Unit - 5

Properties of Matter

~~Elasticity~~

1. Rigid Body:

A:→ A rigid Body is that kind of body which does not change its configuration when external force is applied.

2. Elastic Body:

→ The property of body due to which after removal of external force the body regains its original configuration (shape & size) is called elasticity. and the body is called elastic body.

3. Plastic Body:

→ If after removal of external force the body does not regains its original configuration then it is called a plastic body.

Deforming Force (External force)

→ It is an externally applied force under which the dimension of a body changes

Restoring Force (Internal Force)

→ It is the force produced inside the body which is equal in magnitude and opposite in direction of external ~~body~~ force. applied on the body.

Elasticity:

· Defination of stress and strain

Stress

→ When external deforming force is applied then equal and opposite force acts inside the body which recover the original shape of the body.

→ This restoring force per unit area produced inside the body due to external applied force is called stress.

→ SI unit of stress is $N m^{2}$

→ Dimension $[M^{1}L^{1}T^{-2}]$

→ Stress formula = $\frac{F}{A}$

→ Stress is a tensor quantity because it has different values in different direction

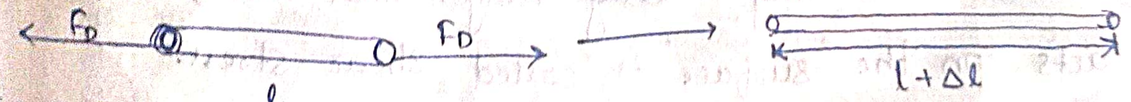
Types of stress

a) Longitudinal Stress/normal stress

→ When the external deforming force acting along the length of the body (wire or rod) then the force per unit area is called longitudinal stress.

(i) Tensile Stress :-

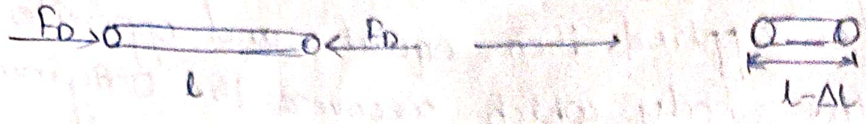
→ The perpendicular force per unit area of cross section which produce elongation of the wire is called tensile stress.



→ Tensile Stress = $\frac{F}{A}$

(ii) Compressive stress :-

→ The perpendicular force per unit area of cross section that produce contraction of the body is called compressive stress.

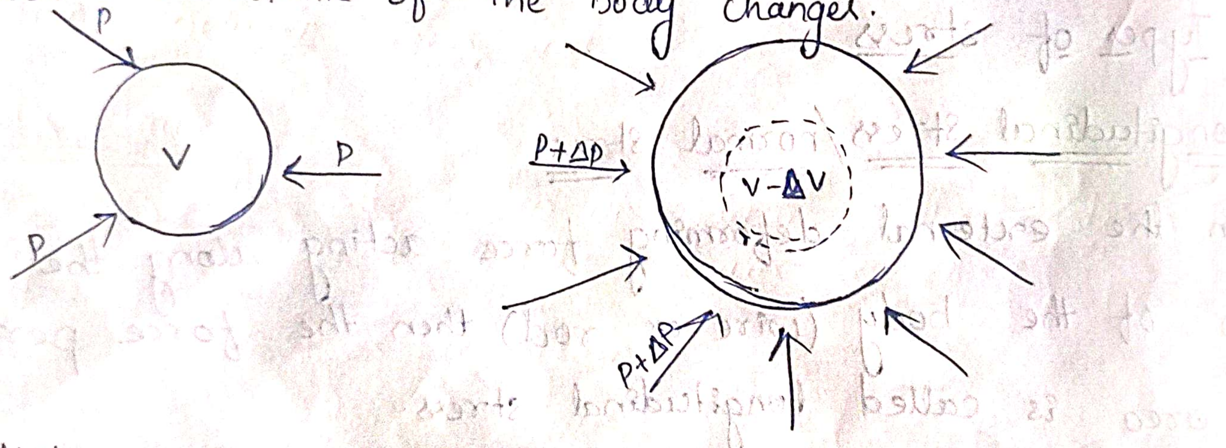


→ Compressive stress = $\frac{F}{A}$

b) <u>Volumetric</u> <u>Stress</u>

→ When force per unit area is acting at each point of the body normally then force per unit area is called volumetric stress.

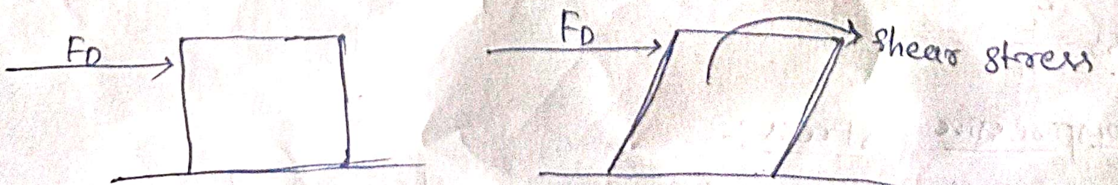
→ When pressure on the body increased P to (P+ΔP) then the volume of the body decreases from V to (V−ΔV). This change in pressure ΔP is the force per unit area due to which the volume of the body changes.



