = 0,$

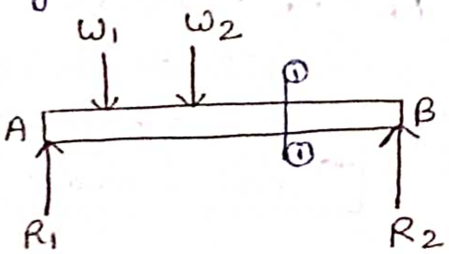
$R_A - 1\times 2 - 4 + R_{DV} - 2 = 0$

$R_{DV} = 8 - 3 = 5$ kN

$$\boxed{R_{DV} = 5KN}$$

Shear force.

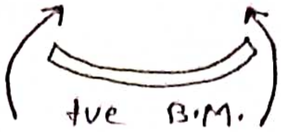
The shear force at any point along a loaded beam is the algebraic sum of all the vertical forces acting on one side of that point.

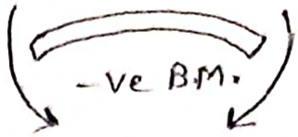


$$SF_{1-1} = R_1 - w_1 - w_2$$

Bending Moment.

The Bending moment at any point on a loaded beam is the algebraic sum of the moments of all the vertical forces acting on one side of that point about that point.





left side ↻+ -↺
right side ↻- +↺

Unit-3.

Introduction to Fuild Mechanics And Application.

Fluid Mechanics :- fluid mechanics is that branch of science which deals with the behaviour of the fluids at rest as well as in motion.

Fluid :- fluid may be defined as a substance which is capable of flowing. It has no definite shape of its own, but conforms to the shape of the containing vessel.

OR

A fluid is a substance which deforms continuously under the action of tangential or shear force.

Liquid :- It is fluid which posses a volume (definite), which may vary slightly with T and P.

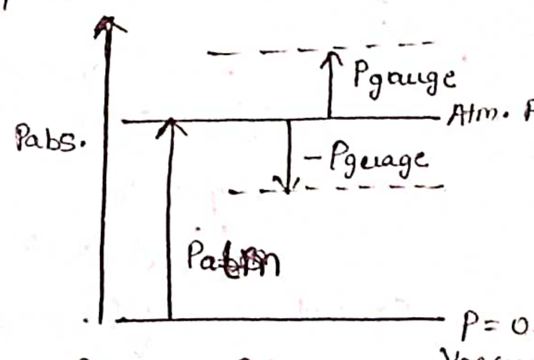
Gas :- A gas is a fluid, which is compressible and posseses no definite volume but it always expands until its volume is equal to that of the container.

Some fluid Properties :-

1) Pressure :- Normal force per unit area.

$$P = \frac{F}{A}.$$

* It is scalar quantity.
* Unit :- N/m^2 or Pascal (Pa)
  atm (1 atm = 101.325 KPa)
  Bar (1 bar = $10^5\ N/m^2$)



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

2) <u>Density (ρ) or Mass density</u> :-

"mass per unit volume of the substance".

Unit :- kg/m^3

g/cm^3 or g/cc $(1 g/cc = 10^3 kg/m^3)$

$\rho_{water} = 1000 \ kg/m^3$

$\rho_{air} = 1.2 \ kg/m^3$

$\rho_{steel} = 7850 \ kg/m^3$

3) <u>Specific Weight (w) or weight density</u> :-

"weight per unit volume"

$$w = \frac{weight}{volume} = \frac{mg}{V} = \rho g.$$

Units = N/m^3

4) <u>Specific Gravity :- (s)</u>

"density of fluid w.r.t the density of standard fluid."

for liquid, standard fluid is water [4°C, 1atm, $1000 \ kg/m^3$]

for gas, standard fluid is Air / H_2

5) <u>Specific Volume :-</u>

"Volume per unit mass"

$$\left\{ v = \frac{V}{m} \right]$$

Units :- m^3/kg.

$$\boxed{\rho = \frac{1}{v}}$$

<u>Numerical</u> :-

Calculate the sp. wt, density, sp. gr. of 1l of a liquid which weighs 7N.

$mg = 7$

$V = 1l = 10^{-3} m^3$

$$\text{Sq. wt} = \frac{mg}{V} = \frac{7}{10^{-3}} = \boxed{7 \times 10^3 \ N/m^3}$$

$$\rho = \frac{(\text{Sp. wt.})}{g}$$

$$\rho = \frac{7 \times 10^3}{10} = 7 \times 10^2 \ kg/m^3$$

$$\boxed{\rho = 7 \times 10^2 \ kg/m^3}$$

$$\text{sp. gr.} = \frac{\rho_{liquid}}{\rho_{water}}$$

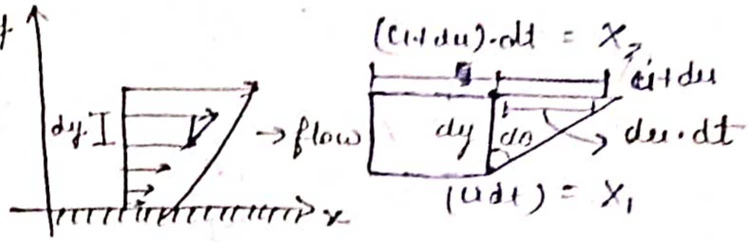
$$= \frac{7 \times 10^2}{1000}$$

$$\boxed{\text{sp. gr} = 0.7}$$

Viscosity. (μ)

Two adjacent layer of the fluid resist the motion of each other such a fundamental property of the fluid is known as viscosity or dynamic viscosity.

* The frictional force b/w the adjacent layers is known as "viscous shear force"



$$\tan(d\theta) = \frac{du \cdot dt}{dy}.$$

If $d\theta$ is very small –

$$d\theta = \frac{du \cdot dt}{dy}$$

$$\boxed{\frac{d\theta}{dt} = \frac{du}{dy}}$$

$\frac{d\theta}{dt}$ = Rate of angular (shear) deformation.

$\frac{du}{dy}$ = Velocity gradient.

Basic cause of viscosity $\longrightarrow$ cohesive force.

liquid – cohesive force $\uparrow$

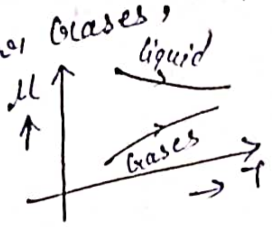
Gas – cohesive force $\downarrow$

Fluid 1	Fluid 2
* Viscosity is high	* Viscosity is low
* (τ) shear stress $\uparrow$	* Shear stress (τ) $\downarrow$
* Angular deformation $\left(\frac{d\theta}{dt}\right)\downarrow$	* $\left(\frac{d\theta}{dt}\right)\uparrow$
* Difficult to flow	* Easy to flow.

2). Dependency of viscosity on Temperature.

for liquid, Temp. ↑ → viscosity ↓ (Cohesive force ↓)

for Gases, Temp. ↑ → viscosity ↑ (Randomness ↑)



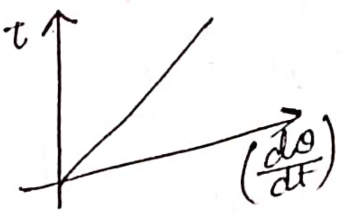
3). Newton's law of Viscosity:

Shear Stress ∝ rate of shear deformation.

$$\tau \propto \frac{d\theta}{dt} \qquad \because \frac{d\theta}{dt} = \frac{du}{dy}$$

$$\tau \propto \frac{du}{dy}$$

$$\tau = \mu \frac{du}{dy}$$



4).

μ is proportionality constant

μ = viscosity (dynamic viscosity)

μ is property of fluid.

5) Unit of μ = $Kg\text{-}m^{-1}\text{-}s^{-1}$ (MKS)

$= 0.1\ Ns/m^2$ (CGS)

$$\boxed{1\ \text{Poise} = 0.1\ \frac{N\text{-}s}{m^2}}$$

Num Kinematic Viscosity:-

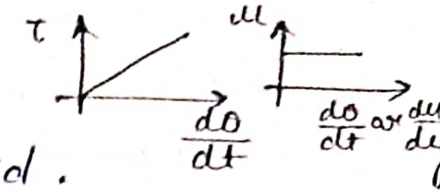
Ratio of dynamic viscosity and density.

$$\nu = \frac{\mu}{\rho}$$

Unit = m^2/s or cm^2/s

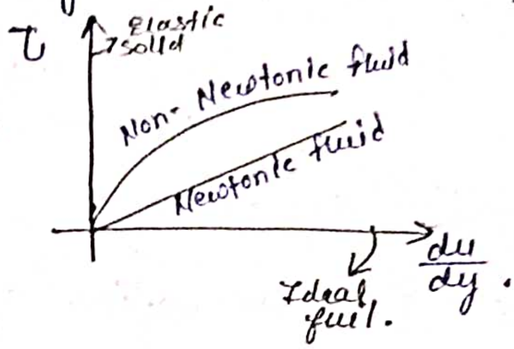
$$\boxed{1\ \text{stoke} = 10^{-4}\ m^2/s}$$

Newtonian Fluid :- obeys Newton's law of viscosity.
linear relation b/w – τ and $\frac{d\theta}{dt}$
Ex:- Air, water, kerosene, petrol etc.



μ is the slope of $(\tau - \frac{d\theta}{dt})$ - diagram
μ does not changes in Newtonian Fluid.

Non- Newtonian Fluid :- Doesn't obey Newton's law of viscosity.

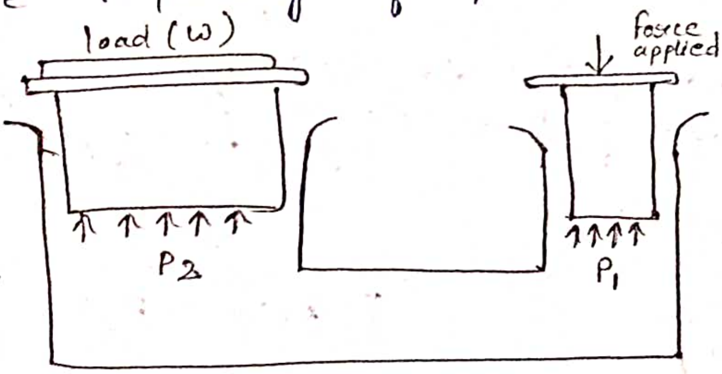


Ideal fluid :-
* Incompressible
* $\mu = 0$
* $\tau = 0$.

Real fluid :-
* $\mu \neq 0$
* have viscous flow.

Pascal's law

If a fluid is in rest, the intensity of pressure is same in all direction.



When a certain pressure is applied in a fluid at rest, the pressure is equally transmitted in all the dirxn.

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

Application of Pascal's law
* Hydraulic lift
* " Jackes
* " brakes
* " pumps.

Numerical

Car's weight = 16,000 N
Plunger area = $50 cm^2$
Ram area = $4000 cm^2$
Input Force = ?

$F_1 = ?$, $F_2 = 16000 N$

$A_1 = 4000 cm^2$, $A_2 = 50 cm^2$

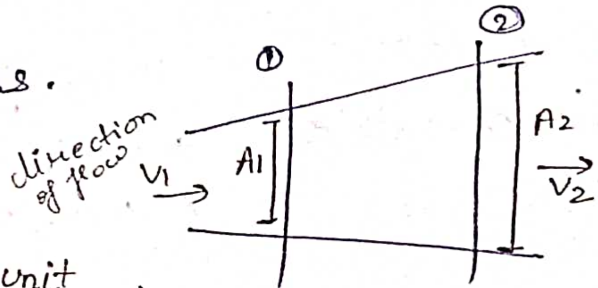
$$\frac{F_1}{F_2} = \frac{A_2}{A_1}$$

$$F_1 = \frac{50}{\cancel{4000}} \times \overset{4}{\cancel{16000}}$$

$$\boxed{F_1 = 200 N}$$

Continuity Equation..

Principle :- Conservation of Mass.



$$A_1 V_1 = A_2 V_2$$

Mass flow rate = constant =

$$= \frac{\rho A L}{t} = \rho A v \cdot \quad \text{unit } (kg/sec)$$

volume flow rate = constant =

$$= \frac{A L}{t} = A v \quad \text{unit } (m^3/sec)$$

According to COM,
Rate of mass flow at ① = Rate mass flow at ②

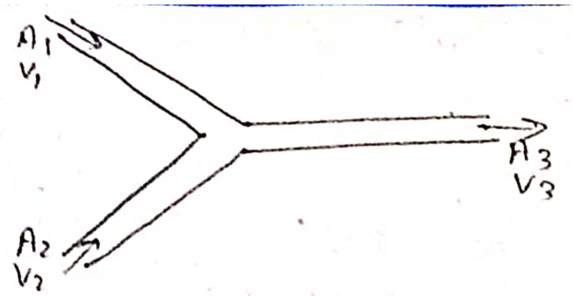
$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

$\rho_1 = \rho_2 = \rho$ (As same liquid) [Incompressible fluid]

$$\boxed{A_1 V_2 = A_2 V_2}$$

for ~~trapor~~ incompressible fluid, $Q = A_1 V_1 = A_2 V_2$
for compressible , $\rho_1 A_1 V_1 = \rho_2 A_2 V_2$

Problem :-



Given :- $A_1 = 1\,m^2$
$A_2 = 2\,m^2$
$A_3 = 2.5\,m^2$

$V_1 = 1\,m/s$
$V_2 = 2\,m/s$
$V_3 = ?$

$$A_1 V_1 + A_2 V_2 = A_3 V_3$$
$$(1)(1) + (2)(2) = (2.5)\,V_3$$
$$\frac{5}{2.5} = V_3$$
$$\boxed{V_3 = 2\,m/s}$$

Bernoulli's Equation

Principle :- Newton's second law of motion.

