Integrating both side

$$\int dw = \int_R^{\infty} \frac{GMm \cdot dx}{x^2}$$

$$w = \int dw = GMm \int_R^{\infty} \frac{1}{x^2} \cdot dx$$

$$w = GMm \left[\frac{x^{-2+1}}{-2+1} \right]_R^{\infty}$$

$$w = GMm \left[\frac{-1}{\infty} + \frac{1}{R} \right]$$

$$w = \frac{GMm}{R}$$

As, $K \cdot E = w$

$$\frac{1}{2} \cancel{m} v_e^2 = \frac{GM\cancel{m}}{R}$$

$$v_e^2 = \frac{2GM}{R}$$

$$v_e = \sqrt{\frac{2GM}{R}} \quad \text{as, } GM = gR^2$$

$$v_e = \sqrt{\frac{2gR^{\cancel{2}}}{\cancel{R}}}$$

$$v_e = \sqrt{2gR}$$

$$v_e \cong 11.2 \text{ kms}^{-1}$$

30/12/23

Unit = 7

Properties of Bulk matter ~~and~~ Radiations

Chapter - I[st]

'Elasticity'

* **Deforming force:** Deforming force is a force which changes shape and size of a body.

* **Restoring force:** The force which helps to regain its original shape and size after removal of deforming force is called restoring force.

* **Elasticity:** The property of material of body to regain its original shape and size after removal of deforming force is called Elasticity.

* **Perfectly Elastic body:** A body which regain 100% its original shape and size after removal of deformin force is called perfectly elastic body. Their is no body which is perfectly elastic but Quartz and Phosphorus Bronze are nearly perfectly elastic body.

* **Perfectly Plastic body:** A body which does not regain its original shape and size at all after removal of deforming force. is called perfectly plastic body. No body is perfectly plastic body but Paraffin wax are examples of nearly plastic body.

* **Elastic limit:** Elastic limit is the largest value of deforming force upto which the body will regain it's shape and size after removal of deforming force. Elastic limit is the property of body whereas Elasticity is the property of material of body.

* **Elastic fatigue**:- It is the property of an elastic body due to which it's elastic behaviour becomes less elastic under the action of repeated deforming force.

* **Stress**: The internal restoring force acting per unit area of a deformed body is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area}}$$

$$\text{Stress} = \frac{F}{A}$$

S.I unit of stress is N/m^2

Dimensional formula $[M^1L^{-1}T^{-2}]$

Imp...

∵ For perfectly elastic body restoring force will be equal to Deforming force.

* **Types of Stress**: Their are two types of stress.

i) **Normal Stress**: When a deforming force acts Normally ($\perp$) over an area of body then ratio of normal restoring force per unit area is known as normal stress.

Normal force changes size of body (length, Area, Volm) but do not change shape of body. There are 3-types of normal stress.

a) **Tensile stress**: If there is an increase in length of a body then normal streching force acting per unit area is called tensile stress.

b) **Compressive stress**: If there is decrease in length of a body then normal compressive force acting per unit area is called comp. stress.

Hydraulic

(c) **Hydrolic stress**: The hydralic force (Thrust) acting per unit area is called Hydraulic Stress. It deals with fluids. like gases and liquids.

* 2) **Tangential stress**: A tangential force change in shape of a body it does not change Volm of body.

The tangential restoring force per unit area is called tangential stress. It is also known as shearing stress.

* **Strain**: When a deforming force is applied on a body, a change in shape, size, volm etc. of the body take place.

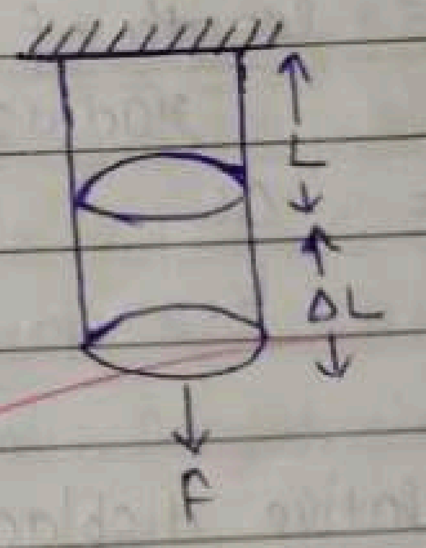
The ratio of change in configuration is called strain.

S.I unit of strain is ——— no unit

Dimensional formula ——— doesn't exist

* **Types of Strain**: There are three types of strain.

1) **Longitudinal Strain**:



The ratio of change in length to original length is called longitudinal strain.

$$\text{longitudinal strain} = \frac{\Delta L}{L}$$

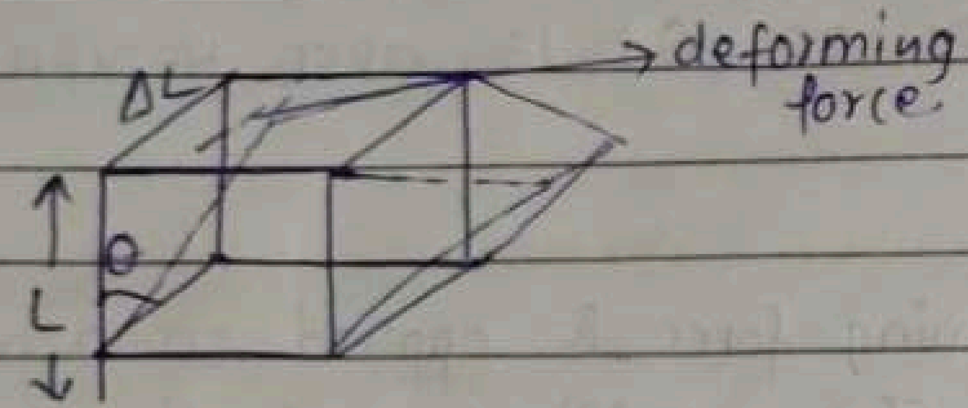
It will be unitless or dimensionless.

ii) **Volumetric Strain**: The ratio of change in vol^m to original vol^m is called volumetric strain.

$$\text{Volumetric strain} = \frac{\Delta V}{V}$$

It will be unitless, dimensionless.

iii) **Shearing (Tangential) Strain**:



When a tangential force is applied, it changes shape of body. If lower plane is fixed than their is relative displacement of upper plane w.r.t lower plane takes place.

The angle by which shape of body changes is called shearing strain.

$$\text{Shearing Strain} = \theta$$

$$\text{or } \theta = \frac{\text{length of arc}}{\text{radius}}$$

$$\theta = \frac{\Delta L}{L}$$

OR

It is ratio of relative displacement (ΔL) of one plane to the ⊥ar dist. (L) from fixed plane.

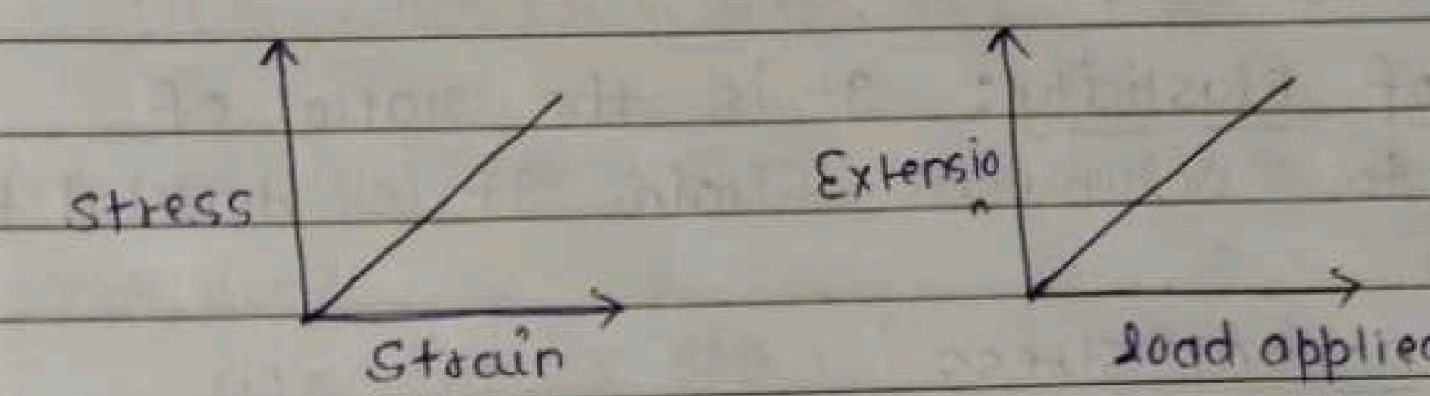
* **Hook's law in elasticity**: Within elastic limit, stress will be directly prop. to strain produced in the body i.e

stress $\propto$ strain.

OR

Within elastic limit, extension in body will be directly prop. to load applied.

extension $\propto$ load applied



* **Modulus of elasticity**:

From Hook's law

stress $\propto$ strain

stress = E · strain

where E is called coff. of elasticity

$$E = \frac{\text{Stress}}{\text{Strain}}$$

Unit of E = Nm^{-2}

Dimensional formula = $[M^1 L^1 T^{-2}][L^{-2}] = [M^1 L^{-1} T^{-2}]$

* **Types of Modulus of elasticity**: There are three types of modulus of elasticity.

i) **Young's Modulus of elasticity**: It is the ratio of longitudinal stress to longitudinal strain. It is denoted by Y.

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$

as, longitudinal stress = $\frac{F}{A}$

longitudinal strain = $\frac{\Delta L}{L}$

$$Y = \frac{F/A}{\Delta L/L}$$

Unit of $Y = Nm^{-2}$

D.F of $Y = [M^1L^{-1}T^{-2}]$

2) **Bulk Modulus of Elasticity:** It is the ratio of normal stress to volumetric strain. It is denoted by 'B' or 'K'

$$K = \frac{\text{normal stress}}{\text{Volumetric strain}}$$

$$\text{volmetric strain} = \frac{\Delta V}{V}$$

$$K = \frac{F/A}{\Delta V/V}$$

Unit of $K = Nm^{-2}$

$D.F = [M^1L^{-1}T^{-2}]$

3) **Modulus of Rigidity:** It is the ratio of tangential stress to shearing strain. It is denoted by 'η'

$$\eta = \frac{\text{tangential Stress}}{\text{Shearing strain}}$$

(ita) $\eta = \frac{F/A}{\phi}$

as, $\phi = \Delta L/L$

So,

$$\eta = \frac{F/A}{\Delta L/L}$$

Unit of $\eta = Nm^{-2}$

$D.F = [M^1L^{-1}T^{-2}]$

* **Elastic P.E of a streched wire:**

Consider a wire of length 'L' having area of cross-section 'A'. Let a deforming force applied on wire increases from 0 to F.