→ Volumetric stress = change in pressure $\Delta P = \frac{F}{A}$

(C) <u>Shear</u> <u>stress</u>:

→ When the force is applied tangentially to the surface of the body due to which its shape ~~chang~~ changes then the force per unit area acts on the surface is called shear stress.



Strain

→ The ratio of change in dimension (length, volume or shape) to the original dimension of the body is called strain.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension.}}$$

→ Strain is a unitless and dimensionless quantity.

Types of Strain:

a) Longitudinal Strain:

→ When a deforming force applied on the rod or wire of length L and the length changes by ΔL either increases from L to $L+\Delta L$ or decreases from L to $L-\Delta L$, the ratio of change in length to original length is called longitudinal strain.

$$\text{Longitudinal strain} = \frac{\text{change in length}}{\text{original length}} = \frac{\Delta L}{L}$$

b) Volumetric Strain:

→ When the volumetric stress is applied on a body and its volume changes, then the ratio of change in volume to original volume is called volumetric strain.

→ If the original volume of a body is V.

→ If the final volume of the body is either $V+\Delta V$ or $V-\Delta V$.

Then the volumetric strain $= \frac{\text{change in volume}}{\text{original volume}} = \frac{\Delta V}{V}$

c) Shear Stress:

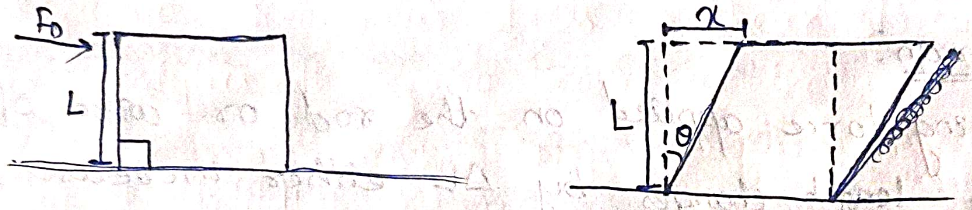
→ When shear stress is aplied then the shape of the body changes.

→ Suppose tangential force F is applied along the upper surface of a body then the shape of the cross-section changes.

from the rectangle to parallelogram. Lower edge of the body displaces by a distance (x).

Then the shear strain is defined as, the ratio of displacement of upper edge to its perpendicular distance from the fixed surface.

$$\text{Shear strain} = \frac{x}{L}$$



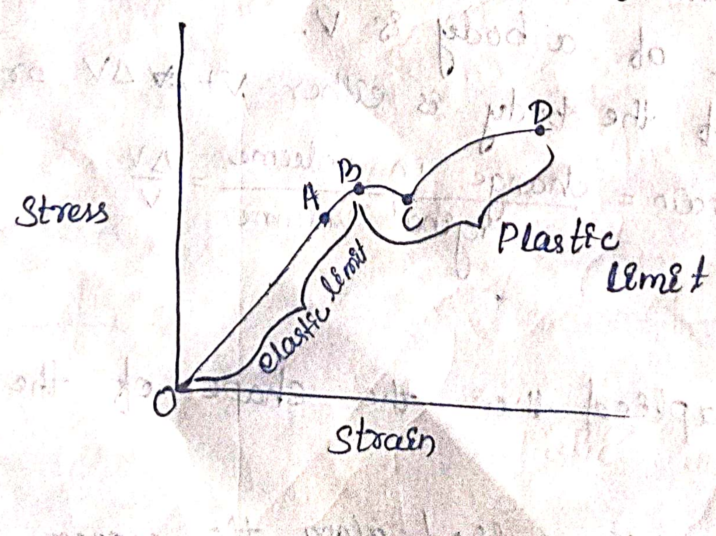
Relation Between stress and Strain

Hook's Law

→ This law states that within an elastic limit, the stress in a body is proportional to the strain in it.

$$\text{Stress} \propto \text{strain}$$
$$\text{Stress} = E \ \text{strain}$$

(here, E is modulus of elasticity)



~~Types of Modulus~~

Modulus of Elasticity

→ The ratio of stress to strain is called the modulus of elasticity. ~~SI unit of modulus of elasticity~~

→ SI unit of modulus of elasticity is N/m^2 or pascal (Pa).

→ It is dependent on the nature of the body and independent ~~to~~ of the length and the volume of that body.