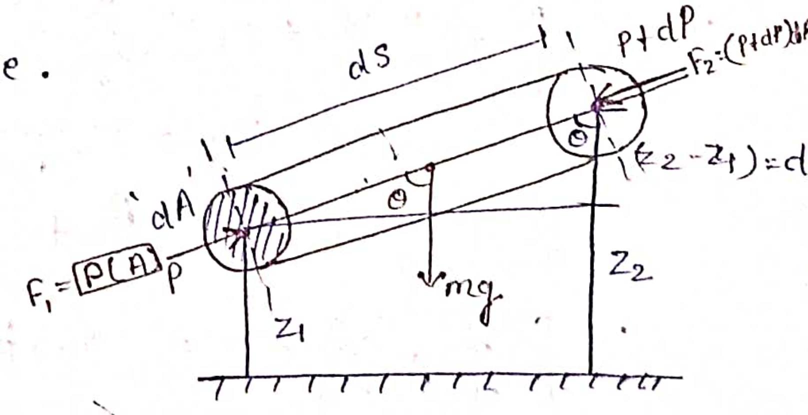
Fluid dynamics :- Study of motion of fluid flow along with force causing the flow.

$$F = m\,a$$

F = Net external force
m = Mass of fluid element
a = total acc.

Assumption's of Bernoulli's Equation.

1) Steady flow (Properties of flow constant & $\frac{dv}{dt}$ = constant)
2) Incompressible flow (ρ = constant)
3) $\mu = 0$ (Ideal fluid)
4) Irrotational flow
5) Flow along the stream line.



From Euler's eq^n,

(Gravitational force) + Pressure force = ma.

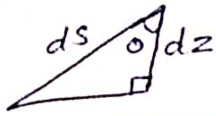
$$F_p + F_g = ma$$

$$P\,dA - (P+dP)\,dA - mg\cos\theta = ma$$

$$-dP\,dA - mg\cos\theta = ma$$

$$a = u\frac{du}{ds} + \cancel{\frac{du}{dt}}^{\,0}$$

$$a = u\frac{du}{ds}$$



$$\boxed{dz = ds\cos\theta}$$

$$\rho = \frac{m}{V} \Rightarrow m = \rho V$$
$$= \rho\, dA \cdot ds$$

$$-dP\cancel{dA} - \rho \cancel{dA} ds\, g\cos\theta = \rho \cancel{dA}\cancel{ds} \cdot u\frac{du}{\cancel{ds}}$$

$$-dP - \rho ds\, g\cos\theta = \rho u\, du.$$

$$-dP - \rho g\, dz = \rho u du.$$

$$-\frac{dP}{\rho} - g\,dz = v\,dv$$

$$\boxed{\frac{dP}{\rho} + g\,dz + v\,dv = 0}.$$

By integrating above eq^n :-

$$\int \frac{dP}{\rho} + \int g\,dz + \int v\,dv = 0$$

$$\frac{1}{\rho}\int_{P_1}^{P_2} dP + g\int_{z_1}^{z_2} dz + \int_{v_1}^{v_2} v\,dv = 0$$

$$\frac{P_2 - P_1}{\rho} + g\,\frac{z_2 - z_1}{1} + \frac{v_2^2 - v_1^2}{2} = 0$$

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + g z_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + g z_2$$

$$\frac{P_1}{\rho g} + \frac{1}{2}\frac{V_1^2}{g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

Specific weight $= \rho g = \omega$

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + z_2$$

$$\boxed{\frac{P}{\omega} + \frac{V^2}{2g} + z = \text{constant.}}$$

Example: $\rho = 10^3\ kg/m^3$

$d_1 = 80\ mm = 80 \times 10^{-3}\ m$, $P_1 = 400\ kPa$, $V_1 = ?$

$d_2 = 40\ mm = 40 \times 10^{-3}\ m$, $P_2 = 130\ kPa$,

Venturimeter horizontal so, $z_1 = z_2$

$$\frac{P_1}{\rho g} + \frac{1}{2}\frac{V_1^2}{g} = \frac{P_2}{\rho g} + \frac{1}{2}\frac{V_2^2}{g}$$

$$\frac{40\cancel{0} \times 10^3}{10^3 \times 1\cancel{0}} + \frac{1}{2} \times \frac{V_1^2}{10} = \frac{13\cancel{0} \times 10^3}{10^3 \times 1\cancel{0}} + \frac{1}{2} \times \frac{V_2^2}{10}$$

$$40 + \frac{V_1^2}{20} = 13 + \frac{V_2^2}{20}$$

$$\frac{V_2^2 - V_1^2}{20} = (40 - 13)$$

$$V_2^2 - V_1^2 = 27 \times 20$$

$$\boxed{V_2^2 - V_1^2 = 540} \quad \text{—(1)}$$

By continuity eq^n :

$$A_1 V_1 = A_2 V_2$$

$$A_1 = \pi \frac{d_1^2}{4} = \pi \times \frac{(80 \times 10^{-3})^2}{4} = \frac{\pi \times \overset{1400}{\cancel{6400}} \times 10^{-6}}{\cancel{4}} = \pi \times 1400 \times 10^{-6}$$

$$A_2 = \pi \frac{d_2^2}{4} = \pi \times \frac{(40 \times 10^{-3})^2}{4} = \pi \times 400 \times 10^{-6}$$

$$\cancel{\pi} 1400 \times \cancel{10^{-6}} \times V_1 = \cancel{\pi} \times 400 \times \cancel{10^{-6}} \times V_2$$

$$\left[\frac{V_1}{V_2} = \frac{4}{14}\right]$$

$$\left[V_1 = \frac{2}{7} V_2\right] \text{—(ii)}$$

$$V_2^2 - \frac{4}{49} V_2^2 = 540 \qquad \text{from (i) and (ii)}$$

$$(49 - 4) V_2^2 = 540 \times 49$$

$$V_2^2 = \frac{\overset{12}{\cancel{540}} \times 49}{\cancel{45}}$$

$$V_2 = \sqrt{588}$$

$$[V_2 = 24.24\ m/s]$$

$$V_1 = \frac{2}{7} \times 14\sqrt{3}$$

$$V_1 = 4\sqrt{3}$$

$$[V_1 = 6.928\ m/s]$$

F_g
F_p } Euler's Eq
F_v
$F_{Turbulance}$
$F_{compressing}$
Other minor force.

Newton's Eq^n of motion

Reynold's Eq^n

Navier stoke's Eq^n.

Hydraulic Machines.

Hydraulic Machines are defined as those machines which convert either hydraulic energy into M.E. or M.E into H.E.

H.E :- energy possesed by water.
M.E. :- power produced by the shaft.

Machines → H.E into M.E → (Turbines.)
Machines → M.E into H.E → (Pumps.)

Hydraulic Machines.

- Turbines (H.E → M.E.)
- Pumps (M.E → H.E.)

Turbines :

1) Machines which converts H.E into M.E
2) M.E. is used in running an electric generator which coupled by the shaft of turbine. (M.E → E.E)
3) The electric power which is obtained from hydraulic energy is known as Hydro-electric power.

Classification of Turbine.

1) On the basis of energy available at inlet.

a) Impulse turbine.
Only kinetic energy is available at inlet of turbine.
Eg. Pelton turbine.

b) Reaction turbine.
If both K.E and Pressure energy is present at inlent of turbine, then it is called Reaction Turbine.
Eg. Francis Turbine, Kaplan Turbine.

2) On the basis of direction of flow of water through runner :-

a) Tangential flow Turbine. (eg. Pelton Turbine)
b) Radial flow Turbine (eg. Francis ")
c) Axial flow Turbine (eg. Kaplan & propeller)
d Mixed (Radial + Axial) flow Turbine (eg. Modern Francis)

3) On the basis of head available at inlet of turbine.

1) High Head Turbine ($150m < H < 2000m$) eg. Pelton
2) Medium Head Turbine ($30 \leq H < 150$ m) eg. Francis
3) Low Head Turbine ($H < 30$ m) eg. Kaplan and Popeller

4) On the basis of specific speed of turbine.
specific speed = speed to generate unit power,

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

a) low (s.s.t) = ($N_s < 50$) rpm Eg :- P.T.
b) Medium (s.s.t) = ($50 < N_s < 250$) rpm Eg :- F.T.
c) High (s.s.t) = ($N_s > 250$) rpm Eg :- K.T.

5) According to the position of shaft of turbine.

a) Horizontal Shaft Turbine. (Pelton Turbine)

b) Vertical Shaft Turbine. (All)

6) According to Name of Originator.

1) Pelton Turbine
2) Francis "
3) Kaplan "

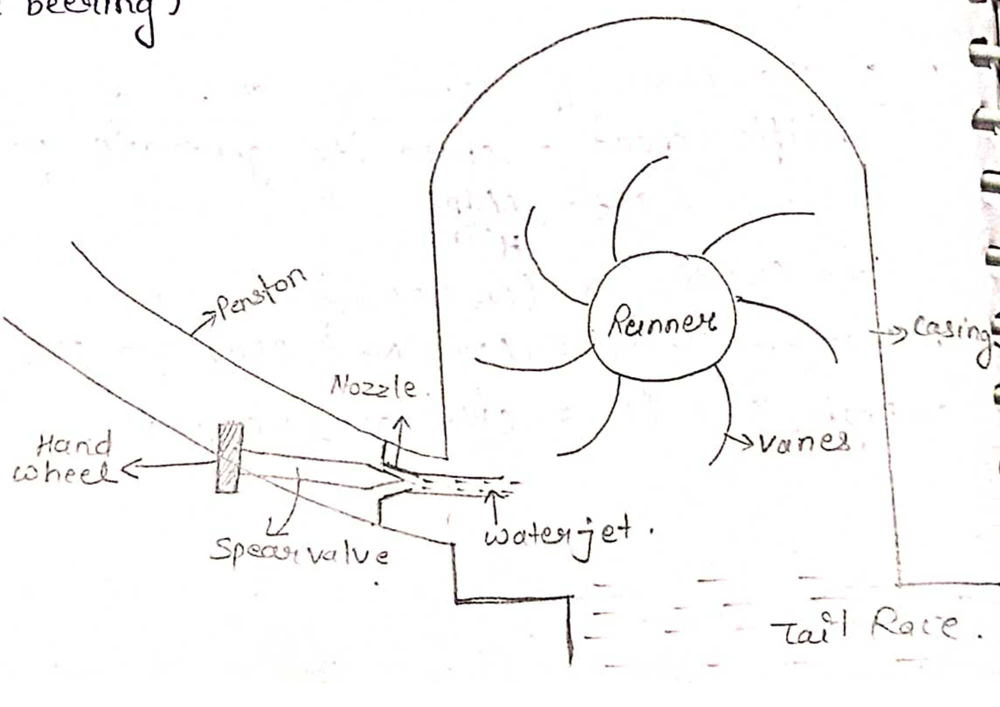
Construction And Working of Impulse Turbine. (Pelton)

Component :-

1) Nozzle and flow regulating Turbine (spear valve). (P.E. → K.E.) in the form of jet.
2) Runner and bucket (Vanes) (wheel of turbine consist of series of bucket/ blades / vanes mounted on its periphery)
3) Casing. (Avoid water splashing and accident)
4) Penstock (Brings water from Reservoir to turbine)
5) Spear valve (To regulate the flow of water)
6) Tail Race. (Discharged storage) → water.

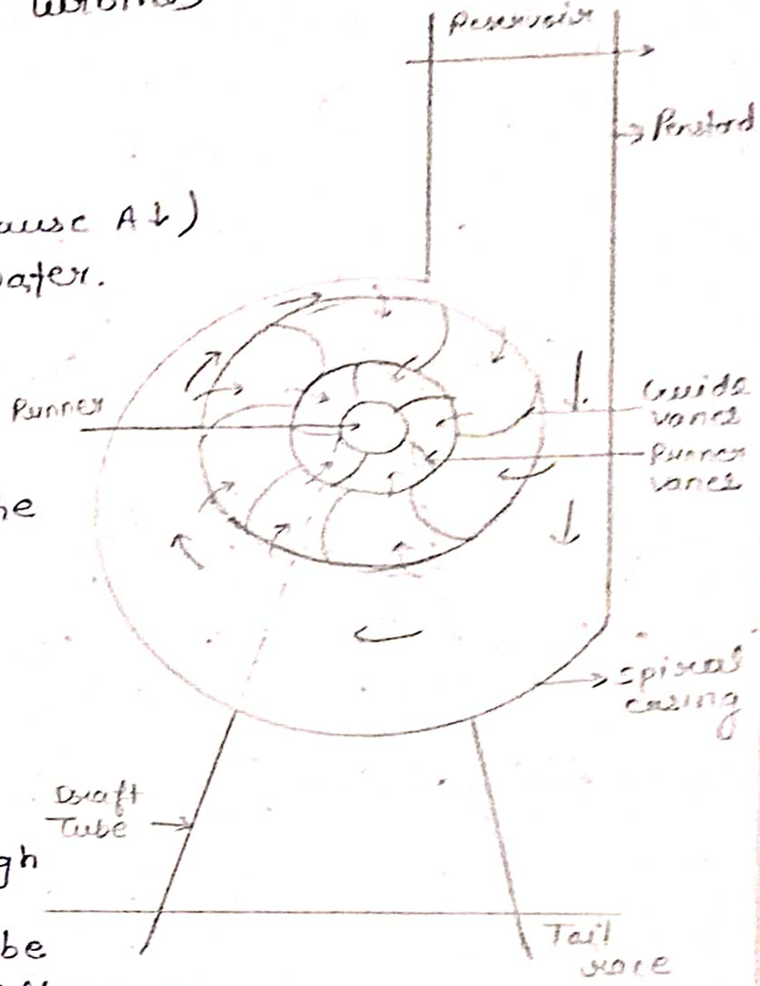
force on Vanes → Tangential (Used to Rotate the turbine), Axial. (damage beering)

replaced → Cancel out each other's Axial force.