Then average deforming force is $= \frac{0+F}{2} = F/2$

Let 'ΔL' be the small extension in the wire. 'ω' be the work done.

ω = Force x disp.

$\omega = F/2 \times \Delta L$

as work done is stored in the form of elastic p.e then,

$E.P.E = \omega = \frac{1}{2} \times F \times \Delta L$

Now, Elastic P.E $= \frac{1 \times F \times \Delta L \times AL}{2 \times AL}$

$= \frac{1}{2} \times \frac{F}{A} \times \frac{\Delta L}{L} \times AL$

as, $\frac{F}{A}$ = Stress, $\frac{\Delta L}{L}$ = Strain

$AL = vol^m$.

Elastic P.E $= \frac{1}{2} \times$ Stress $\times$ Strain $\times$ vol^m

as Young's Modulus of elasticity $= \frac{\text{Stress}}{\text{Strain}}$ = Y x strain = stress

or strain $= \frac{\text{Stress}}{Y}$

Elastic P.E $= \frac{1}{2} \times Y \times$ strain $\times$ strain $\times$ vol^m

$\frac{1}{2} \times Y \times (\text{Strain})^2 \times \text{vol}^m$

Elastic P.E $= \frac{1}{2} \times$ stress $\times \frac{\text{stress}}{Y} \times$ vol^m

It consist of a master cylinder 'M'. A large piston 'P' and two small pistons P_1 and P_2. The master cylind. filled with breake oil. The piston P is connected to break pedal. Small piston P_1 and P_2 are connected to break shoe S_1 and S_2.
When breaks are applied, we press pedal F. Due to this piston P is pushed inwards. So, a press. is created. Acc to pascal law equal press is shared by piston P_1 and P_2. Piston P_1 and P_2 will push break shoe S_1 and S_2. As a result breaks are applied.

* **Atmospheric pressure**: The pressure exerted by atmosphere is called atmospheric pressure. The value of atmospheric press. is $1.01 \times 10^5 Nm^{-2}$ or 1.01×10^5 pascal or 1.01×10^6 $dyn.cm^{-2}$ or 76cm of mercury atom.
It is measured by Barometer.

* **Buoyant force or Buoyency**: The upward force exerted by fluid on a body when body is immersed in the fluid is called buoyant force.
The process is called Buoyency.

Buoyant force $(F_B) = mg$

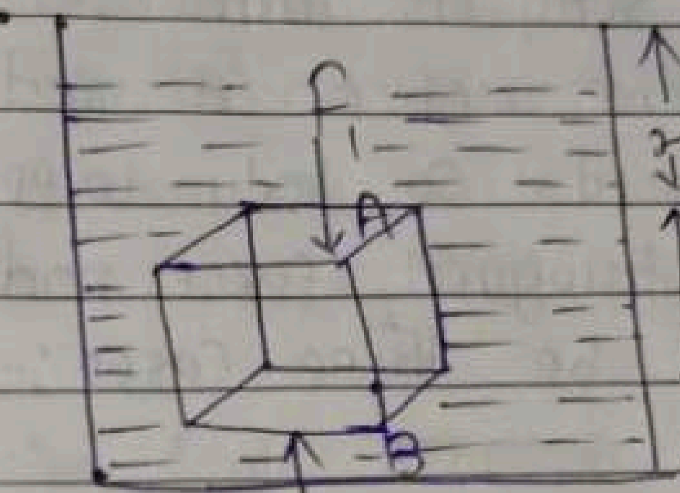
$F_B = \rho . V . g$

Where, ρ = density of fluid

$V = Vol^m$, g = acc. due to gravity.

* **Archimede's Principle**: When a body is immersed in a fluid, loss in weight of body take place. This loss in weight will be equal to weight of fluid displaced by body.

Proof:



Consider a liquid of density 'ρ' is filled in a container. A vessel of cubic shape is immersed in liquid. Let 'F_1' be the force exerted by upper F_2 layer of liquid and P_1 be the pressure exerted.

As, we know

$P = h \rho g$

$P_1 = x \rho g$

$P_1 = \frac{F_1}{A}$

Where 'a' is area of upper force

$F_1 = P_1 a$

$F_1 = x \rho g a$ — i)

let 'F_2' be the force exerted by lower liquid on face 'B'. 'P_2' be the pressure exerted

$P_2 = (x+h) \rho g$

$P_2 = \frac{F_2}{a}$

$F_2 = P_2 a$

$= (x+h) \rho g a$ — 2)

Net force on the vessel $= F_2 - F_1$

Net force $= (x+h) \rho g . a - x \rho g a$

Net force $= h \rho g a$

$= V \rho g$ [$h.a = Vol^m$]

Net force $= mg$ [$V.\rho = Mass$]

Where 'mg' is weight of liquid displaced by vessel which is equal to buoyant force.

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Total force on cylinder

$mg + F_1 = F_2$

as, $M = \rho A h$

$F_1 = \rho A h g = F_2$

$P_1 A + \rho A h g = P_2 A$

$\cancel{A}(P_1 + \rho h g) = P_2 \cancel{A}$

$P_1 + \rho h g = P_2$

$P_2 - P_1 = \rho h g$

So, with increase in depth, press exerted by liq. increases

Special case :- If $h = 0$

$P_2 - P_1 = 0$

$P_2 = P_1$

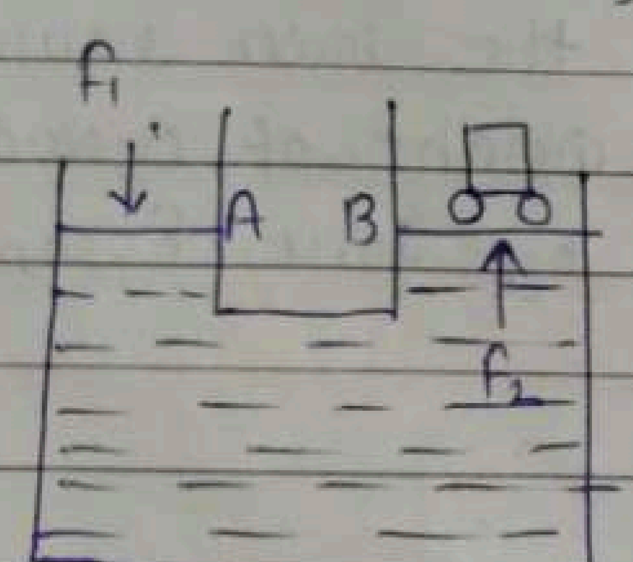
* **Pascal's law**: If effect of gravity is neglacted then press at all points inside liq. will be same.

OR

It states that the pressure exerted at 1 point on a liq. will be equally transmitted to all other points of the liq. i.e $P_1 = P_2$

Applications of Pascal's law:

1) **Hydraulic lift**: It is used to lift heavy loads. Its working is based on pascals law.



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Working: A hydraulic lift consist of two pistons, one small and other large. A and B are two pistons. The piston are ~~ai~~ tight piston. A has smaller area of cross-section while piston B has large area of cross section. let 'a' be the area of cross-section of piston 'A' and 'A' be the area of cross-section of piston 'B'. when force F_1 is applied on piston A. it apply force on the liq. and the liquid will apply force on piston 'B'. According to Pascal law

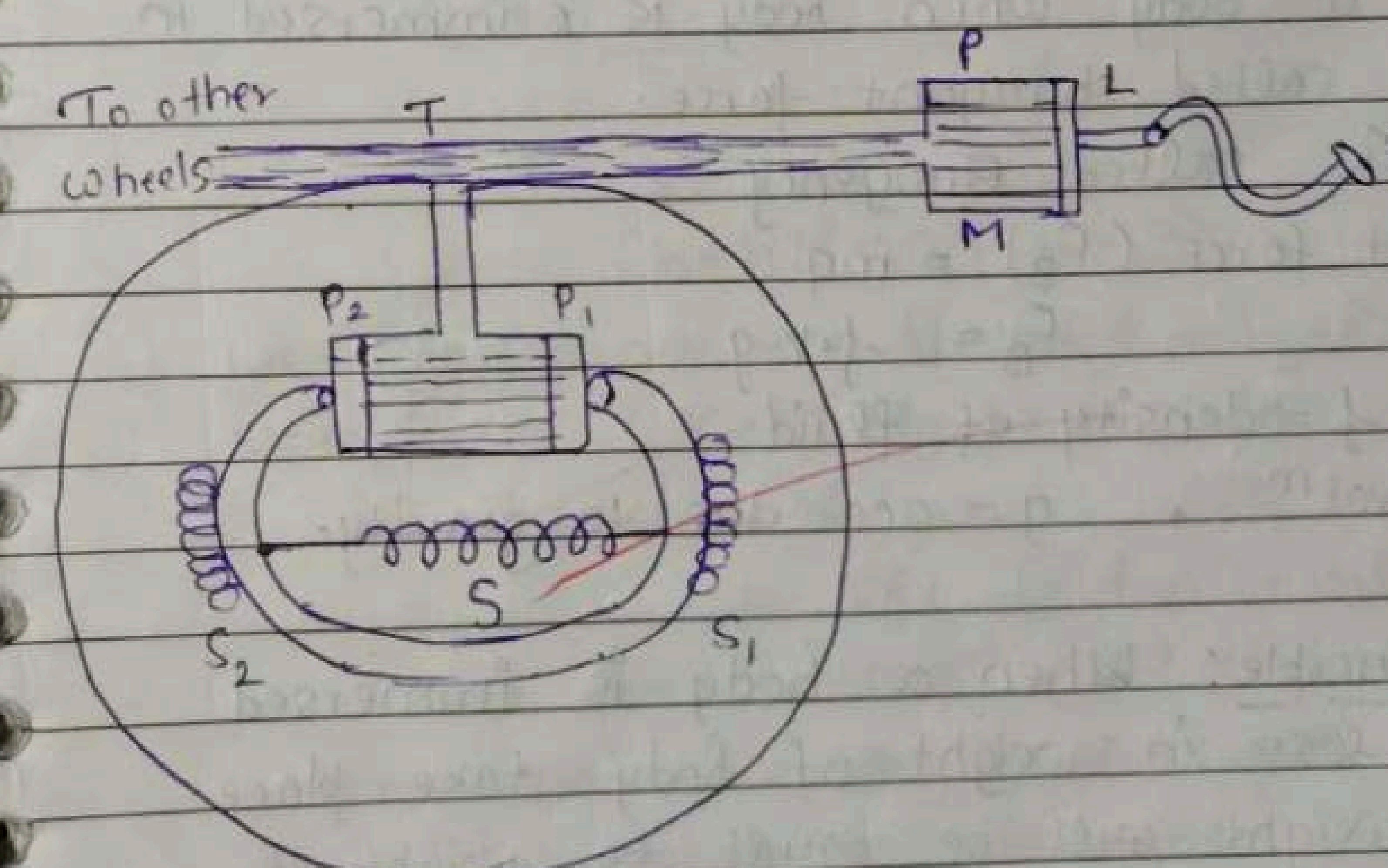
$P_1 = P_2$

$\frac{F_1}{a} = \frac{F_2}{A}$

$\frac{F_2}{F_1} = \frac{A}{a}$

$A >> a$ then $F_2 >> F_1$

2) **Hydraulic Breaks**: These are used in automobiles vechiles for applying breakes. It's working is based on pascal law.