Construction And Working of Reaction Turbine.

1) Radial flow Turbine (Francis Turbine)



Components :-

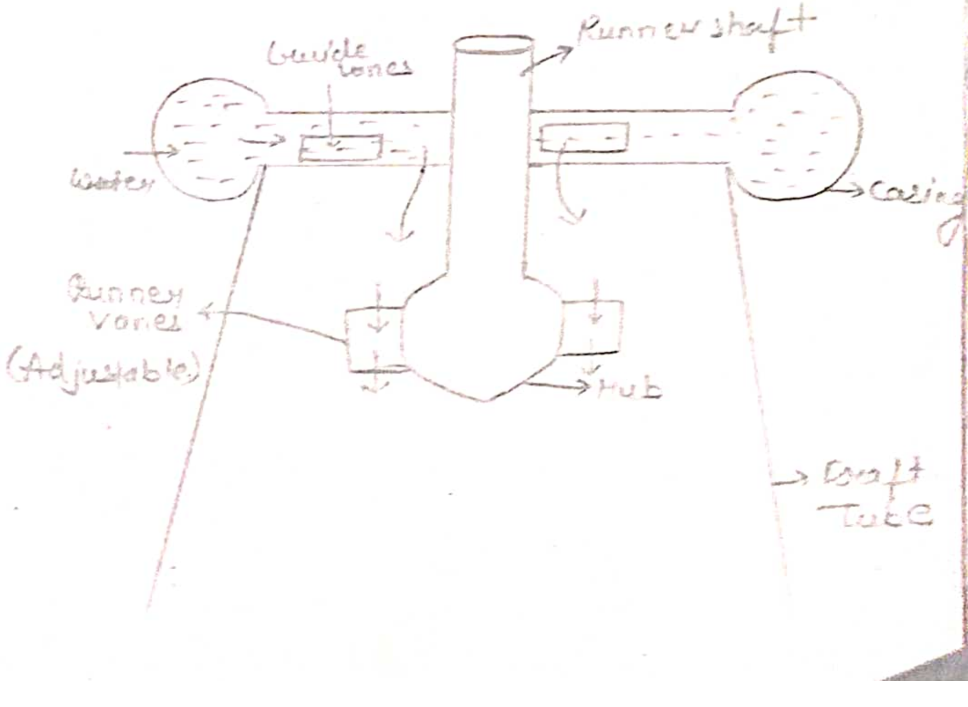
1) Casing.
- Spiral Casing. (to increase v because $A\downarrow$)
- Casing and runner are full of water.
-

2) Runner Vanes

3) Guide Vanes.
Allow the water to strike the fixed blades on the runner without shock at inlet.

4) Draft Tube.
to draw out discharge water
$A\uparrow \rightarrow v\downarrow$ to $P\uparrow$
because in runner $v\uparrow$ too high so $P\downarrow$ too low, otherwise water start flowing from draft tube to Runner due to Pressure difference.

2) Axial flow Turbine (Kaplan Turbine.



Pump.

The hydraulic machine which converts M.E into H.E.

* H.E in form of Pressure Energy.

Pump:

- (Centrifugal) M.E → P.E by (centrifugal force)
- (Resiprocatory) M.E → P.E by (Resiprocatory motion)

(Principle:- Forced vortex flow)

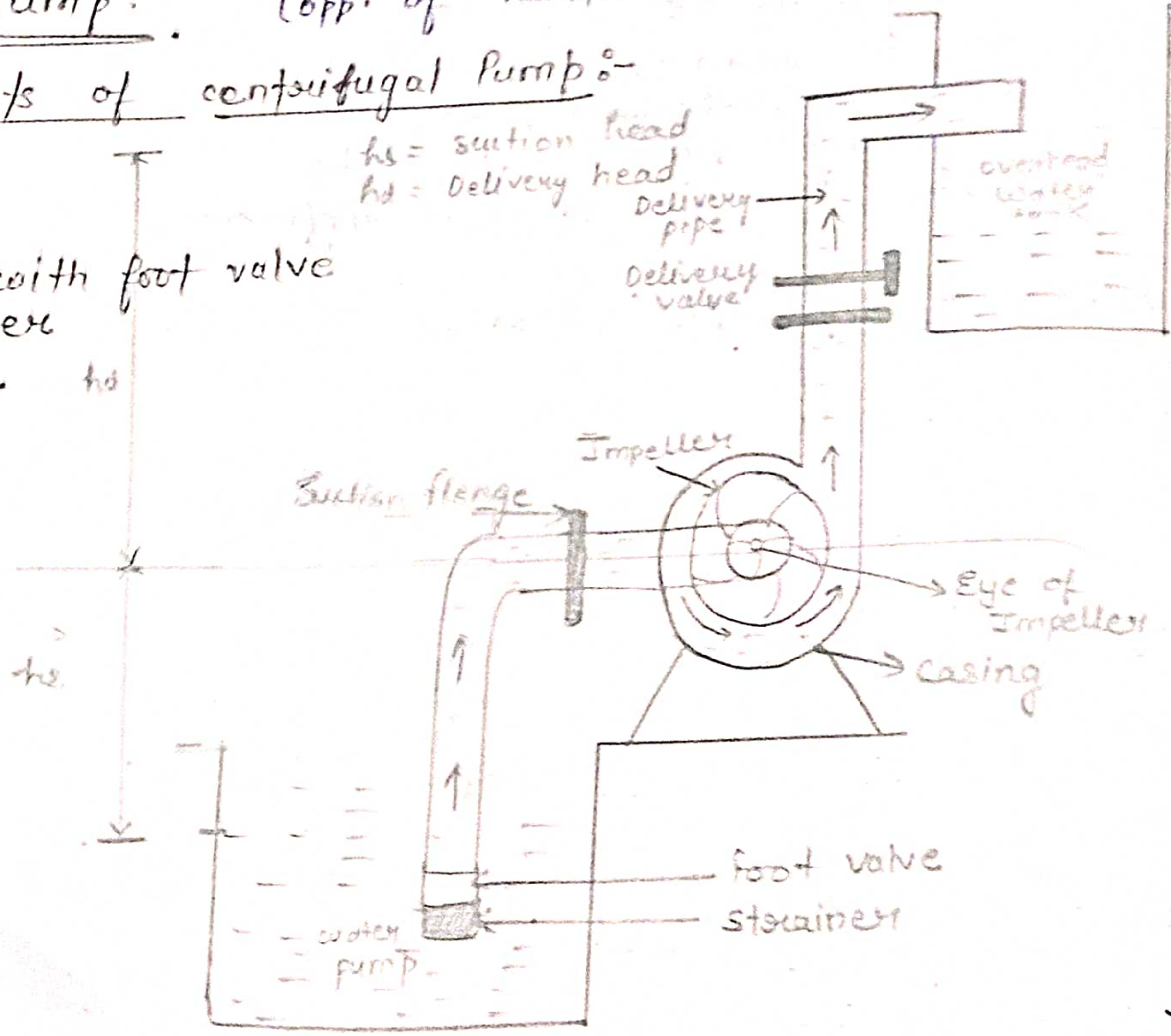
(Pump) broadly

- (Dynamic Pressure Pump)
- (Positive displacement Pump)

Centrifugal Pump. (opp. of Reaction Turbine)

Main Components of centrifugal Pump:-

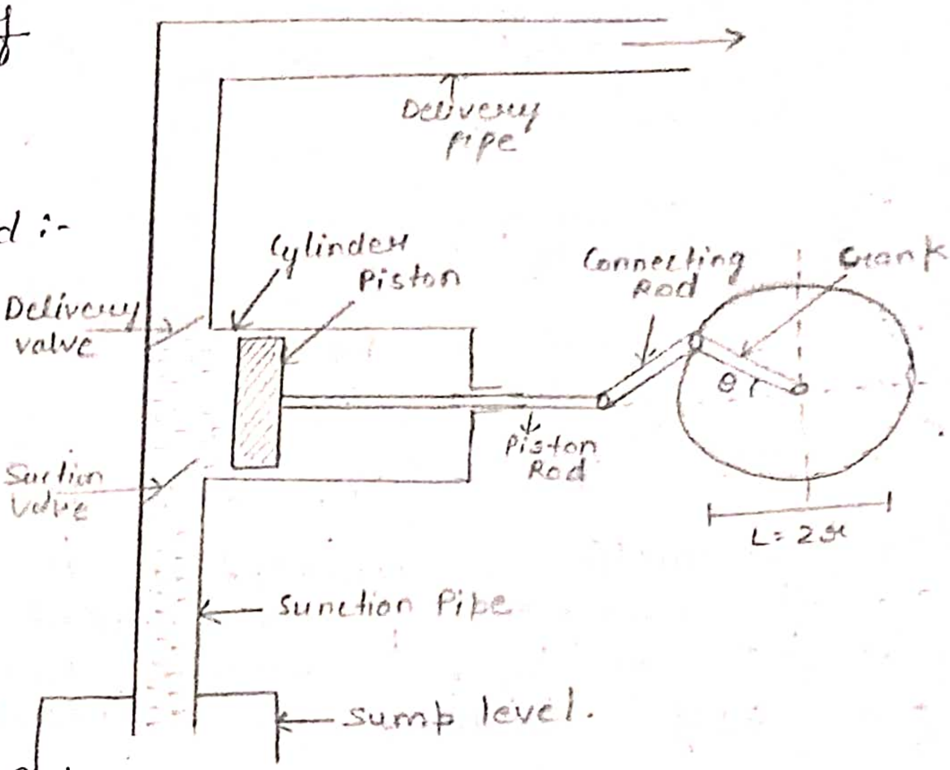
1) Impeller.
2) Casing
3) Suction pipe with foot valve and a strainer
4) Delivery pipe.



Reciprocatory Pump.

The main components of R.P.

1) cylinder :-
2) piston and Piston Rod :-
3) Crank and connecting Rod :-
4) suction pipe
5) Suction Valve
6) Dilevery pipe
7) Delivery valve.

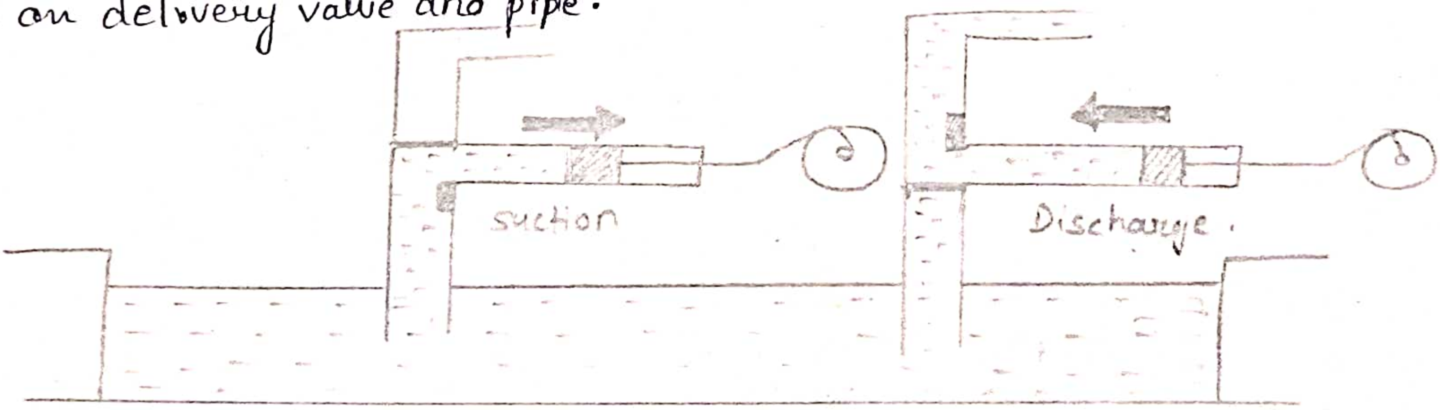


* $\theta = 0$, Extreme left = Piston.
  Piston L → R suction valve open and D.V. closed.
* $\theta = 180$, Piston = Extreme Right.
  cyclinder filled will with water.
* $\theta = 360$, Piston = Extreme left.
  Delivery open → water discharges.