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CHAPTER = 2

: Hydrostatics :

* **Hydrostatics:** Hydrostatic is the branch of physics which deals with study of properties of fluids at rest.

* **Fluid:** Fluids are the substances which begin to flow when external force is applied on them. Liquids and gases are examples of fluids.

Properties:

i) They have definite volm.

2) They do not have definite shape.

3) Fluids exert force on container wall.

* **Thrust:** The force exerted by fluid on container wall is called thurst. It's S.I unit is 'N'.

D.F = $[M^1 L^1 T^{-2}]$

* **Pressure of fluid:** Thrust exerted by fluid per unit area is known as hydrostatic press.

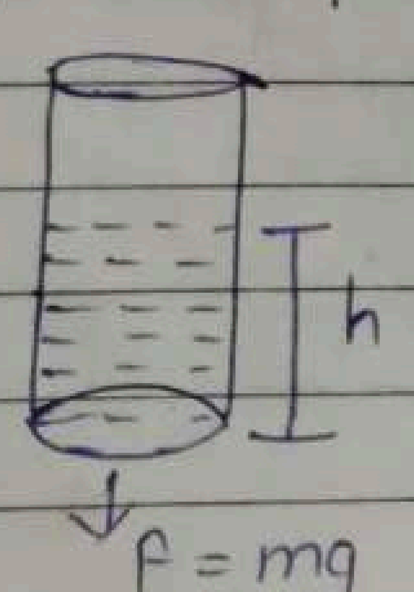
$P = \frac{F}{A}$ S.I unit of Press. Nm^{-2}

$D.F = \frac{[M^1 L^1 T^{-2}]}{[L^2]}$

$= [M^1 L^{-1} T^{-2}]$

It is Scalar quantity.

* **Expression for press. exerted by liquid (fluids) :-**



Consider a cylindrical container having a liq. of density 'ρ' filled up to height 'h'. 'A' be the area of container.

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$\vec{F}$ be the force exerted by liquid.

$F = mg$ — i)

as density 'ρ' = $\frac{Mass}{Volm}$

$\rho = \frac{M}{V}$

$\rho = \frac{M}{A \times h}$

$M = \rho \cdot A \cdot h$ — 2)

Let 'P' be the press. exerted by liq.

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

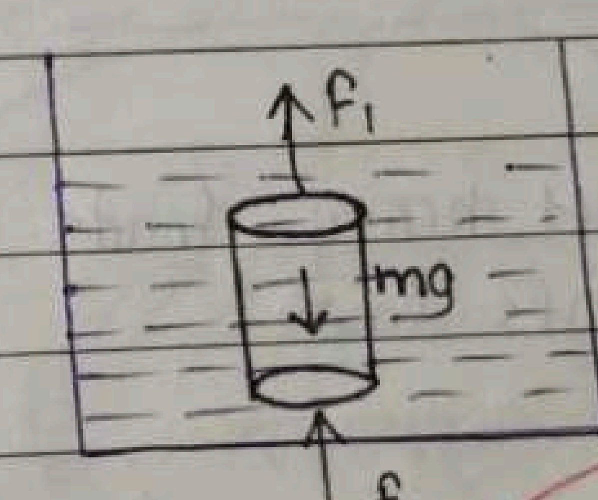
using eqn i) and ii)

$P = \frac{mg}{A}$

$= \frac{\rho \cdot \cancel{A} \cdot h \cdot g}{\cancel{A}}$

$P = \rho \cdot h \cdot g$

* **Variation of press. with depth:**



Consider a cylinder placed in a liq. let three faces on the cylinde

F_1 = exerted by upper liquid.

F_2 = exerted by the lower liquid

mg = be the weight of cylinder

P_1 and P_2 be the press exerted by force F_1 and F_2 resp.

$P_1 = \frac{F_1}{A}$, $P_2 = \frac{F_2}{A}$

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Elastic P.E = $\frac{1}{2} \times \frac{(\text{Stress})^2}{Y} \times \text{Vol}^m$

as, Elastic P.E density = $\frac{\text{Elastic P.E.}}{\text{Vol}^m}$

$\Rightarrow$ Elastic P.E density = $\frac{1}{2} \times$ stress $\times$ strain

or elastic P.E density = $\frac{1}{2} \times Y \times (\text{Strain})^2$

Elastic P.E density = $\frac{1}{2} \times \frac{(\text{stress})^2}{Y}$

* **Poisson's Ratio:** It is the ratio of lateral strain to longitudinal strain.

Poission's Ratio = $\frac{\text{lateral strain}}{\text{longit. strain}}$

as, lateral strain = $-\frac{\Delta R}{R}$ $\left(\frac{\text{Change in radius}}{\text{Original Radius}}\right)$

longitudinal strain = $\frac{\Delta L}{L}$

Poission's Ratio = $\frac{-\frac{\Delta R}{R}}{\frac{\Delta L}{L}} = \frac{-\Delta R \times L}{R \times \Delta L} = \frac{-L}{R}\frac{\Delta R}{\Delta L}$

It is denoted by 'σ'

It is unitless, dimensionless

In terms of diameter

$\sigma = \frac{-\frac{\Delta D}{D}}{\frac{\Delta L}{L}}$

$\sigma = \frac{-L}{D} \times \frac{\Delta D}{\Delta L}$

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* **Thermal stress:** When a rod fixed b/w two ends is heated, its length increases.
Let 'L' be the length of rod, 'ΔL' be the extension in length and ΔT be the temp. provided to the rod.

Then, $\Delta L \propto L$ — i)
or $\Delta L \propto \Delta T$ — 2)
Compareing eqn 1) and 2)
$\Delta L \propto L \Delta T$
$\Delta L = \alpha L \cdot \Delta T$
where 'α' is called proportionally constant.

$\frac{\Delta L}{L} = \alpha \cdot \Delta T$

Where, $\frac{\Delta L}{L}$ is called thermal stress.

For solids:

$Y = \frac{\text{Thermal Stress}}{\text{Thermal Strain}}$

$Y = \frac{\text{Thermal stress}}{\alpha \cdot \Delta T}$

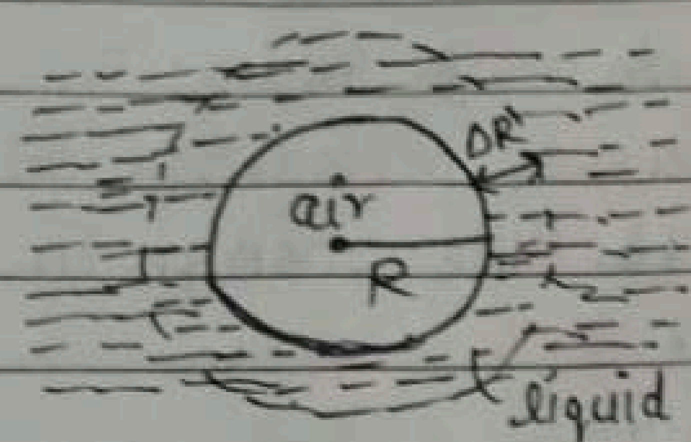
Thermal stress = $Y \cdot \alpha \cdot \Delta T$

* **Relation b/w Y, B, η, σ**

i) $Y = 2B(1 - 2\sigma)$
2) $Y = 2\eta(1 - \sigma)$
3) $\sigma = \frac{3B - 2\eta}{2\eta + 6B}$

4) $\frac{9}{Y} = \frac{1}{B} + \frac{3}{\eta}$

* Excess press. inside an Air bubble in water :

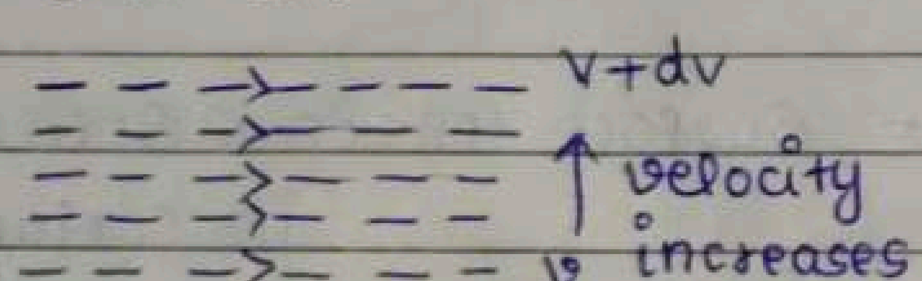


Similar to excess pressure inside a liquid drop.

CHAPTER = 3
Hydrodynamics

* It is the branch of physics which deals with study of fluids during their motion.

* Viscosity :-



The property by which fluid layer oppose their relative motion is called viscosity.

OR

The property by which internal friction b/w diff. layer of fluids takes place which opposes their relative motion is called Viscosity.

Let us consider a fluid flowing in layers. The velocity of fluid in diff. layers will increase as we go from bottom to top.
Let 'dv' be the small change in velocity
'dx' be the small gap b/w layers
'a' be the area of layers
'F' be the viscous force.

Then force is
$F \propto A$ — i)
$F \propto \frac{dv}{dx}$ — ii)

Where $\frac{dv}{dx}$ is called velocity gradient

From eqⁿ ① and ②
$F \propto A \cdot \frac{dv}{dx}$

$$\boxed{F = \eta \cdot A \cdot \frac{dv}{dx}}$$

Unit of coff. of viscosity (η) is 'Poise'
Dimensional formula $= \frac{F \cdot dx}{A \cdot dv}$

$$= \frac{M^1L^1T^{-2} \times L}{L^2 \times LT^{-1}}$$

$$\boxed{\eta = [M^1L^{-1}T^{-1}]}$$

* Factors affecting viscosity :

i) If temp. is increased, the viscosity of liquid decrease.
2) If press. is increased, viscosity of liquid decrease except water. ~~Velocit~~ Viscosity of water increases with increase in press. While viscosity of gases do not change with press.

* Stoke's law:

If a body is dropped in a container filled with fluid then fluid will apply an opposing force (viscous force on the body) Acc. to this law, viscous force is given by

$$F = 6\pi r \eta v_t$$

Where, 'r' is radius of body
η = coff. of viscosity.
v_t = terminal velocity.

consider a liquid drop or radius 'R'. Let 'P' be the excess pressure inside liquid drop. 'ΔR' be the change in radius of drop.

Then, 'W' be the workdone

$W = \text{Force} \times \text{disp.}$

$W = F \times \Delta R$

as, $\text{Press.} = \frac{\text{Force}}{\text{Area}}$

$$P = \frac{F}{4\pi R^2}$$

$$F = P \cdot 4\pi R^2 \quad \text{--- i)}$$

$$W = P \cdot 4\pi R^2 \cdot \Delta R$$

Then,

Surface energy $= \omega =$ Surface tension $\times$ increase in Surface area

Increase in Surface area = final Surface Area − Initial Surface

$$\text{Increase in Surface area} = 4\pi(R+\Delta R)^2 - 4\pi R^2$$
$$= 4\pi(R^2 + \Delta R^2 + 2R\cdot\Delta R) - 4\pi R^2$$

as, ΔR is small so ΔR^2 will be neglected

Thus,

$$\text{Increase in Surface area} = \cancel{4\pi R^2} + 8\pi R\cdot\Delta R - \cancel{4\pi R^2}$$
$$= 8\pi R\cdot\Delta R$$

Surface energy $= \omega = S \times 8\pi R\cdot\Delta R$

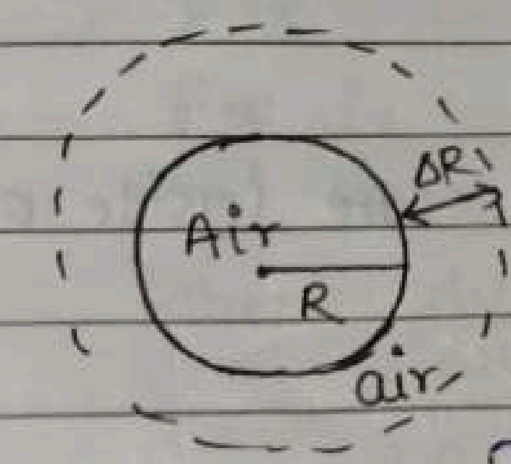
Equating i) and ii)

$$P \cdot 4\pi R^2 \cdot \Delta R = S \times 8\pi R \cdot \Delta R$$

$$P = \frac{2S}{R}$$

where 'S' is Surface tension and 'R' is radius of liq. drop

*Excess press. inside a soap bubble :



consider a Soap bubble of Radius 'R' let 'P' be the excess pressure inside Soap bubble. 'ΔR' be the change in radius of bubble.

Then, 'W' be the workdone

$W = \text{Force} \times \text{disp.}$

$W = F\cdot\Delta R$

as, $\text{Pressure} = \frac{\text{Force}}{\text{Area}}$

$$P = \frac{F}{4\pi R^2}$$

$$F = P \cdot 4\pi R^2$$

$$W = P\cdot 4\pi R^2 \cdot \Delta R \quad \text{--- i)}$$

Then,

Surface energy $= \omega =$ Surface tension $\times$ Increase in Surface area

Increase in Surface area = 2 [Final Surface area − Initial Surface

Because there are two free surfaces.

$$\text{Increase in Surface area} = 2[4\pi(R+\Delta R)^2 - 4\pi R^2]$$
$$= 2[4\pi(R^2 + \Delta R^2 + 2R\cdot\Delta R] - 4\pi R^2$$

as, ΔR is small so ΔR^2 will be neglacted

Thus,

$$\text{Increase in Surface area} = 2[\cancel{4\pi R^2} + 8\pi R\cdot\Delta R - \cancel{4\pi R^2}]$$
$$= 16\pi R\cdot\Delta R$$

Surface energy $= W = S\cdot 16\pi R\cdot\Delta R$ --- ii)

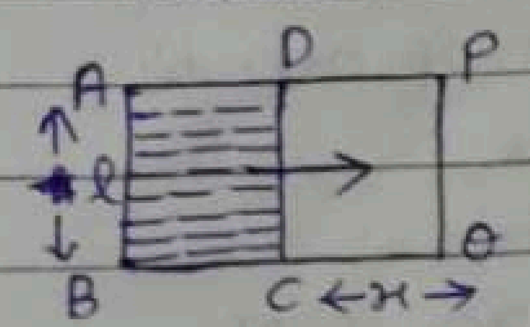
Equating ① and ②

$$P\cdot 4\pi R^2\cdot\Delta R = S \times 16\pi R\cdot\Delta R$$

$$P = \frac{4S}{R}$$

Where 'S' is Surface tension and R is radius of soap bubble

* **Surface Energy:** Workdone against surface tension to increase surface area is called surface energy.



Consider a surface ABCD of length 'l'. Let CD be the free surface on which a Force 'F' is exerted.

'x' be the displacement of the surface.

Now, workdone(w) = Force × displacement

$= F \times x$ —— (i)

Let 's' be the surface tension

$S = \frac{F}{l+l}$ [Total length of free surface $= l+l$]

$S = \frac{F}{2l}$

$F = S \cdot 2l$

Put this value in eq^n (i)

$W = S \cdot 2l\, x$

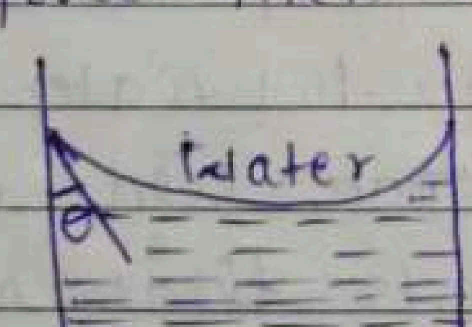
So, Surface energy $= w = S \cdot 2l \cdot x$

as, $2 \cdot l \cdot x$ = Surface area

$$\boxed{\text{Surface energy} = \text{Surface tension} \times \text{increase in Surface area}}$$

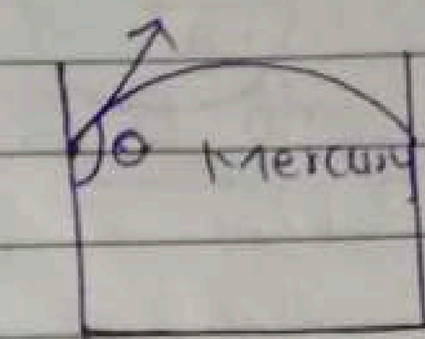
* **Angle of Contact:** The angle b/w solid surface and a tangent of liquid surface is known as angle of contact.

→ i) If Adhesive force > cohesive force then a concave meniscus will be formed.



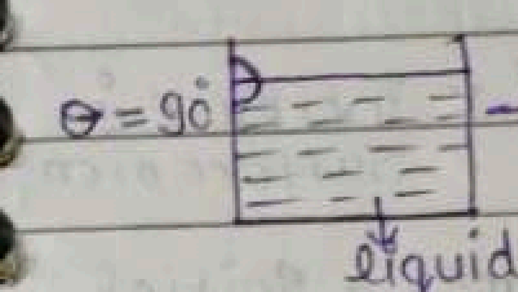
So, angle of contact will be an acute angle (less than 90°)

→ If Adhesive force < Cohesive force then a convex meniscus will be formed.



So, angle of contact will be an obtuse angle (More than 90°)

→ If Adhesive force = cohesive force than a plane meniscus will be formed.



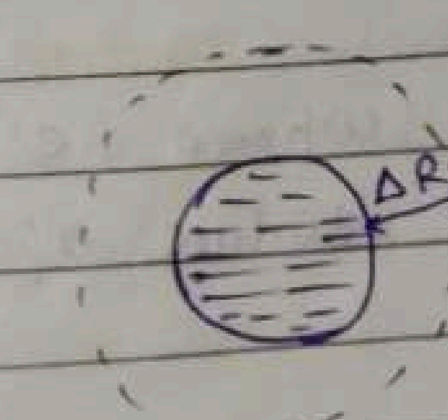
So, angle of contact will be 90°

* **Factors affecting angle of contact:**

i) Nature of solid and liquid in contact.
2) Temp. of liquid.
3) Medium above free surface of liquid

* **Excess pressure:** Excess pressure is the pressure difference b/w two sides of surface. Due to excess press. the surface will either lower meniscus or upper meniscus. Due to excess press. Surface area of surface increases.

* **Excess pressure due to a liquid drop:**



*** Laws of floatation:** When a body is immersed in a fluid an upward buoyant force act on it and weight of body acts downward. So, body will float or not, it will depend on buoyant force and weight of body. There will be three cases:-

Case (i):- The buoyant force is greater than weight of body i.e

$f_B > \omega$

$mg > Mg$

$m > M$ — M is mass of body

where 'm' is mass of liquid displaced

If density of body is less than density of fluid then the body will float on the surface of fluid.

Case (ii):- If buoyant force is less than weight

i.e $f_B < \omega$

$mg < Mg$

$m < M$

Thus $\rho < \sigma$

If density of body greater than density of fluid then body will sink into the fluid.

Case (iii):- If buoyant force is equal to weight of body

i.e $f_B = W$

$mg = Mg$

$m = M$

then, $\rho = \sigma$

If density of a body is equal to density of fluid then the body will remain in eqbm inside the fluid.

*** Adhesive force:** The force of attraction b/w molecules of two diff. surfaces are called adhesive forces.

Ex: When we write on paper, the force of att. b/w ink and paper molecules.

*** Cohesive force:** The force of att. b/w molecules of same substance are called cohesive force.

Ex: Solids have definite shape and size due to their strong force of cohesive.

*** Molecular Range:** The max. distance upto which a molecule applies force on other molecules is known as Molecular Range.

*** Surface Tension:** The property of fluid due to which it tends to minimize it's surface area is called Surface tension.

It arises due to cohesive force.

Mathematically surface tension is the ratio of force per unit length of the surface. It is denoted by 'S'.

$S = \frac{F}{L}$ where, F = Force, L = Length of surface.

S.I unit is Nm^{-1}

$D.F = \frac{[M^1L^1T^{-2}]}{[L^1]} = [M^1L^0T^{-2}]$

*** Applications of Surface tension:**

1) Rain drops are generally spherical in shape.
2) Oil drop spread on the surface of cold water but remain as drop on hot water because surface tension of oil is less than cold water but greater than hot water.
3) Small insects float on water surface.

* **Reynold number:** It is a pure no. which determines type of flow. It is denoted by N_R.