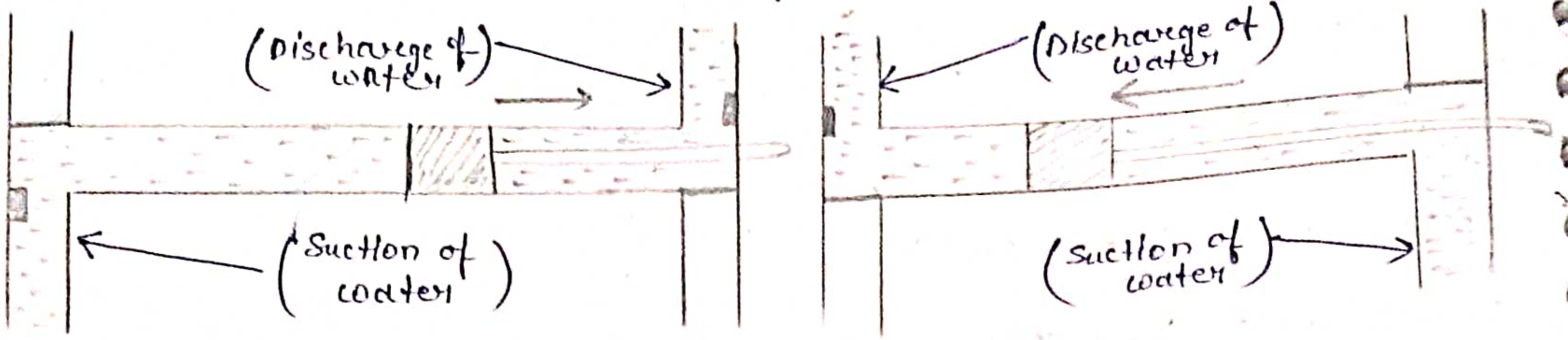
Classification of Reciprocating Pump.

1)
a) single Acting Reciprocating pump.

Only one suction valve and pipe.
Only on delivery valve and pipe.



2) Double Acting Reciprocating Pump.



Two suction valve and pipe
Two delivery valve and pipe.

Question:- Describe hydraulic Accumulator with diagram. Also explain construction & working

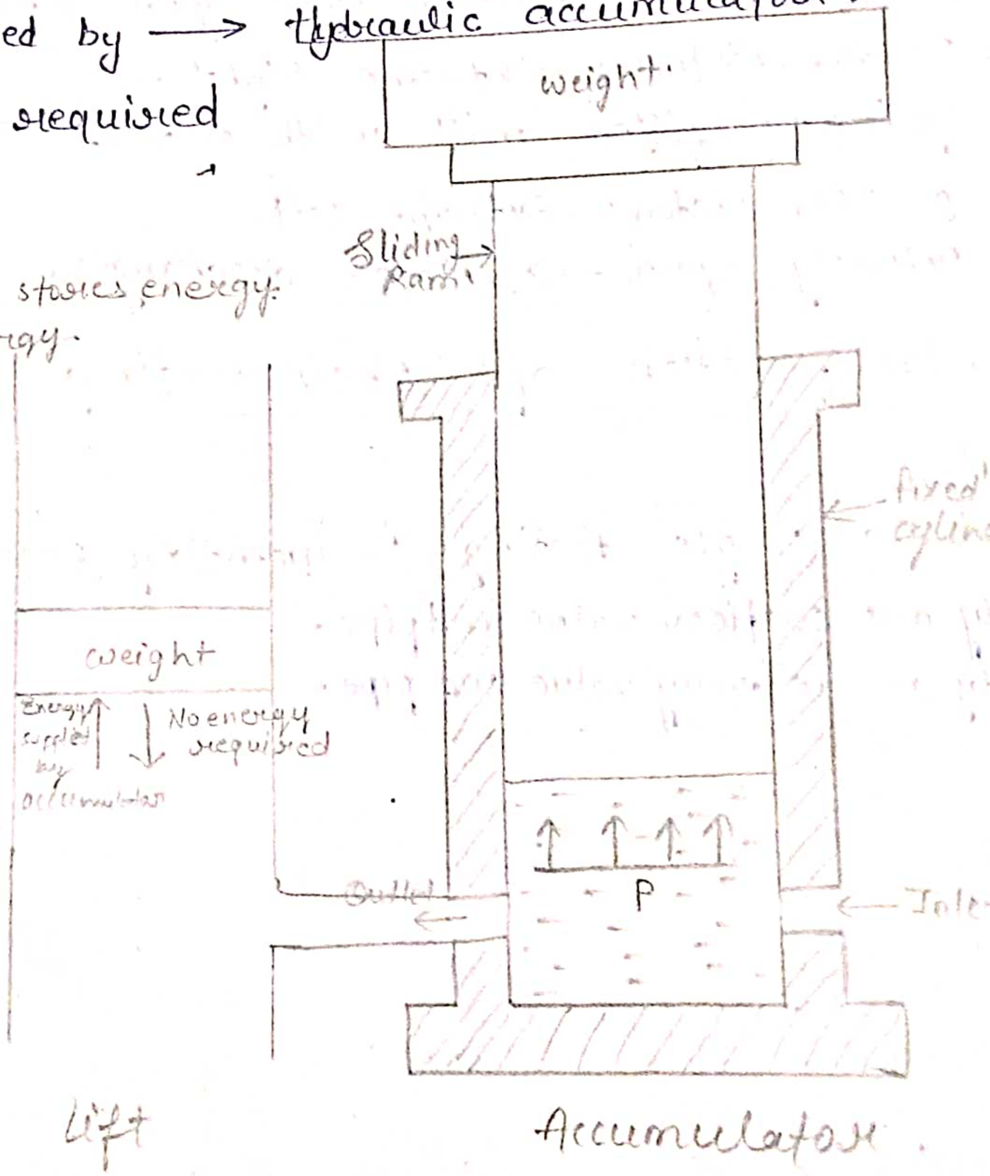
Hydraulic Accumulator.

Ans. The hydraulic accumulator is a device used for storing energy of a liquid in form of pressure energy, which may be supplied for any sudden or intermittent requirement.

In hydraulic lift and crane → large amount of energy → required → supplied by → hydraulic accumulator.

lift ↓ → no energy required

lift ↓ → Accumator stores energy.
lift ↑ → supplies energy.



Lift Accumulator

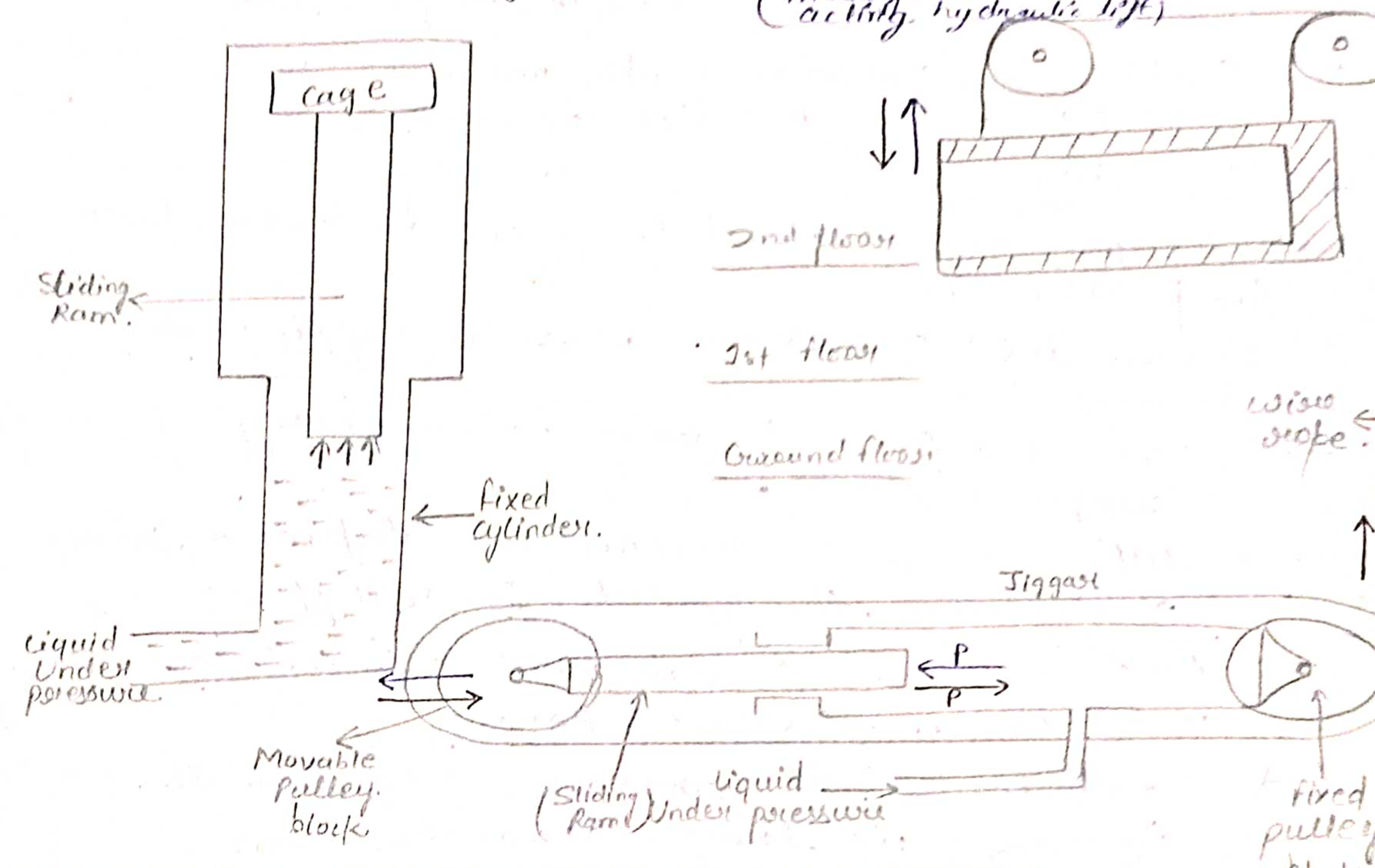
Ques - Describe hydraulic lift and its construction & working.

Hydraulic lift

Hydraulic lift is a device used for carrying passenger or goods from one floor to another in multistoried building to raise heavy object.

Principle — Pascal law.

Hydraulic lift
- (Direct Acting)
- (Suspended) (modified form of direct acting hydraulic lift)



→ Accumulators are simple devices that store energy in the form of fluid under pressure.

→ Accumulators are of three types -

(i) Weight loaded accumulators.

(ii) Spring loaded accumulator. (multiple springs are used.)

(iii) gas loaded accumulator.

Construction & Working.

→ In accumulator, a fixed vertical cylinder is used ~~in~~ which containing a sliding ram.

→ When weight applied on ram, It lowers down the place.

~~Ikara valve~~ One inlet & one outlet also present in cylinder.

→ Inlet of cylinder attached to the pump which Continuously supply water under pressure.

→ Outlet is connected to the machine. Here machine is may be lift or crane.

→ **Working** :-

→ When pressure, exerted on ram it lowers down the position.

→ From inlet of cylinder, water is supply under pressure.

→ This will raise the ram where, heavy weight is placed.

→ When ram is reached at topmost place of cylinder, the cylinder is full of water

→ At this time, accumulator stored the maximum pressure energy.

→ Whenever, the machine requires the energy, it lowers down the ram So, it get the energy.

Interchangeability :- The term interchangeability implies that the parts which go into the assembly can be selected at random from a large no. of identical parts that have been manufactured within the prescribed limits of dimensions. Apparently then a selecting fiting become unecessary except when special allowance are.

OR.

It is called principle of normalisation of requirement to the size of elements of parts, junction, mechanism used in design through which it is possible to produce independently and replaced without further processing or any disturbance in the assembly.

Terminology :-

1) Hole :- Any internal diameter is considered as Hole.

2) Shaft :- Any external diameter is considered as shaft.

3) Basic Size :- Normal or standard size of part by which strength can be calculated is called basic size.

4) Actual size :- Size which is measured on a manufacturer part.

Note - Basic size is never equals to Actual size.

5) limits of size :- Maximum and minimum size that can be permitted.

Maximum limit of size = high limit
Minimum limit of size = low limit .

6) zero line :- Straight horizontal line along ... size which helps to refer deviation.

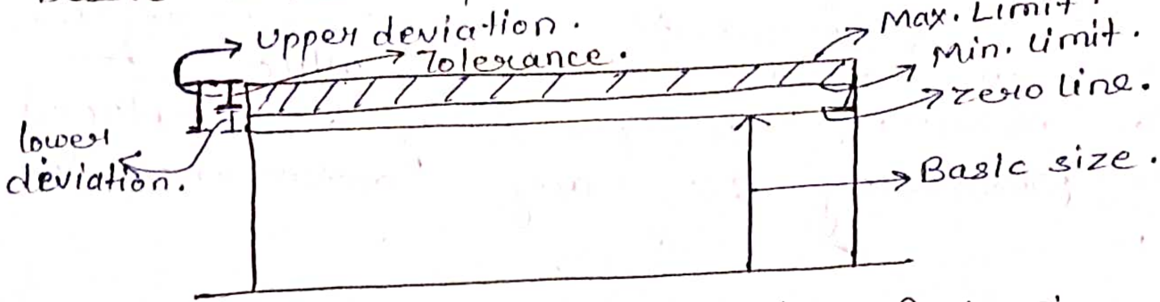
7) Deviation :- The algebraic Difference b/w actual size and corresponding to basic size.

a) <u>Upper deviation</u> :- Difference b/w max. limit of size and corresponding to basic size. is called upper deviation limit.

When max. limit is greater than basic size is called +ve deviation. and when it is lower than basic size is called -ve deviation (quantity).

b) <u>Lower deviation</u> :- Difference b/w min. Limit of size and corresponding to basic size is called lower deviation limit.

When min. limit is greater than basic size is called +ve deviation and when it is less than basic size it is called -ve deviation.



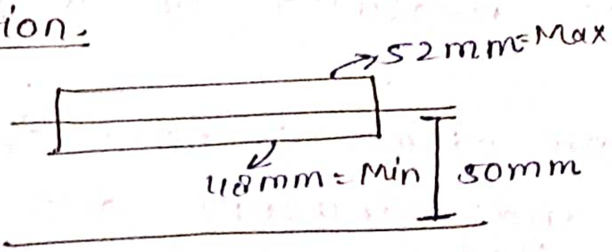
$$U.D. = (\text{Max. Limit of size}) - \text{Basic Size}$$

$$L.D. = (\text{Min. Limit of size}) - \text{Basic size.}$$

<u>Tolerance</u> :- Difference b/w upper limit deviation and lower limit deviation is called <u>Tolerance</u>.

$$\boxed{\text{Tolerance} = U.L.D - L.L.D.}$$

<u>Question.</u>



U.L.D = 2mm

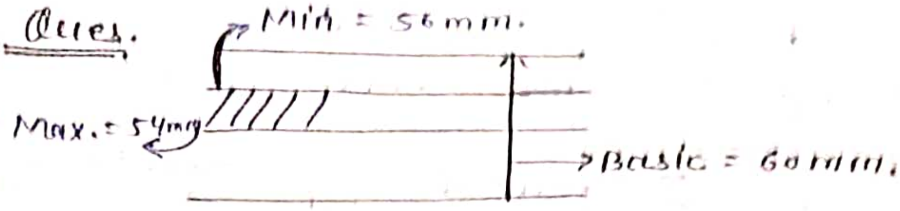
L.L.D = -2mm

Tolerance = U.L.D − L.L.D

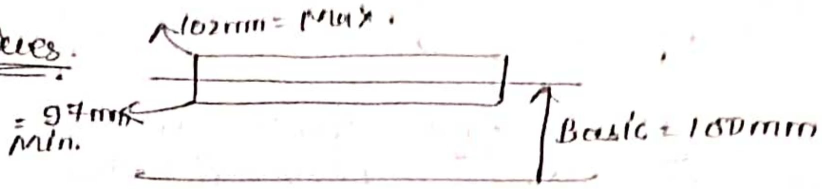
= 4.

Fundamental deviation:- The deviation either it is upper or lower limit which is closest to the basic size, it is called fundamental deviation. (or zero line) of hole or shaft

Ques.



Ques.



U.L.D = 2

L.L.D = -3

Tolerance = U.L.D - L.L.D

= 2 - (-3)

= 5.

Ques. A shaft as diameter $\phi = 35^{-0.009}_{-0.025}$ the respected value of fundamental deviation and tolerance is –

ULD = 0.025

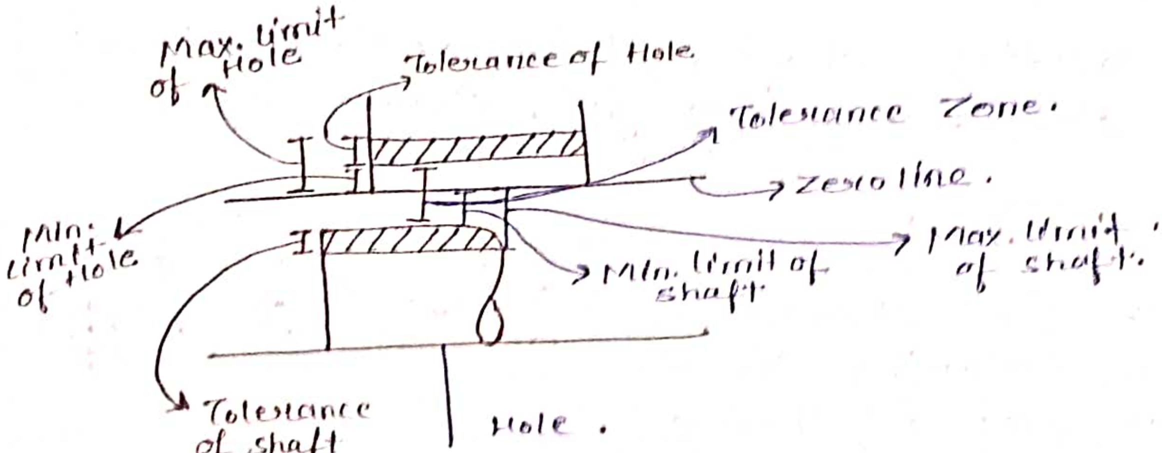
LLD = 0.009

Tolerance = ULD - LLD

= 0.025 - 0.009

= 0.016

fundamental deviation = 0.009.



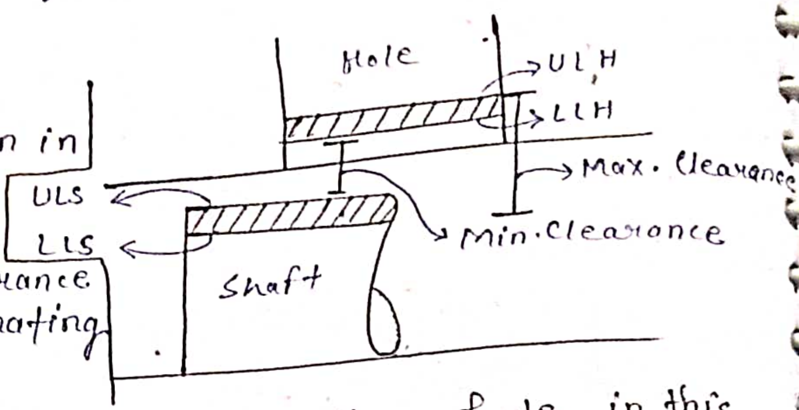
The degree of tightness and loseness b/w the two mating parts is known as fiting of System.

Types of Fiting.

- Clearance
- Interference
- Transition

1) Clearance fiting.

An clearance fit shown in fig. is one having limit of size so prescribed that a clearance always results when mating parts are assembled.



The shaft is always smaller than the hole in this system. Clearance is +ve difference between the size of hole and shaft.

Tolerance zone never meet.

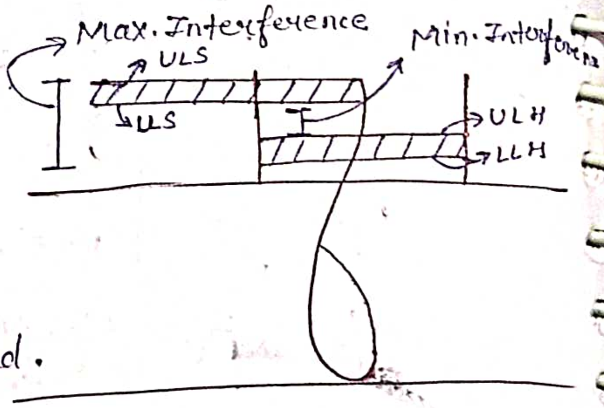
$$\text{Max. clearance} = ULH - LLS$$
$$\text{Min. clearance} = LLH - ULS$$

Applications:-

1) Used on rotating shaft, loose pulleys, bearing, cross head slider, running fit, sliding fit.

2) Interference Fit.

An interference fit shown in figure. is one having limit of size so prescribed that a interference always results when mating parts are assembled.



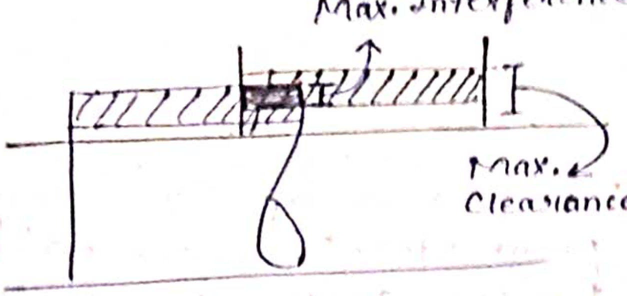
The shaft is always bigger than the hole in this system. Interference is negative difference b/w hole and shaft system. And Tolerance zone never meet but cross to each other in this system.

Max. Interference = ULS − LLH
Min. Interference = LLS − ULH

Applications :-
1) Used in crank pin, shrunk on coupling, iron type railway wheels, shrunk axles, pressed M/c.

5) Transition Fitting :-

A transition fitting shown in fig. is one having limit of size so prescibed that either clearance or interference always results when mating parts are assembled.



The shaft may be bigger, smaller or of same size of the hole in this fitting.
Tolerance zone always overlap to each other.

$$\text{Max. clearance} = ULH - LLS$$
$$\text{Max. Interference} = ULS - LLH.$$

Application :-
Used in bushes, spigot, keys, pin, fastener.

Measurement :- It is the process of obtaining a quantitative comparision b/w a predefined standard and measurand.

Measurand :- A physical quantity to be measured.

Standard :- A physical quantity to which quantitative comparision are to be made.

Measurement

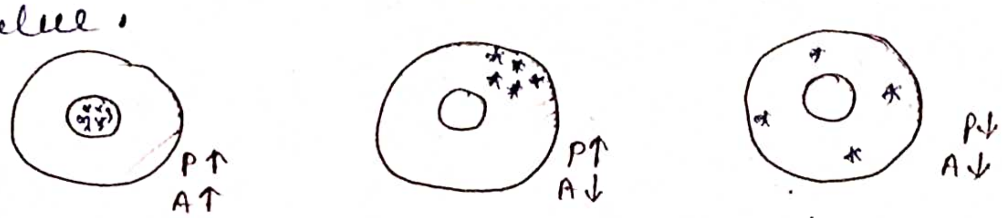
- **Direct** (mass, length,)
  The value of the physical parameter (measurand) is determined by comparing it directly with references (standard).
- **Indirect** (density, temperature)
  The value of the measurand is determined by indirect comparision with sec. stand. through calibration.

Measurement

- **Primary**
  (By senses)
  (direct comparsion)
  subjective information
  Eg. more or less hot or cool.
- **secondary**
  (Primary → Analogous)
  (Calibration of physical prop.)
  (involved one conversion)
  Eg. Temp. in thermometer.
  length of Hg → Temp.
- **Tertiary**
  (Enlarge the secondary one)
  (involved two conversion)
  Eg. Bourdon Tube Pressure Gauge.

Precision :- (Closeness in the result)↑ → (highly precise)
Precision is the closeness of the measurements to each other.

Accuracy :- (Closeness with the right value)↑ → (high accuracy)
Accuracy is closeness of the measurement to a true value.

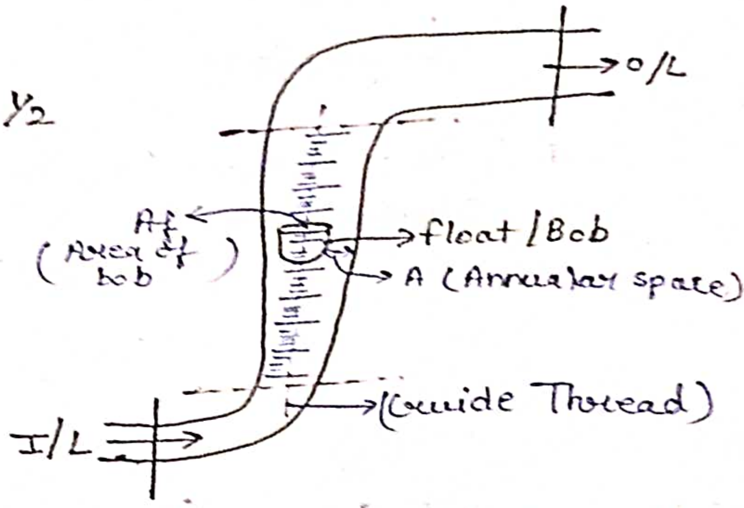


Note :- Measuring instrument should be precise and accurate both.

2) Orifice Meter.

3) Rotameter.

$$Q = A\left[2g \cdot V_f (\rho_f - \rho)/A_f \rho\right]^{1/2}$$



V_f = Volume of float
ρ = density of fluid
ρ_f = density of float
A_f = Area of float
A = Area of annular space.

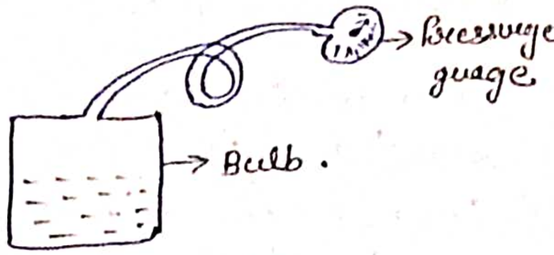
Temperature Measurement.

1) Liquid in glass thermometer. ((-35) - 500)°C

Mercury → density ↑
volume ↓ - used.

Change in length in Hg Tube = Change in Temp.

2) Pressure Thermometer :-



Pressure $\propto$ Temperature.

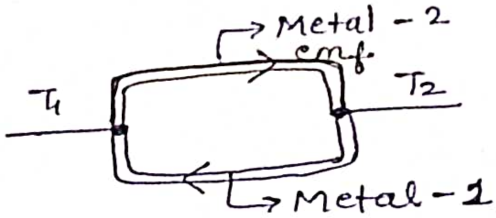
Change in Pressure in Bulb } = Change in temp. of gas.