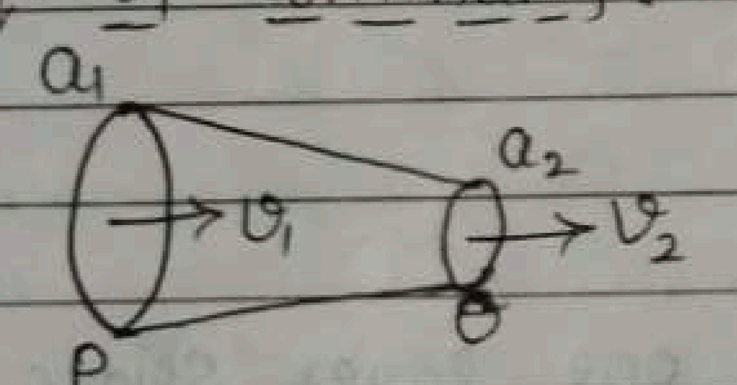
$$N_R = \frac{v_c \cdot \rho \cdot D}{\eta}$$

If $N_R < 2000$ then flow is streamline | laminar flow.

If $N_R > 3000$ then flow is turbulent flow.

If $2000 < N_R < 3000$, then flow is unstable. Sometimes flow becomes laminar while sometimes it become turbulent.

* **Eqⁿ of continuity:**



Velocity of fluid coming out from a hole is inversly prop. to area of cross-section of hole such that,

$$v \propto \frac{1}{a}$$

Where 'v' is velocity of fluid

'a' is area of cross-section

$$v = \frac{K}{a}$$

$$av = \text{constant}$$

This is called eqⁿ of continuity.

* **Proof:** Consider a pipe of variable cross-section. Area of cross-section of end P is greater than that of end Q

Then mass of fluid at end P = mass of fluid at end Q

$$m_1 = m_2$$

Let 'ρ' be the density of fluid, V_1 and V_2 be the volᵐ of fluid at end P and Q resp.

$$\rho V_1 = \rho V_2$$

$$V_1 = V_2$$

Dividing by 't' throughout

$$\frac{V_1}{t} = \frac{V_2}{t}$$

as, $V = a \cdot d$

where 'd' is distance travelled by fluid

$$\frac{a_1 d_1}{t} = \frac{a_2 \cdot d_2}{t}$$

$$a_1 v_1 = a_2 v_2 \quad [\because \frac{d}{t} = v]$$

$$\Rightarrow av = \text{constant}$$

* **Energy of fluid:** There are three types of energy in a flowing fluid — kinetic energy, potential energy and pressure energy.

1) **K.E** → The energy which comes due to motion of fluid is known as K.E. It is given by $\frac{1}{2}mv^2$

K.E per unit volᵐ is given by

$$\frac{K.E}{V} = \frac{\frac{1}{2}mv^2}{V} = \frac{1}{2}\rho v^2$$

2) **P.E** → The energy possessed by fluid due to it's height or position above a referance is known as P.E

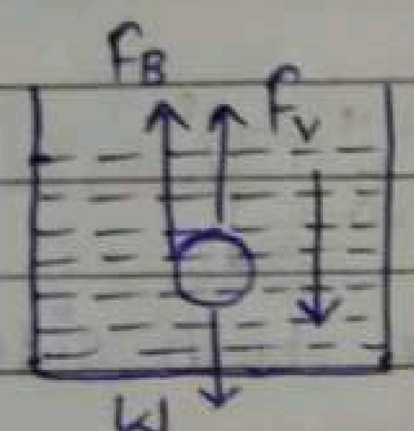
It is given by $P.E = mgh$

Potential energy per unit volᵐ is given by

$$\frac{mgh}{V} = \rho gh$$

* **Terminal velocity:** It is the maximum constant velocity acquired by body while falling freely in a fluid. It is denoted by 'v_t'

$$v_t = \frac{2}{9}\frac{(\sigma-\rho)r^2 g}{\eta} \quad (i\,t\,a)$$



Consider a body of Mass 'M' is immersed in a fluid with a velocity 'v_t'. 'W' be the weight of body acting in downward direction. F_B be the Buoyant force and F_v be the viscous force acting in upward

$W = Mg$

F_B = Weight of liquid displaced

$= mg$

$F_B = mg$

$F_v = 6\pi\eta r v_t$

Net force acting on body is $= W - [F_B + F_v]$

$Ma = W - (F_B + F_v)$

As velocity is constant then $a = 0$

$0 = W - (F_B + F_v)$

$W = F_B + F_v$

$Mg = mg + 6\pi\eta r v_t$

let σ and ρ be the density of body and fluid.

Then,

$Mg - mg = 6\pi\eta r v_t$

$(M-m)g = 6\pi\eta r v_t$

$(\sigma-\rho)Vg = 6\pi\eta r v_t$

$$v_t = \frac{(\sigma-\rho)V\cdot g}{6\pi r\eta}$$

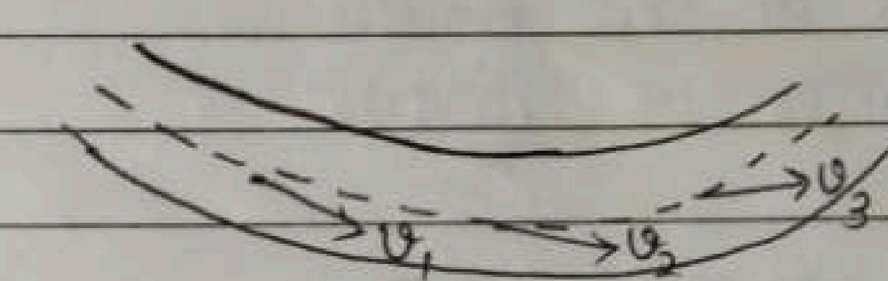
as, $V = \frac{4}{3}\pi r^3$

$$v_t = \frac{(\sigma-\rho)\cdot\frac{4}{3}\times\cancel{\pi}r^{\cancel{3}\,2}\times g}{\cancel{6}_{3}\cancel{\pi}\eta\cancel{r}}$$

$$\boxed{v_t = \frac{2}{9}\frac{(\sigma-\rho)r^2 g}{\eta}}$$

* **Types of flow:**

1) **Streamline flow:** The flow in which every particle of the liquid follows excatly the path and velocity of its preceeding particle is called Streamline flow.



2) **Laminar flow:** In this flow one layer slides over the other layer.

3) **Turbulent flow:** When velocity of liquid increases beyond a limit and becomes very high, the flow of fluid becomes irregular this irregular flow is called Turbulent flow.

4) **Critical Velocity:** The critical velocity is that velocity of flow after which flow type is changed from streamline to turbulent. It is denoted by v_c.

$$v_c = \frac{N_R\cdot\eta}{\rho\cdot D}$$

where, $N_R \rightarrow$ Reynold number.
$\eta \rightarrow$ coff. of viscosity
$\rho \rightarrow$ density of fluid
$D \rightarrow$ Diameter of tube.

Proof:

$F \propto r^a \eta^b v_t^c$

$F = K r^a \eta^b v_t^c \quad -(i)$

$[M^1L^1T^{-2}] = [L]^a [M^1L^{-1}T^{-1}]^b [LT^{-1}]^c$

$[M^1L^1T^{-2}] = [M^a L^{a-b+c} T^{-b-c}]$

Equating power of M, L, T

$b = 1$

$a - b + c = 1$

$-b - c = -2$

$b + c = 2$

$1 + c = 2$

$c = 1$

$a - \cancel{1} + \cancel{1} = 1$

$a = 1$

Put these value in eq^n i)

$F = K r^1 \eta^1 v_t^1$

$F = K r \eta v_t$

where $K = 6\pi$ [experimentally]

* Poiseuille formula: Acc. to this formula rate of flow of liquid is given by

$$V = \frac{\pi P r^4}{8 \eta l}$$

Where, V = vol^m flowing through pipe per unit time (rate of flow)

P = press. of liquid

r = radius of pipe

η = coff. of viscosity

l = length of pipe.

* Expression: Rate of flow of liquid $V \propto \left(\frac{P}{l}\right)^a r^b \eta^c$

$V = K\left(\frac{P}{l}\right)^a r^b \eta^c \quad$ —— *

$[M^0L^3T^{-1}] = \left[\frac{M^1L^{-1}T^{-2}}{L}\right]^a [L]^b [M^1L^{-1}T^{-1}]^c$

$[M^0L^3T^{-1}] = [M^1L^{-2}T^{-2}]^a [L]^b [M^1L^{-1}T^{-1}]^c$

$= [M^{a+c} L^{-2a+b-c} T^{-2a-c}]$

Equating power of M, L, T from both side

$a + c = 0 \quad -(1)$

$-2a + b - c = 3 \quad -(3)$

$-2a - c = -1 \quad -(2)$

Add eq^n ① and ②

$a + c = 0$

$-2a - c = -1$

$\cancel{-}a = \cancel{-}1$

$a = +1$

Put this value in eq^n (i)

$1 + c = 0$

$c = -1$

Put these value in eq^n (iii)

$-2 \times 1 + b + (-1) = 3$

$b - 1 = 3$

$b = 4$

Put these value in eq^n *

$V = K\left(\frac{P}{l}\right)^1 r^4 . \eta^{-1}$

$= \cancel{K\left(\frac{P}{l}\right)\frac{r^4}{\eta}}$

$$V = \frac{K P r^4}{\eta l}$$

Where, $K = \pi/8$

$$V = \frac{\pi}{8} \frac{P r^4}{\eta \cdot l}$$

$$L' = L(1+\alpha\cdot\Delta T)$$

or

$$\alpha = \frac{\Delta L}{L\cdot\Delta T}$$

2) Superficial expansion: If increase in surface area takes place then the thermal expansion is called superficial expansion.

Let 'S' be the surface area of solid

'ΔS' be the small increase in surface area.

'ΔT' be the increase in temprature

$\Delta S \propto S$ — i)

$\Delta S \propto \Delta T$ — 2)

from eqⁿ (i) and (ii)

$\Delta S \propto S\cdot\Delta T$

$\Delta S = \beta S\cdot\Delta T$

Where 'β' is coff. of superficial expansion

S' be the final increase in surface area

Then change in surface area $(\Delta S) = S'-S$

$S'-S = \beta\cdot S\Delta T$

$S' = S+\beta\cdot\Delta T S$

$S' = S(1+\beta+\Delta T)$

3) Cubical expansion: If increase in volᵐ take place then the thermal expansion is called cubical expansion.

Let V be the volᵐ of solid

ΔV be the ~~r~~ small increase in volᵐ at ΔT temp.