Range – (–200) – 500°C

why so much change in negative temp. can be measured ?

Reason – As Gases are filled so Volume ↓↓↓ so change in –ve temp ↓↓↓

3) Thermocouple :-



Metal Used – Al, Cr, Cu, Ni

" due to temp. difference an emf is induced in loop".

4) Resistance Thermometer :-

$$R_t = R_o(1 + AT + BT^2)$$

A, B = material constant

R_o = Resistance at 0°C

5) Thermistor :-

* Ceramics is used
* larger temperature variation could be done as compared to metal.

$$t = R_o e^K$$

$$k = \beta\left(\frac{1}{T} - \frac{1}{T_o}\right)$$

where β = material constant.

6) Pyrometer :-

* Change in colour of body when temperature is raised. is measured.
* Change in colour due to change in frenquecy of radiation emitted by material.

1) What is mechatronics ?

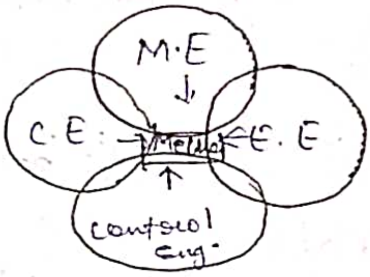
It is a concept of Japanese origin (1970's) and can be defined as the appl^n of electronics and computer technology to control the motions of mechanical system.

Mechanism Electronics.

↓

Mechatronics

Multidisplinary approach to product and manfucturi system ~~degin~~ design.



→ to develop products, processes and system with greater flexibil and ability of reprogra

Example. Automobiles → [Mechanical fuel injection system] → [electronic fuel injection system]

2) Advantages of Mechatronics –

1) Enehances functionality and features.
2) more efficient.
3) brings intelligence in system.
4) less expensive compared to mechanical solution.
5) Reliable.
6) User-friendly and safer.
7) Precision, Accuracy, speed → ↑ → controlled.

3) Disadvantage of Mechatronics –

1) High intial cost.
2) knowledge different field is required.
3) problem should be addressed seperately.
4) Expensive to existing/old system.
5) Maintenence and service cost ↑.

6 4) What are the industrial appl^n of Mechatronics?

⇒ Automated system :-

{Automatic inspection, quality assurance, packaging, record making, dispatch}

(expedite the entire manufacturing operation)

⇒ Aeronautics Engineering :-

⇒ Defence Industry :- (guided vehicle)

⇒ Mine detection.

5) Write short notes on Autotronics.

"Combination of automobile and electronics OR use of electronics in automobile vehicles."

Major Areas :-

1) (75-85) % → automobile parts are electronics system.

2) Engine controlling system, airbags, antilock braking, GPS, music etc.

3) Use of sensor, motors and digital equipment

(likage b/w essential system and components of vehicle)

6) **Bionics.**

Bionics → Biology $\xleftarrow{uses}$ Mechatronics.

⇒ implantation of broken body parts.

7) **Avionics.**

aircraft, Artifical Satllite and spacecraft → Mechatronics

It includes → communication, navigation, the display and management of multiple system.

- Avionics equipment on a modern military or civil aircraft account for around –

⇒ 30% of the total cost of aircraft

⇒ 40% in the case of a maritime patrol.

⇒ 75% of cost

Sensor.

A device that provides usable output in response to change in a specified physical quantity which is measured.

Physical changes → sensor → Output signal

Transducer:

- A device that change the physical attributes of the non-electrical signal into an electrical signal which is easily measurable. The process of energy conversion in the transducer is known as Transducer.

Transducer.

(Sensing Element/detector) (Transduction Element)

Input signal → ~~sensor~~ sensor + Transduction element → Output signal

Types of Sensor

1) Temperature Sensor
2) Infrared sensor
3) Pressure sensor
4) Light sensor
5) Ultrasonic sensor
6) Humidity sensor
7) Particulate sensor
8) Touch/colour sensor
9) Smoke, Gas, C_2H_5OH sensor
10) flow and level sensor.

Types of Transducer.

FOS = Ult Str / Work Stress

1) Transducer based on Quantity to be Measured.
- Temperature (Thermocouple)
- Pressure (diaphragm)
- Displacement (LVDT)
- Oscillator
- flow.

2) Based on Principle of Operation.
- Capacitive
- Inductive
- Resistive
- Photoelectric
- Chemical.

3) Based on need of ~~of~~ an External Power Source.

Active Transducer — (Don't require any power source for their operation.)
⇒ Thermocouple, thermometer etc.

Passive Transducer — It requires external power source.
⇒ strain gauge, thermistor etc.

Characteristics of Sensors and Transducers

The performance characteristics are mainly divided into two categories —

i) Static Characteristics
- Input is constant or varying very slowly.
- Range, Sensitivity, Linearity etc.

ii) Dynamic Characteristics.
- Input is variable rapidly
- speed of response
- dynamic error.

⇒ Define Kinematic link or element with an example

Every part of a machine which is having some relative motion with respect to some other parts will be known as kinematic link or element.

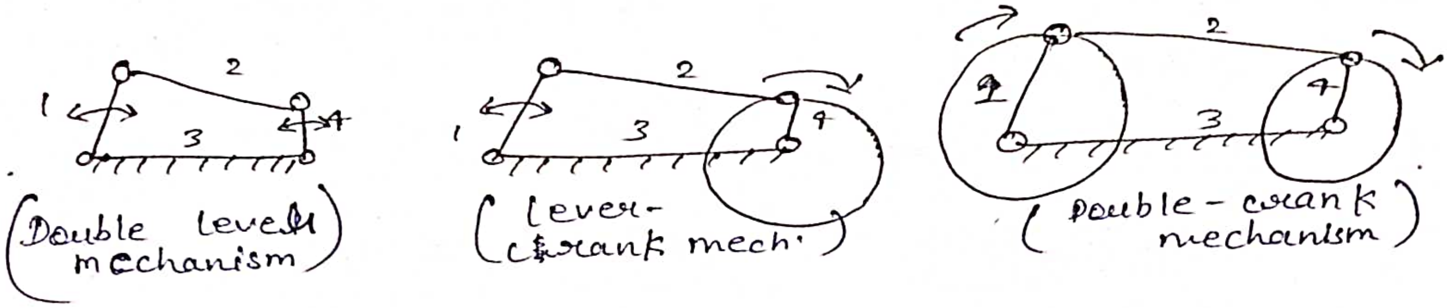
Example :- Piston, Connecting rod, crank, lever etc.

⇒ Kinematic Chain.

If all the links are connected in such a way that first link is connected to last link in order to get the close chain are constrained, then such a chain is known as "Kinematic chain"

The four bar Chain.

4 links + 4 joints.



Mechanism.

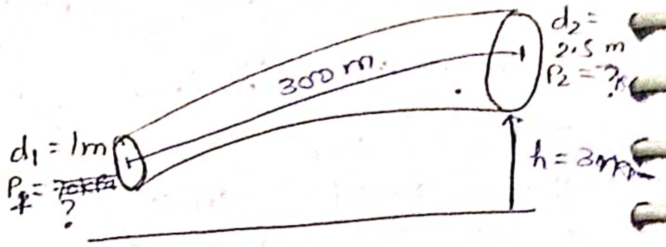
"If one of link of kinematic chain is fixed, then it will be known as mechanism".

Machine

"When a mechanism is utilized in order to get desired output in respect to given input then it will be known as machine"

A pipe 300m long as a slope of ~~one in hindered~~ 1 in 100 from 1m dia at the high end 0.5m at low end. Quantity of water flowing is 5400 l/min if the pressure at the high end is 70 kPa. find the pressure at the lower end.

$h = 300 \times 100 = 30000\,m$



$P_1 + \frac{1}{2}\rho v_1^2 + \rho h g = P_2 + \frac{1}{2}\rho v_2^2 + \rho h g.$

$Q = \frac{\cancel{5400}^{90}}{\cancel{60}} \times 10^{-3}\ m^3/sec.$

$Q = 0.09\ m^3/sec.$

$Q = A_2 v_2$

$0.09 = \frac{1}{4}\pi d_2^2 \times v_2$

$\frac{0.09 \times \cancel{4}^2 \times 7}{\cancel{22}_{11}} \times \frac{1}{(1)^2} = v_2$

$\boxed{v_2 = 0.11\,m/s.}$

$v_2 = \frac{0.09 \times 4 \times 7}{22} \times \frac{1}{(0.5)^2}$

$v_2 = \frac{0.09 \times 2 \times 7}{11 \times 0.25}$

$\boxed{v_2 = 0.45\,m/s}$

$P_1 + \frac{1}{2} \times 10^3 (0.46)^2 + 0 = 70 \times 10^3 + \frac{1}{2} \times (0.11)^2 \times 10^3 + 3 \times 9.8 \times 10^3$

$P_1 = \left[\frac{1}{2}(0.11 + 0.46)(0.46 - 0.11)\right]10^3 + 70 \times 10^3 + 83.4 \times 10^3$

$= \left[\frac{1}{2} \times (0.57)(0.35)\right]10^3 + 70 \times 10^3 + 83.4 \times 10^3$

$= (0.00605 - 0.6125)10^3 + 70 \times 10^3 + 83.4 \times 10^3$

$= (-0.0552) \times 10^3$

$= -55.2 + (70 + 83.4) \times 10^3$

$= 153.4 \times 10^3$

$\boxed{P_1 = 99.33\ kPa}$

$$P_1 + \frac{1}{2} \times 10^3 (0.46)^2 = 70 \times 10^3 + \frac{1}{2} \times 10^3 \times (0.11)^2 + 3 \times 10^3 \times 9.8$$

$$\underline{\underline{P_1}}$$

Sol:

Given:-

Sp. gr. = 0.87 , $d_1 = 200mm$, $\Delta z = 4m$

$P_1 = 1 bar$, $d_2 = 500mm$

$P_2 = 0.6$ bar. head loss = ?

$Q = 0.2 m^3/s$. dirxn of flow = ?

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\rho g = 0.87$$

$$\frac{1}{0.87} + \frac{V_1^2}{2\times 9.8} + 0 = \frac{0.6}{0.87} + \frac{V_2^2}{2\times 9.8} + 4 + h_L$$

$$V_1 = \frac{0.2\times 4\times 7}{22\times 200\times 200} = \frac{5.6}{22\times 4}\times 10^{-4}$$

$$\left[V_1 = 0.06\times 10^{-4}\right] = 6.36 \ m/s$$

$$V_2 = \frac{0.2\times 7\times 4}{22\times 500\times 500} = \frac{5.6\times 10^{-4}}{22\times 25}$$

$$\left[V_2 = 0.01\times 10^{-4}\right] = 0.51 \ m/s$$

$$\frac{0.4}{0.87} + \frac{V_1^2 - V_2^2}{2\times 9.8} - 4 = h_L$$

$$\frac{0.4}{0.87} + \frac{[(0.06)^2 - (0.01)^2]\times 10^{-8}}{2\times 9.8} - 4 = h_L$$

$$0.45 + \frac{0.0035\times 10^{-8}}{2\times 9.8} - 4 = h_L$$

$E_1 = 13.705 m$, $E_2 = 11.083$

$h_L =$

Construction of direct acting hydraulic lift.

hydraulic lift consist of some parts –

(i) Fixed cylinder. –
→ It is attach or fixed with the wall of the floor.

(ii) Cage – On this the load is placed, it is fitted at the top of the sliding ram.

(iii) Sliding ram – This can moves in downward & upward direction, when pressure is applied on it. It is present at the fixed cylinder

Working.

→ When fluid ~~or~~ any such as liquid or gas under pressure is forced into the cylinder,

→ The sliding ram is moved in upward direction upto required height.

→ The limited pressure is given so, it can reached upto their required floor.

→ In this, the stroke of ram is equal to the lift of the cage.

Construction of Suspendended hydraulic lift

(i) wire rope. – It heps in connecting the cage to pulley

(ii) Pulleys. – Two pullys are used –
one pulleys is fixed and other is movable
→ It is attached with sliding ram and fixed cylinder.

(iv) Hydraulic jigger – It is a movable part, It slides inside a fixed hydraulic cylinder.
It is also known as moving ram.

A venturimeter of 15cm inlet diam... in a pipe ... the throat is left horizontally of 0.9 sp. gr. measure the flow of oil manometer is 20cm. Calculate reading of mercury the discharge in l/min?

$$sp.\ gr = \frac{\rho_l}{\rho_w}$$

$$0.9 = \frac{\rho_l}{1000}$$

$$\boxed{\rho_l = 0.9 \times 10^3}$$

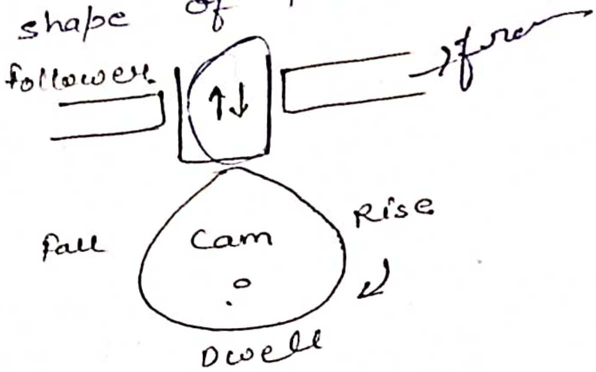
~~Working of suspended hydraulic lift.~~

~~→ When, pressure is generated by fluid which forced the cylinder,~~

CAM.

Cam is a body which can rotate or oscillates and in doing so imparts a reciprocating motion to a second body called follower:

Then length of time spent for the rotation is depending on the ~~spe~~ shape of the cam.



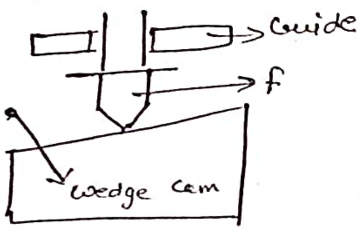
Cam - Driving Member.
Follower - Driven "
Frame - Supporting. "

Types of cams :-

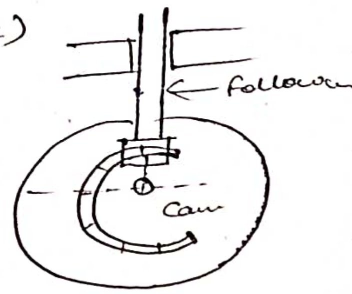
1) On the basis shape —

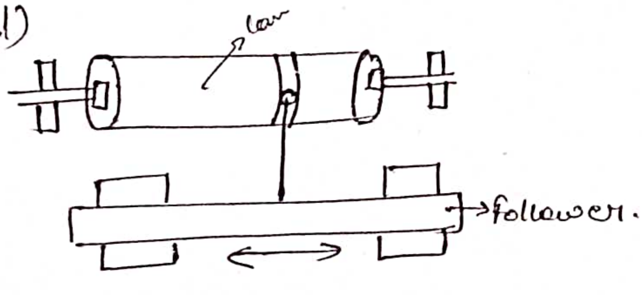
a) wedge and flat
b) Radial or disc
c) spiral
d) Cylindrical
e) spherical

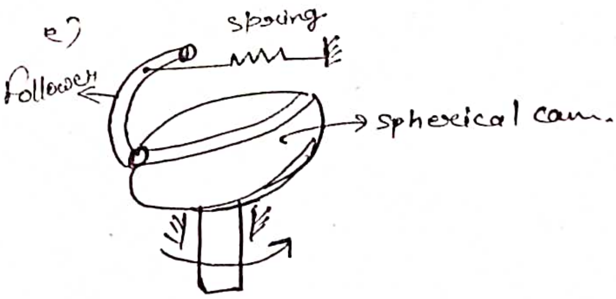
~~2) On the follower mom.~~

a)


b)


c)


d)


e)


Types of Follower.

- Point
- Knife
- Roller (↓ friction)
- sliding and oscillated
- flat
- Mushroom

Uses of Gears and Gear drives.

Uses.

~~Transmi~~ - Transmit Power
- Change the v
- " " dirn

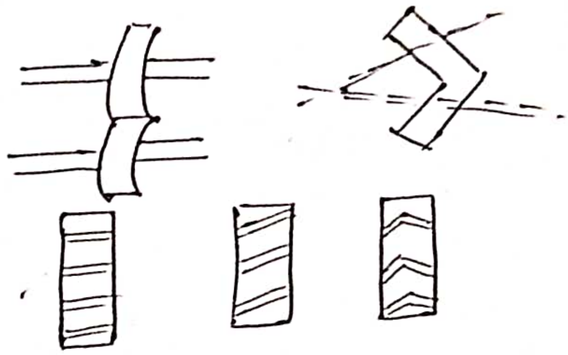
~~Gear~~ Gear Ratio :-

$$\frac{\omega_1}{\omega_2} = \frac{T_2}{T_1} = \frac{d_2}{d_1}$$

ω = angular v
T = no. of Teeth
displacement = d.

Types of Gear

a) Parallel gear axes
b) axes inclined to one another.
c) Axial teeth.
d) helical teeth
e) double helical teeth.



Chapter-2.

Engine :- converts one form of energy into another form.

Engine.

- IC Engine (Inter combⁿ)
- E.C engine (External combⁿ)

Internal combⁿ Engine :-	Combⁿ of fuel takes place inside the cyline Ex :- Petrol Eng., Disel engi
External combⁿ Engine :-	Combⁿ outside the cylinder Ex :- steam Eng., Closed gas turbine.

EC Engine	IC Engine.
⇒ Combⁿ outsid $\eta = 15\text{-}20\%$	⇒ Inside. $\eta = 35 - 40\%$
⇒ Bulky → Apparatus like boiler.	⇒ Light and compact
⇒ weight/Power ↑	⇒ weigh/Power ↓
⇒ can use cheap fuel.	⇒ Uses high grade fuel.
⇒ Requirement of water for heat dissipation.	⇒ Lesser requirement of wate
⇒ Silent operation due to outside combustion	⇒ very noisy operated Engi

Advantages of I.C. Engine :-

1) Mechanical simplicity
2) low initial cost (Apparatus) ✱
3) Efficiency ↑
4) weight/Power ↓
5) Suitable for small power
6) Starting time ↓
7) low maintenance.

Disadvantages of I.C. Engine :-

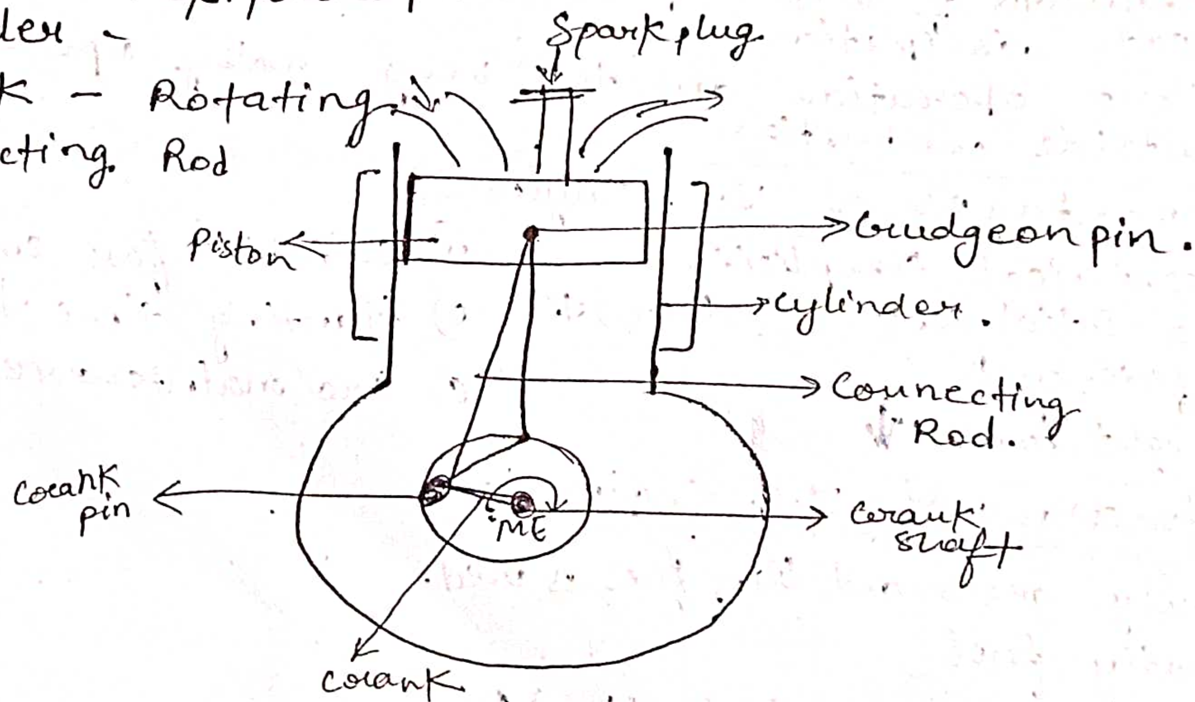
1) Only gases and liq. fuel is used.
2) Costly fuel
3) Engine Emission (Pollution) ↑
4) Not suitable for large power gen.
5) noisy operation

I.C. Engine

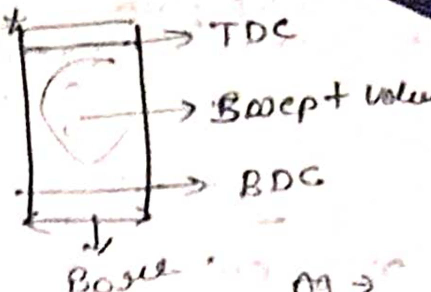
- Basis of Stroke Used
  - 2 Stroke
  - 4 Stroke
- Basis of cycle used
  - Otto
  - Diesel
  - Dual.
- Basis of fuel
  - Petrol
  - Diesel
  - Gas
- Types Ignition
  - Spark Ignition (SI) (Petrol)
  - Compression Ignition (CI) (Diesel)
    - self ignition
- Cooling.
  - Air cooled
  - Water cooled
- Position of cylinder
  - Horizontal cylinder engine
  - vertical
  - Inclined.

Main Components of I.C.E.

1) Pistion - reciprocation
2) Cylinder -
3) Crank - Rotating
4) Connecting Rod



Top Dead centre ⇒ farthest from Crank Shaft
Bottom " " " → closest " "



Stroke :→ TDC → BDC
BDC → TDC
↓
Distance → Stroke length.

Bore – Inner diameter

Swept Volume – Volume displace by piston

$$\boxed{V = \frac{\pi}{4} D^2 L}$$

Clearance Volume :- (V_c) The Volume of cylinder when it is at TDC, it i minimum volume.

Compression Ratio :- $V_T = V_c + V_s$ (Before Compression)
$V_0 = V_c$ (After Compression)
$$r = \frac{V_c + V_s}{V_c}$$

SI → P (6-12)
CI → D (14-22)

Four Stroke Engine

1 stroke → 180° Crank shifts.
(4 stroke → 720° → 2 revolution)

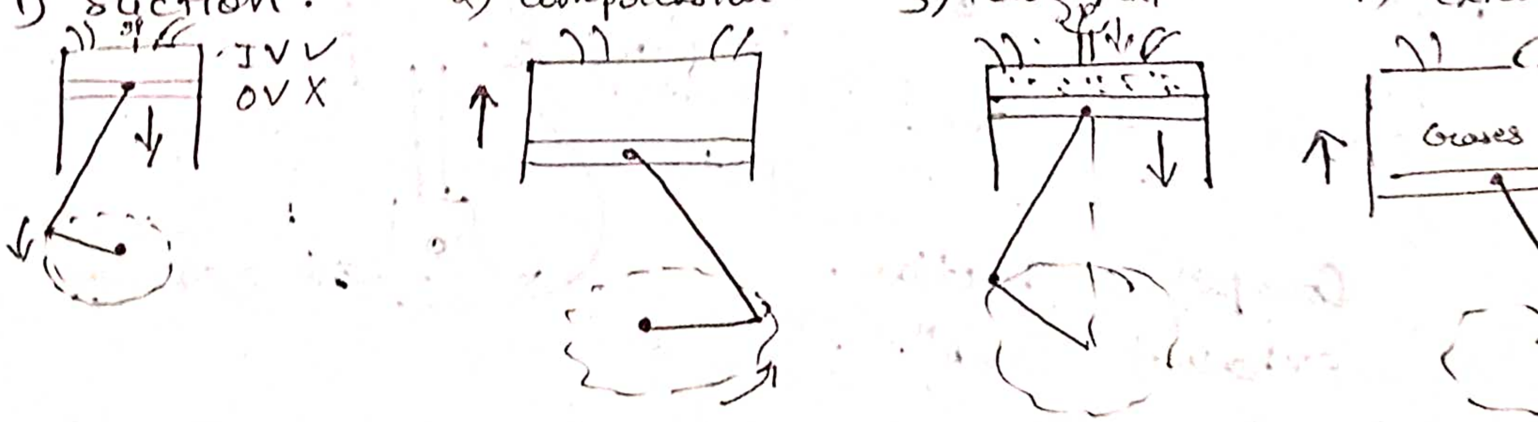
Cycle operation (Intake, compression, Expansion/Power, Exha (720°) completed in 4 strokes of piston or two rev. of crank.

4 stroke < SI (spark plug)
CI (fuel injector)

$\boxed{\text{4 stroke SI Engine}}$ Petrol engine

Carburator → Air + fue
↓
Engi

1) Suction. 2) Compression. 3) Power/Expansion. 4) Exhau



CI Engines
1) Suction Stroke (Air) → IV.
2) compression stroke (P↑ T↑) → Air ← then fuel is added by fuel injector.