$\Delta V \propto V$ — i)

$\Delta V \propto \Delta T$ — 2)

from i) and 2)

$\Delta V \propto V\cdot\Delta T$

$\Delta V = \gamma\cdot V\cdot\Delta T$

Where 'γ' is called coff of cubic expansion

$$\gamma = \frac{\Delta V}{V\cdot\Delta T}$$

S.I unit of γ is K^{-1} or $°C^{-1}$

'V'' be the final increase in volᵐ after expansion

Then,

$\Delta V = V'-V$

$V'-V = V\cdot\gamma\cdot\Delta T$

$V' = V+V\gamma\cdot\Delta T$

$V' = V(1+\gamma\cdot\Delta T)$

Relation b/w α, β, γ

$$\frac{\alpha}{1} = \frac{\beta}{2} = \frac{\gamma}{3}$$

* States of Matter: The conversion of one state of matter into other is called change of state of matter.

Their are three states of matter — Solid, Liq. and Gas

The change of state from solid to liquid is called melting

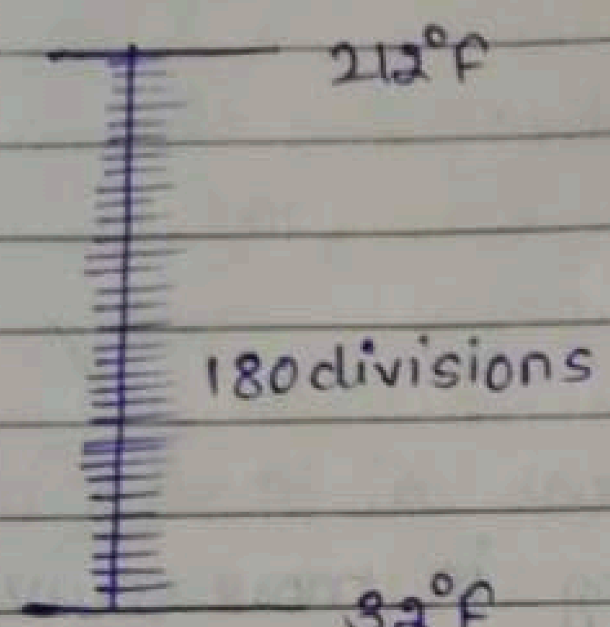
The change of state from liquid to gas is called boiling

The change of state from solid to gas is called Sublimation.

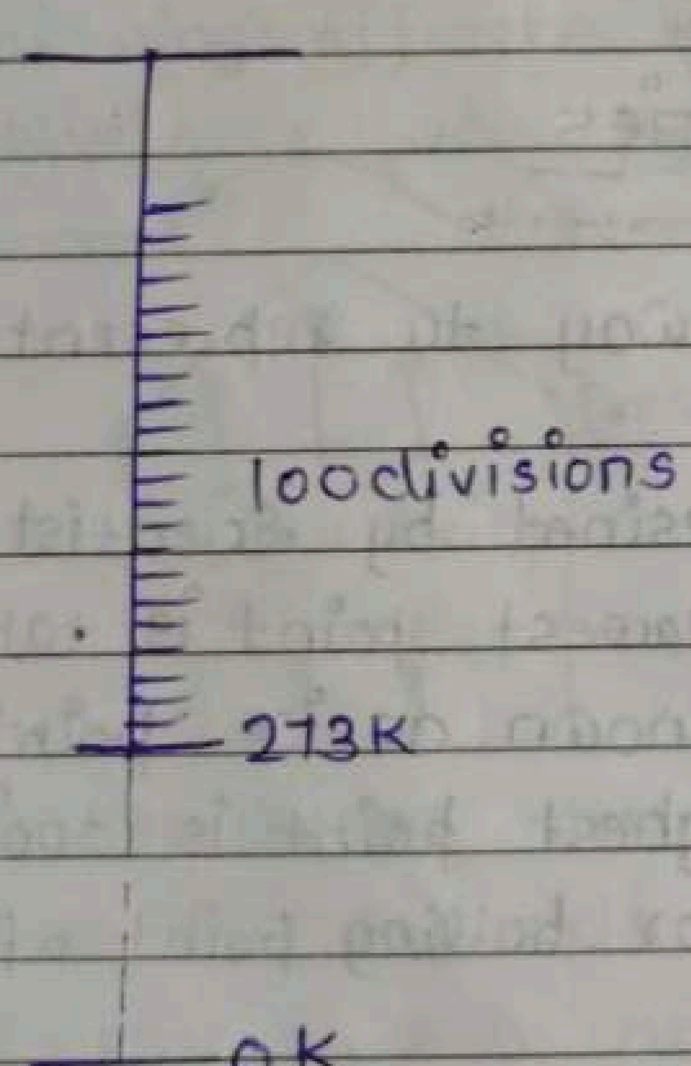
The change of state from liq. to solid is called fusion.

The change of state from gas to liquid is condensation.

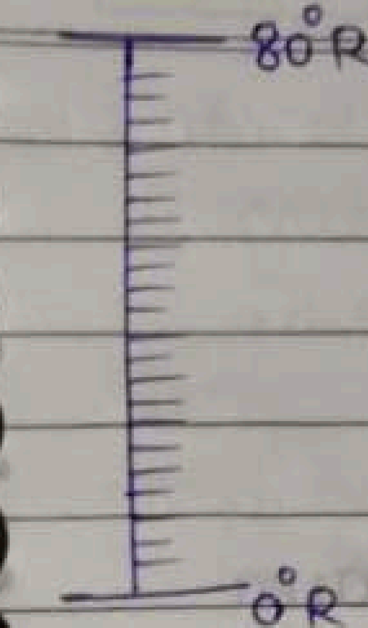
2) **Fahrenheit Scale:** In this scale the lowest point as taken as $32°F$ and highest point is $212°F$. The gap b/w $32°F$ and $212°F$ is divided into 180 divisions.



3) **Kelvin Scale:** In this scale the lowest point is taken at 273 K and highest point is 373 K. the gap is divided in 100 equal parts. This scale is also extended to zero Kelvin. The temp. of zero Kelvin is known as Absolute zero. Which is equal to $-273°C$.



4) **Reaumer Scale:** In this scale the lowest point is taken at $0°R$ and highest point is $80°R$. The gap is divided in equal 80 parts.



* **Conversion formula:**

$$\frac{C-0}{100} = \frac{F-32}{180} = \frac{K-273}{100} = \frac{R-0}{80}$$

* **Thermal Expansion of Solid:**

When solids are heated they expand. This expansion is called thermal Expansion. There are 3 types of thermal expansion.

i) **Linear expansion** – If increase in length take place then the expansion is called thermal expansion.

let 'L' be the length of rod.

ΔL be the small change in length of rod after increasing temp. by ΔT.

Then, $\Delta L \propto L$ –(1)

$\Delta L \propto \Delta T$ –(2)

From eq^n (1) and (2)

$$\Delta L \propto L \cdot \Delta T$$

$$\Delta L = \alpha \cdot L \Delta T$$

Where, 'α' is called the cofficient of thermal expansion.

let 'L'' be the final increase in length

Then change in length $(\Delta L) = L' - L$

$$L' - L = \alpha \cdot L \Delta T$$

$$L' = L + \alpha L \cdot \Delta T$$

* Application of Bernaulli's thm :

Acc. to Bernoull's thm

$$\frac{1}{2}\rho v^2 + \rho gh + \frac{P}{\rho} = \text{constant}$$

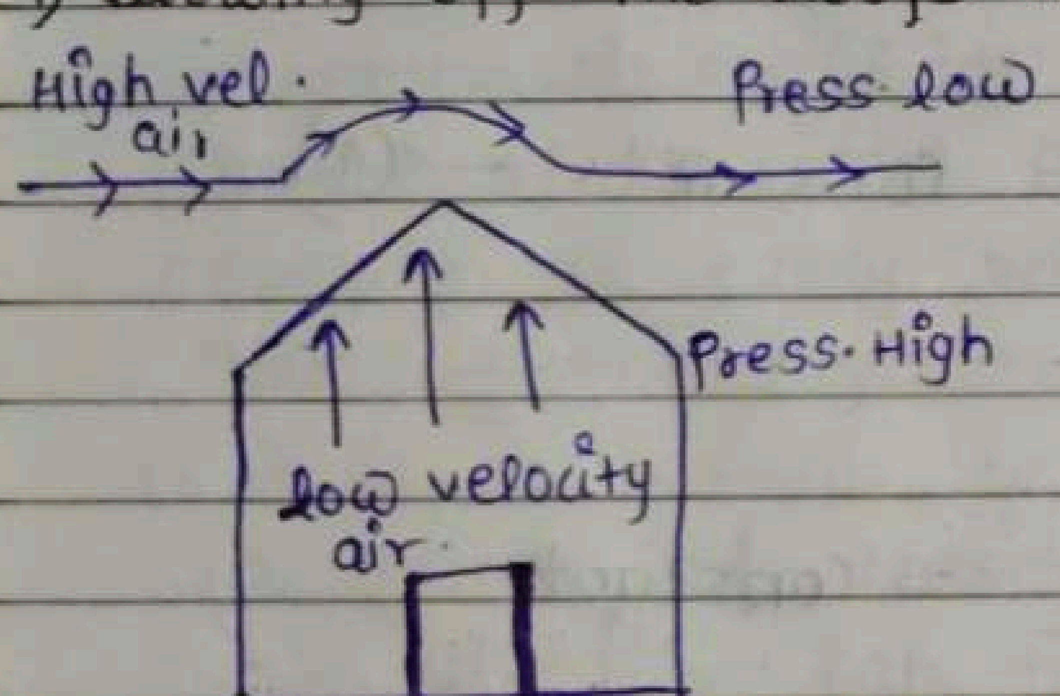
If two points lying at same horizontal dist. than, P.E becomes zero

$$\frac{1}{2}\rho v^2 + P = \text{constant}$$

Case I = If in some area velocity of fluid is low then press created by fluid in that area will be high.