SI Engine (Petrol)	CI Engine (Disel)
1) OTTO cycle or const. volume heat addn.	1) DISEL cycle or const. pre. heat addn.
2) fuel + Air – (suction	2) Air (suction)
3) carburetor for (fuel + Air) supply.	3) fuel injector.
4) Self ignition temp↑	4) Self ignition temp.↓
5) Maintenance cost is ↓	↑
small vehicle.	Heavely vehicle
Initial cost ↑	Initial cost ↓
Compr ratio – 6-10	Compr ratio – 16-to22
starting – easy.	diff.
less noise	high noise.
Thermal efficient	↑

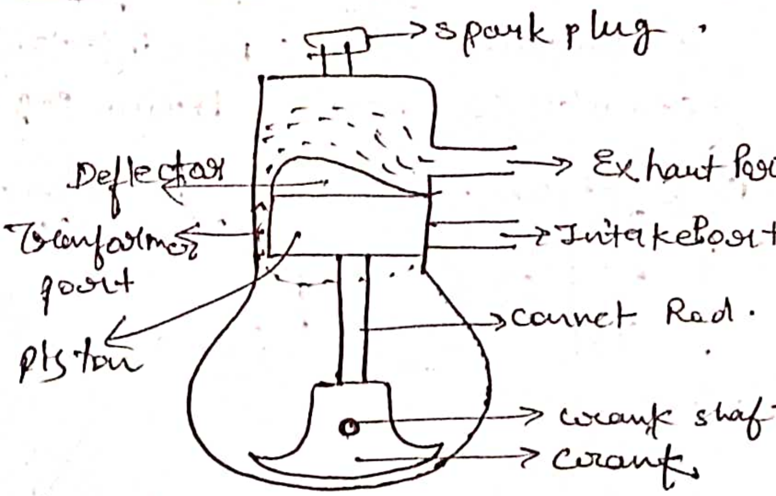
Two stroke

Cycle operations in two strokes of the piston or one revolution (360°) of the crank.

SI CI

Two Stroke SI.

Port
- inlet
- output
- transfer.



Compr + suction.
Exhaust Combn.

Scavanging Process → pushing burnt gas by fresh gas

CI Engine

Spark plug → fuel injector or nozzle.

4 Stroke.	2-Stroke.
4 stroke - 2 rev.	2 stroke 1 rev.
1 Power stroke in 2 revolution	1 power in each revolution
Power produce ↓	↑
Heavy flywheel	↓
lesser cooling requirement and lubrication.	High.
Contain valve	Ports.
Vol. eff and Ther. Eff ↑	↓
Heavy bulky	Light and compact

Refrigeration

It is a process of maintaing lower temp. compared to surrounding temp.

Refrigerant – substance used to produce lower temp.

Example – water, NH_3 . . . etc.

→ working → absorb heat at a low temp.
and. reject " " " high temp.

environment friendly – ethane propane, isobutane.

Unite of Refrigeration

It is the amount of heat that is to be removed from one tonne of water at zero (0°C) in order to convert it into ice at 0°C in one day (24 hrs.)

$$\text{water} \xrightarrow[0^\circ C]{\text{freezing}} \text{ice}$$

$$T.R. = 3.5\ kJ/s = 3.5\ kW = 210\ kJ/min.$$

Methods of Refrigeration

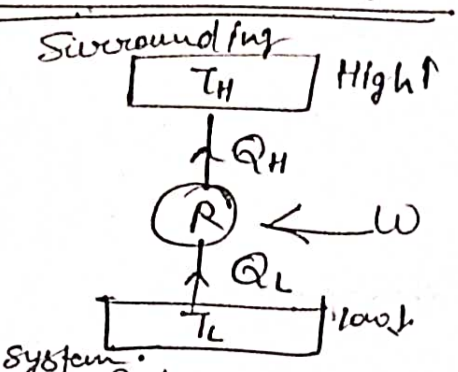
Natural
- Natural ice ref.
- Evaporitive cooling

Artificial
- Gas refrigeration sys
- Vap. compr ref. sys.
- Vap. abs " "

Refrigerator and Heat Pump.

working principle

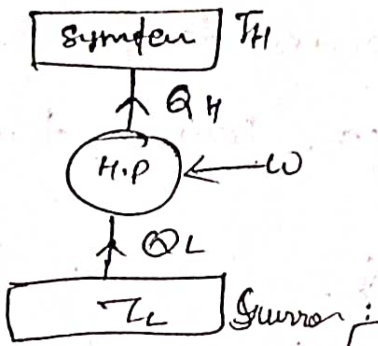
Clausius Statement : Impossible → device (high T body $\xleftarrow{\text{heat}\uparrow}$ Low T body) without external work.



Refrigerator.

$$COP_R = \frac{\text{Desired Effect}}{\text{Work Required}}.$$

$$COP_R = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L}$$



heat from Low T body → high T body. by consuming some work.

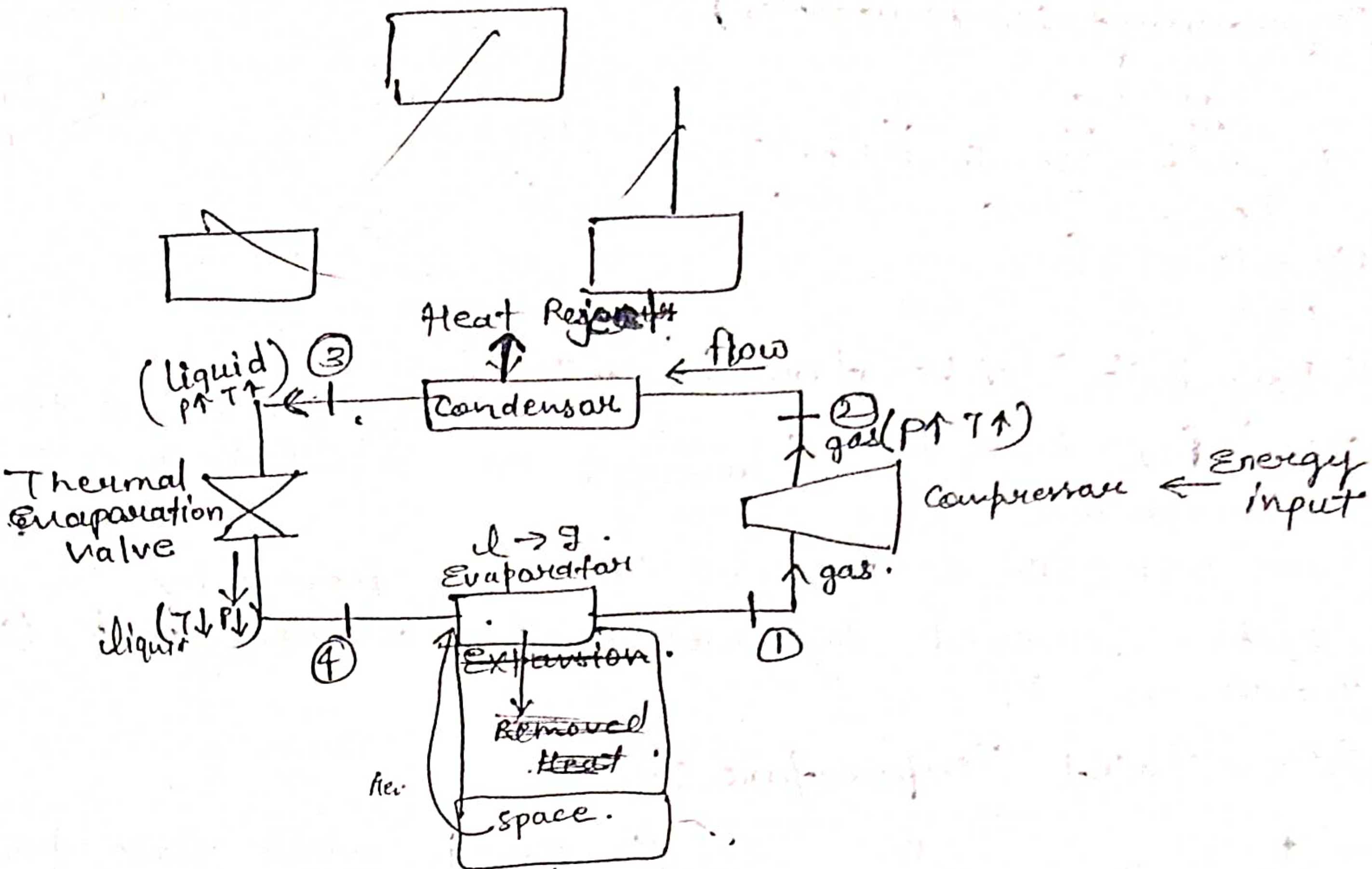
$$COP_{HP} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_L}$$

$$\boxed{COP_{HP} = COP_R + 1}$$

Could. COP > 1 ✓ (COP) ↑ → Running Cost ↓

But $\eta > 1$ ✗

Refrigerator.



Phase change - Eva, Cond.

Air Conditioning:

process of controlling air temp., humidity, ventilation, air circulation in space, and filtration and other gases.

Dry Air :- Mixture of N_2, O_2 and other gases.

Atmospheric Air :- Dry Air + Moisture + Pollutant

Saturated Air :- Air which hold water vapour at its highest level, i.e, just about to condense.

Specific Humidity :- / Absolute / humidity ratio. (ω)

$$\omega = \frac{\text{mass of water vapour}}{\text{mass of dry air}}$$

$$\omega = \frac{V/\rho_v}{V/\rho_a} = \frac{\rho_a}{\rho_v}$$

Relative Humidity :-

measure of how much water vapour in a water-air mixture compared to maximum amount possible.

$$\phi = \frac{\text{actual mass of w.v. in a given volume}}{\text{max. mass of w.v. in a given volume}}$$

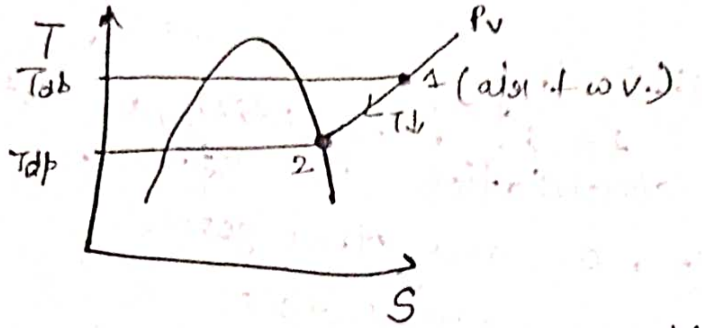
Moist air → Water Vap. + dry.
↓ properties
(Psychrometric properties)

↓ Dry bulb Temp. (Actual Temp.) (Bare.
↓ Wet bulb Temp
↓ Dew point Temp

1) Dry bulb Temperature :- (T_{db} or T)
Its thermometer has bare bulb which is directly exposed to air and measure the actual temp.

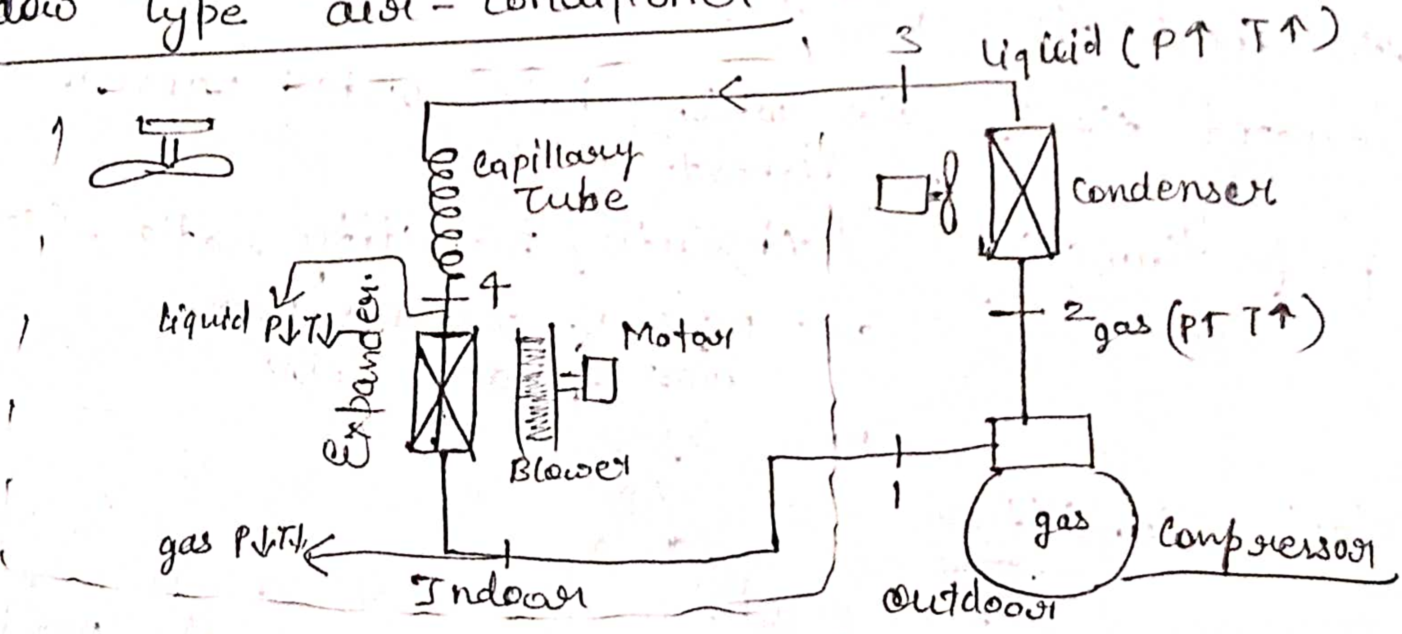
2) Wet Bulb Temperature :- T_{wb} temp. measu. by bulb is covered by wet wick, a covered bulb is known as are —

3) Dew Point Temperature :-



(temp. at which first drop of dew is formed are from where condensation starts.)

Window Type air - conditioner :-



Expander → liquid → gas
(by absorbing heat from Room)

Specification .

1) Capacity ÷ Ton
2) dimension – l x b x h
3) Power supply – A C, – 220-240V
4) Control – site or remote