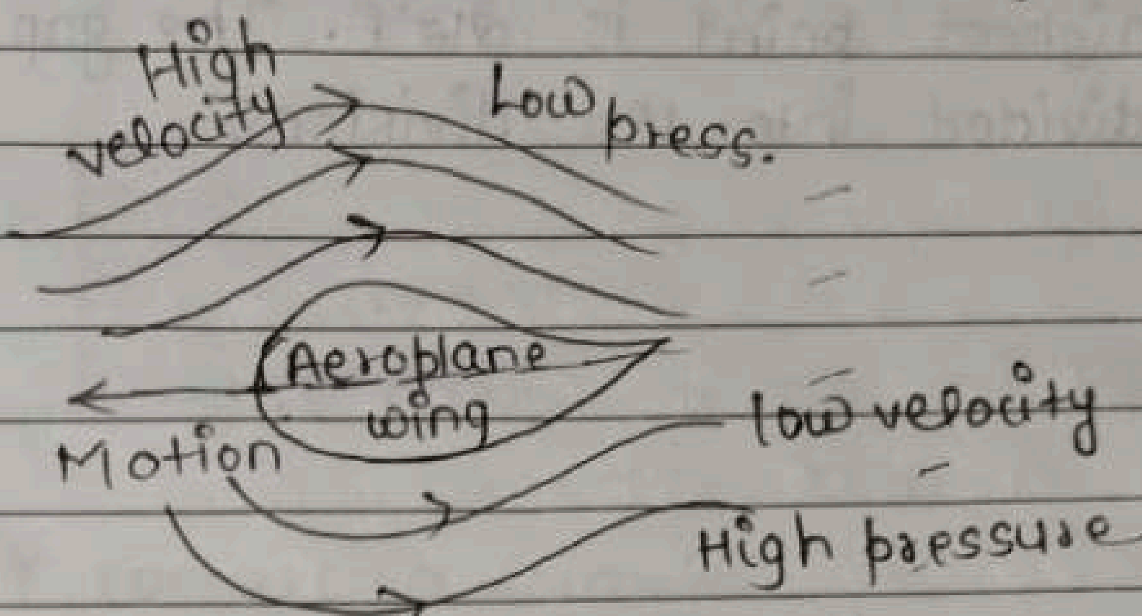
Case II = If in some areas velocity of fluid is high then, press created by fluid in that area will be low.

1) Blowing off the roofs during storms



During storms, the wind blows with very high speed over the top side of the Roofs. This high speed will create a low pressure over the roof. Inside the hut the wind speed is very less as compare to outside. So, a high press is created below the roof. Since roofs are blown off.

2) Lift of an aeroplane wing



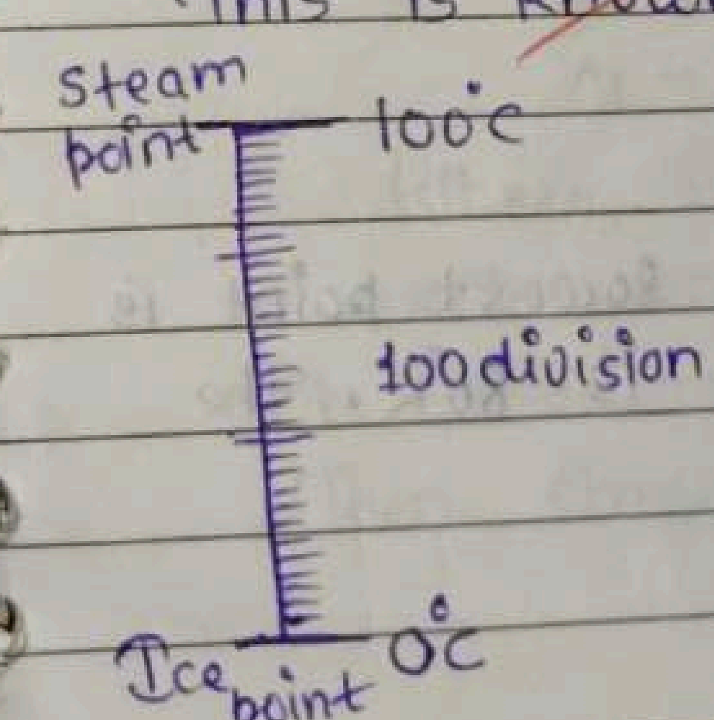
The upper surface of aeroplane wing is more curved then it's lower surface. Due to this the wind speed is higher on upper surface as compare to lower surface. So, a high press. is created at lower surface while a low press. is created at upper surface. This pressure difference helps the aeroplane to lift up.

CHAPTER = 4

THERMAL PROPERTIES

* Temprature Scale: Temp. Scale is a way to represent temprature.

i) celsius Scale: This scale was desined by Scientist celsius. In celsius scale, the lowest point is taken as zero degree celsius. This is known as ice point or melting point of ice. The highest point is 100°C. This is known as steam point or boiling point of H_2O.



Press. Energy : The energy possesed by a fluid due to its press. is known as pressure energy.
Let 'x' be the disp. of fluid after applying some pressure on it.

Then, workdone = Pressure Energy

W = Force x disp.

$W = F \times x$

ω = Press. Energy $= F \cdot x$ — (i)

as, press. $= \frac{F}{A} = P \cdot A = P$

Put this value in eqⁿ i)

W = press. energy $= P \cdot A \cdot x$

Pressure energy $= P \cdot V$

Pressure energy per unit volᵐ

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

M.M.I

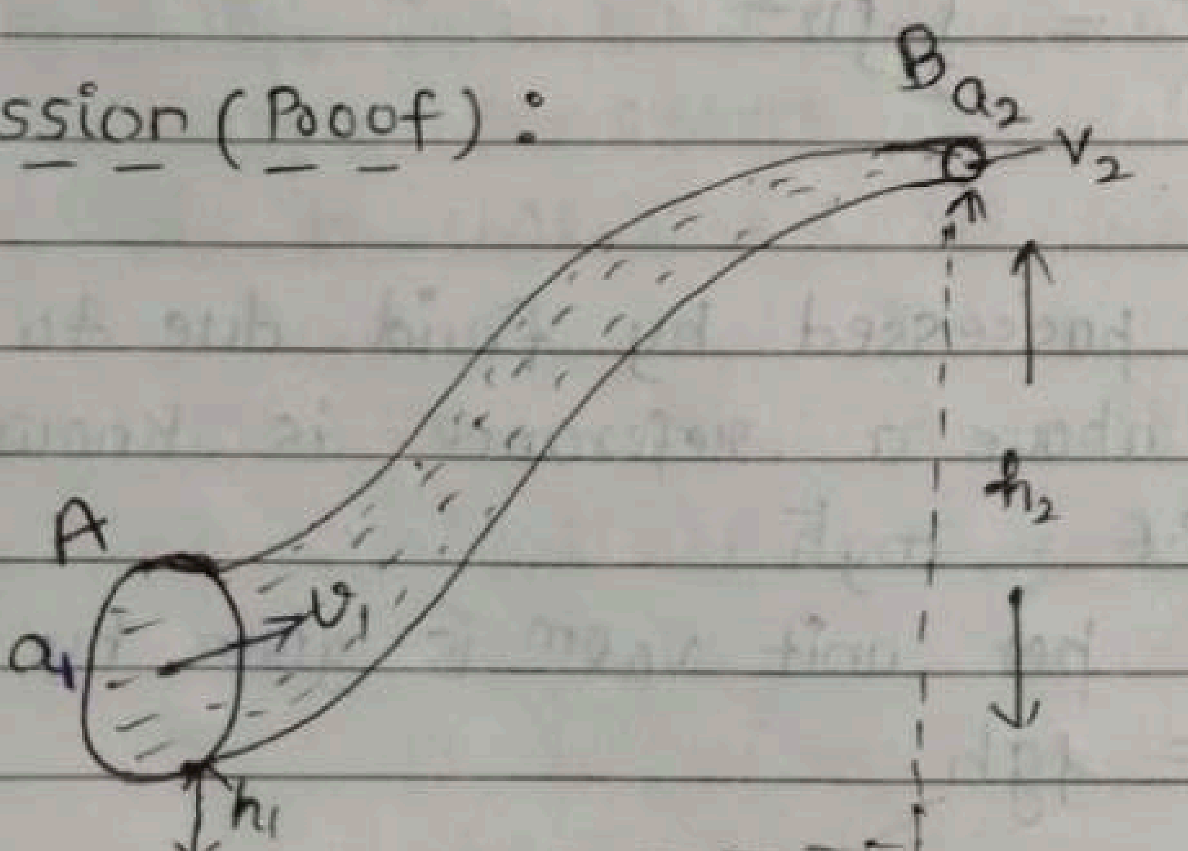
* Bernoulli's Theorem: This thᵐ deals with law of conservation of energy for flow of an ideal and incommpressible fluid such that for a streamline flow of an ideal fluid, the total energy remains constant at every point.

Thus, $\frac{1}{2}mv^2 + mgh + PV =$ Constant.

In terms of density

$\frac{1}{2}\rho v^2 + \rho gh + P =$ constant

* Expression (Proof) :



Consider a bernoulli tube.

As, $h_2 > h_1$

then, P.E at B > P.E at end A

change in P.E $= m_2gh_2 - m_1gh_1$ — (1)

$v_2 > v_1$ then,

K.E at end B > K.E at end A

change in K.E $= \frac{1}{2}m_2v_2^2 - \frac{1}{2}m_1v_1^2$ — (2)

$P_1 > P_2$ then liquid flow from A end to B end.

Press. at end A > Press. Energy at end B

$P_1V_1 > P_2V_2$

Change in press. energy $= P_1V_1 - P_2V_2$ — (3)

For total energy

Adding eqⁿ (1), (2) and (3)

$\frac{1}{2}m_2v_2^2 - \frac{1}{2}m_1v_1^2 + m_2gh_2 - m_1gh_1 + P_1V_1 - P_2V_2 = \text{const}$

$\frac{1}{2}m_2v_2^2 + m_2gh_2 + P_1V_1 = \frac{1}{2}m_1v_1^2 + m_1gh_1 + P_2V_2$

In general :

$\frac{1}{2}mv^2 + mgh + PV =$ Constant — (4)

Dividing by volᵐ (V) :-

$\frac{\frac{1}{2}mv^2}{V} + \frac{mgh}{V} + \frac{PV}{V} =$ Constant

$\frac{1}{2}\rho v^2 + \rho gh + P =$ constant

Dividing by 'm' in eqⁿ (iv)

$\frac{\frac{1}{2}\cancel{m}v^2}{\cancel{m}} + \frac{\cancel{m}gh}{\cancel{m}} + \frac{PV}{m} =$ constant

$\boxed{\frac{1}{2}v^2 + gh + \frac{P}{\rho} = \text{Constant.}}$

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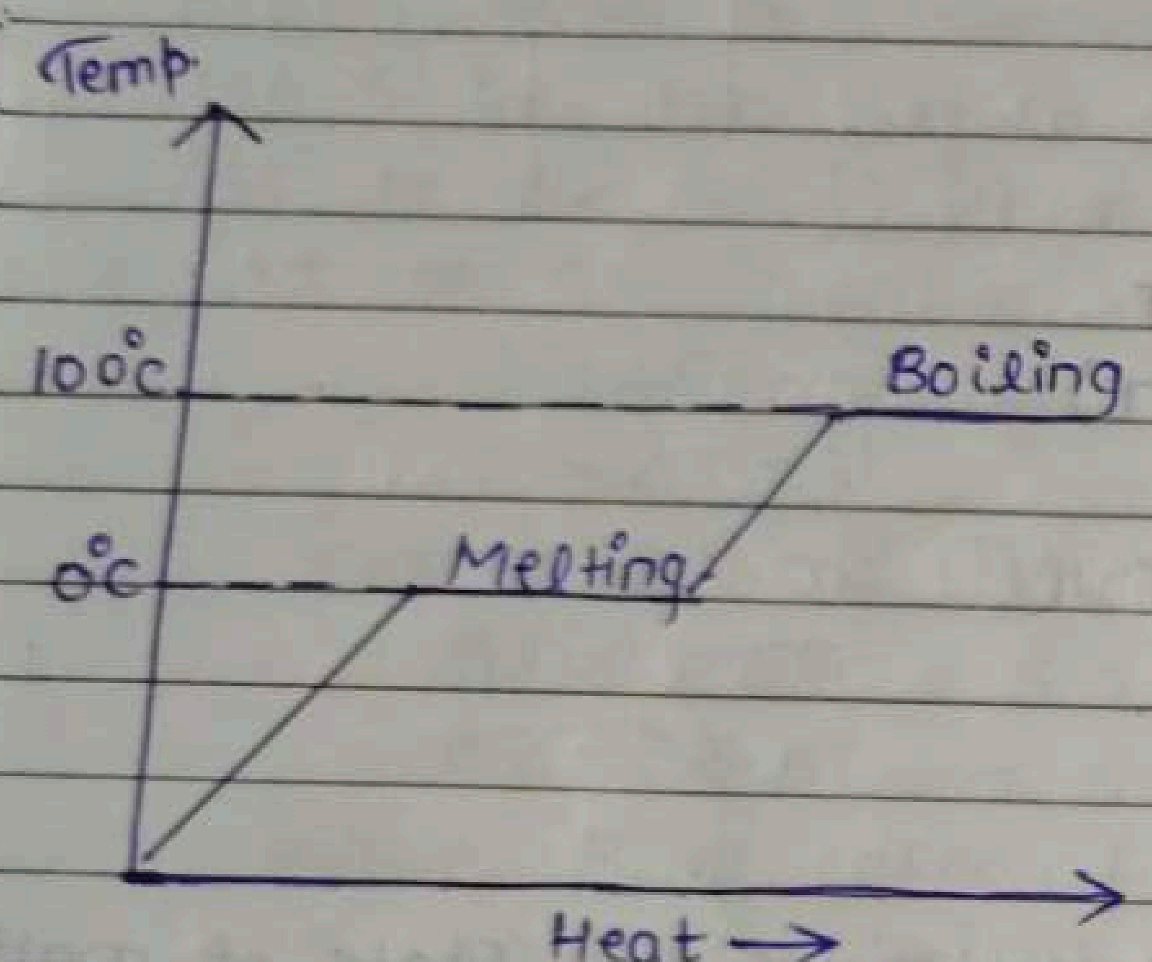
* **Melting point**: The temp. at which solid converts into liquid is called melting point. For ex – Melting point of ice is zero °c.

* **Boiling point**: The temp. at which liq. converts into gas is called boiling point for ex. The boiling point of water is 100°c.



* **Specific heat**: The heat required to raise the temp. of a unit mass body by 1°c. is called specific heat. The heat required to raise the temp. of a body depends on mass of body and temp. difference.

$\theta = M \cdot S \cdot \Delta T$

Where θ = Heat energy

S = Specific Heat

ΔT = temp. diff.

$S = \frac{\theta}{m \cdot \Delta T}$

S.I unit of specific Heat (s) $= \frac{J}{Kg \cdot K}$

$= J kg^{-1} K^{-1}$

D. formula $= [M^0 L^2 T^{-2} K^{-1}]$

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* **Latent heat**: The heat required to change state of matter of a unit mass body is called latent heat.

The heat required to change state of matter of a body depend on mass of body.

$\theta = m \cdot L$

Where, θ = heat energy

m = mass body

L = Latent heat

$L = \frac{\theta}{m}$

S.I unit of latent heat (L) $= \frac{J}{kg} = J kg^{-1}$

D.f $= \frac{M^1 L^2 T^{-2}}{M} = [M^0 L^2 T^{-2}]$

* **Modes of Transmission of heat**: There are three modes of Transmission of heat

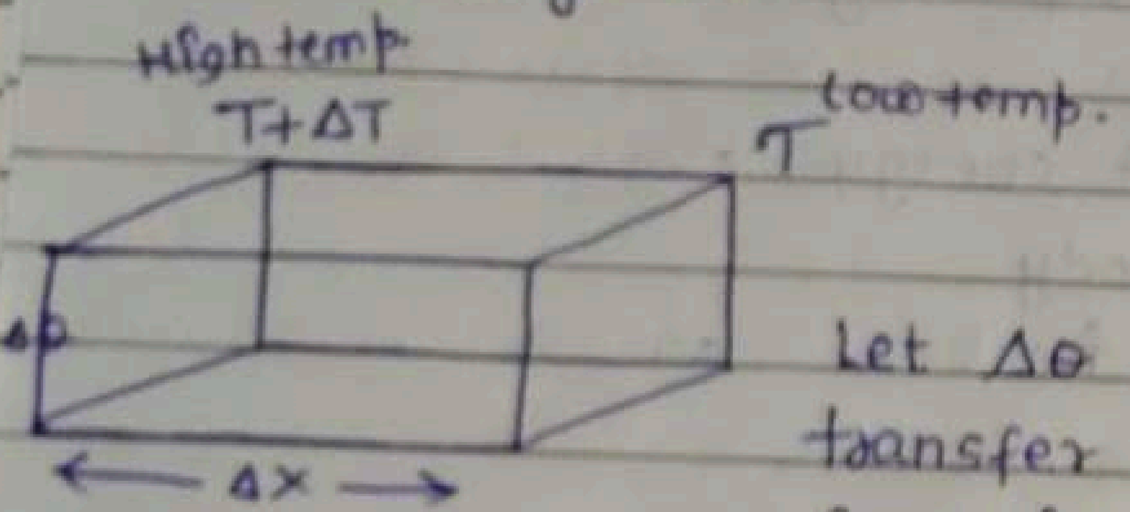
i) **Conduction**: The phenomenon of transfer of heat from one part of body to other part from particle to particle without any movement of atoms. is called conduction. This type of transmission of heat mainly occurs in solids.

2) **Convection**: The phenomenon of transfer of heat from through actual movement of particles is called convection. This type of transmission of heat occurs in liquids and gases.

3) **Radiation**: The phenomenon of transfer of heat directly from source to recieves without any movement of particles and without heating medium b/w them.

It is the fastest mode of heat transfer. Heat from Sun comes to us through radiation.

* **Thermal conductivity**: It is the ability of solid to conduct heat through it.



Let $\Delta\theta$ be the amount of heat transfer from one face to another force in time Δt.

Rate of flow of heat $= \frac{\Delta\theta}{\Delta t}$

Then,

$$\frac{\Delta\theta}{\Delta t} \propto A \quad \text{—— (i)}$$

$$\frac{\Delta\theta}{\Delta t} \propto T \quad \text{—— (ii)}$$

$$\frac{\Delta\theta}{\Delta t} \propto \frac{1}{\Delta x} \quad \text{—— (iii)}$$

from i), ii) and (iii)

$$\frac{\Delta\theta}{\Delta t} \propto A \cdot T \cdot \frac{1}{\Delta x}$$

$$\frac{\Delta\theta}{\Delta t} = K \cdot A \cdot T \cdot \frac{1}{\Delta x}$$

where 'K' is called coff. of thermal conductivity.

$$K = \frac{\Delta\theta}{\Delta t} \cdot \frac{\Delta x}{AT}$$

Where A = area of face

Δx = dist. b/w two ends

T = temp.

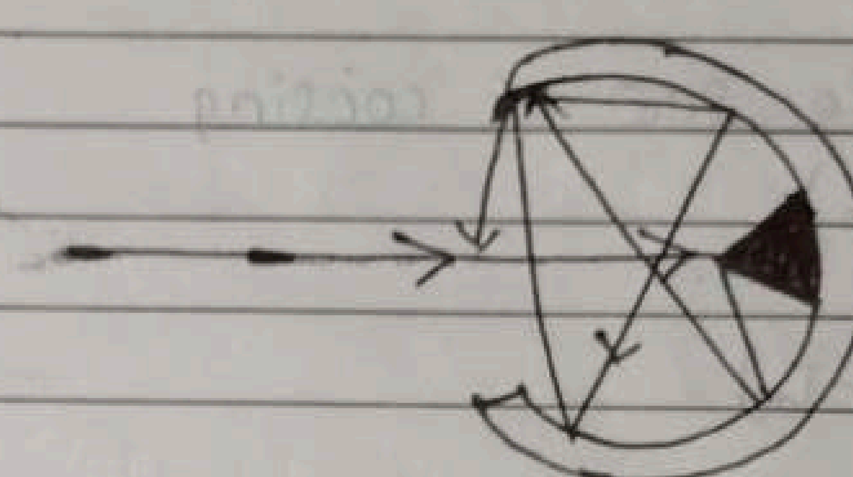
S.I unit of $K = \frac{J \cdot m}{S \cdot m^2 \cdot K} = Js^{-1}m^{-1}K^{-1}$

$= Wm^{-1}K^{-1}$

D.F of $K = M^1L^2T^{-2} \times T^{-1} \times L^{-1} \times K^{-1}$

$= K = [M^1L^1T^{-3}K^{-1}]$

* **Perfectly Black body**: A perfectly black body is that body which will absorb completely absorb radiation of all wavelength incident on it. The radiation emitted by a black body are known as Blackbody radiation or full radiations of total radiations. A perfectly black body cannot be desined in real practice



* **Kirchoff's law**: Acc. to this law the ratio of emissive power to absorptive power for a particular wavelength of a given body at a given temp. is always constant such that $\frac{e_\lambda}{a_\lambda}$ = constant = E_λ

* **Stefan's law**: Acc. to this law the amount of heat energy radiated per second by unit area of a perfectly black body is directly prop. to 4^{th} power of Absolute temp. of body. It is also called Stefan's boltzman's law.

Mathmetical expression:

$$E \propto T^4$$

$$E = \sigma T^4$$

Where, σ = Stefen's constant $= 5.96 \times 10^{-8} Wm^{-2}K^{-4}$

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* **Newton's law of cooling:** Acc. to this law the rate of cooling of a body is directly prop. to temp diff. of body and surrounding.

OR

The rate of loss of heat from a body is directly prop. to temprature diff. of body and surrounding

Let 'T' be the temp. of body

T_0 = temp. of surrounding

$\frac{-dT}{dt}$ = rate of fall temp.

Then acc. to Newton's law of cooling

$$\frac{-dT}{dt} \propto (T-T_0)$$

$$\frac{-dT}{dt} = K(T-T_0)$$

where 'K' is propotionally constant.

Good

Ayadont 18/11/24

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