Types of ~~the~~ Modulus of elasticity:-

a) Young's Modulus of elasticity (Y)

→ When the force F is applied on a rod of area of cross-section A then longitudinal stress $= \frac{\text{Force}}{\text{Area}}$

Let the original length of the rod is L due to the stress the change in length is ΔL then

$$\text{Longitudinal Strain} = \frac{\Delta L}{L}$$

Then, young's modulus is given as the ratio of ~~that body~~ longitudinal stress to longitudinal strain

$$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{\frac{F}{A}}{\frac{\Delta L}{L}} = \frac{FL}{A\Delta L}$$

b) Bulk Modulus (B):

→ The ratio of volumetric stress to the volumetric strain of a body is known as bulk modulus. So, bulk Modulus

$$B = \frac{\text{Volumetric stress}}{\text{Volumetric strain}} = \frac{FV}{A\Delta V}$$

If the pressure increases then the volume decreases then,

$$\text{Bulk Modulus } B = -\frac{FV}{A\Delta V}$$

Compressibility(K)

→ compressibility is reciprocal of Bulk Modulus

$$K = \frac{1}{B}$$

→ SI unit of compressibility is (m^2/N) or $(pascal)^{-1}$

c) Shear Modulus or Modulus of Rigidity

→ The ratio of shear stress to shear strain is called shear modulus. It is also known as the modulus of rigidity

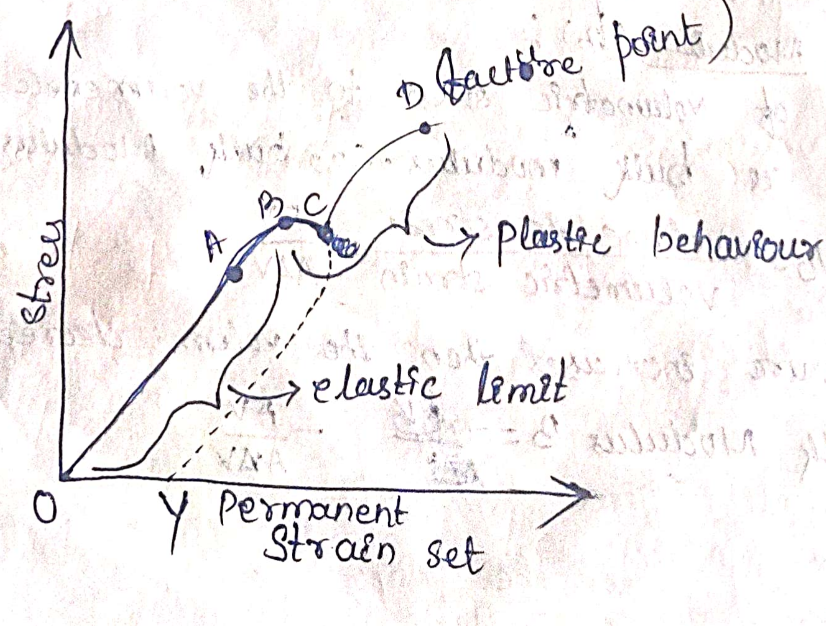
$$\text{Modulus of rigidity}(\eta) = \frac{\text{Shear stress}}{\text{Shear strain}} = \frac{F/A}{x/L} = \frac{FL}{Ax}$$

Imp

Significance of Stress-Strain Curve:-

- To study the behaviour of a wire of uniform area of cross-section under the influence of applied force, it is suspended ~~at its free end then~~ from a rigid base and weight is slowly increased at its free end then the length of the wire also increases.

The curve between stress and strain is shown in the graph.



→ In this graph stress ~~and strain~~ is proportional to strain upto ~~poi~~ point A and ~~OA~~ OA is straight line.

~~→ The point A is called proportional to strain upto point A and OA is straight line.~~

→ The point A is called proportional limit. Hook's law is obey upto point A.

Now strain further increases from A to B with the increase in stress, the stress is not proportional to strain but the strain increases more rapidly then the stress and Hook's law is not obey.

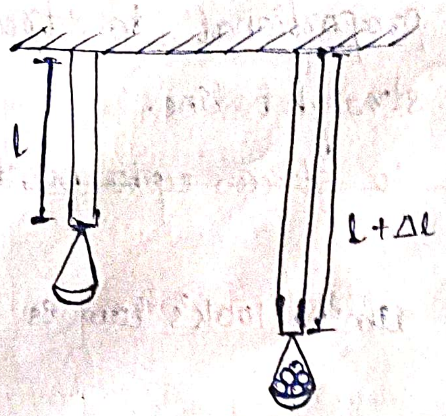
→ Even between points A & B after removal of deforming force, the wire comes to its original length, thus elastic behaviour is shown by the wire upto point B. The end point B of this part of the curve is called elastic limit or yield point.

Beyond the elastic limit B say point C even after the removal of the deforming forces the wire does not regain its original length. Some permanent increases in length remain in wire (OY) it is called permanent set.

→ Now wire behaves as a plastic material.

Further increases of deforming force beyond point C strain increases more rapidly with a small increase in stress and wire breaks at point D. This point is called fracture point and stress at point D is ~~called~~ called breaking stress.

→ Wire behaves as a plastic material between point B to D.



→A material with a small plastic region is called brittle material
example – Glass, stone, etc.

→A material with high plastic region is called ductile material.
Ductile material can have more ~~deforming~~ deformation before fracture.
example – steel, lead, etc.

Pressure:–

→Pressure at a point of a fluid is the average force acting per unit area surrounding that point.

→If the magnitude of the average force exerted on the fluid is F and area is A then pressure is defined as the ratio of force per unit area

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

→Pressure is a scalar quantity.
→SI unit of pressure is Nm^{-2} or pascal (Pa).

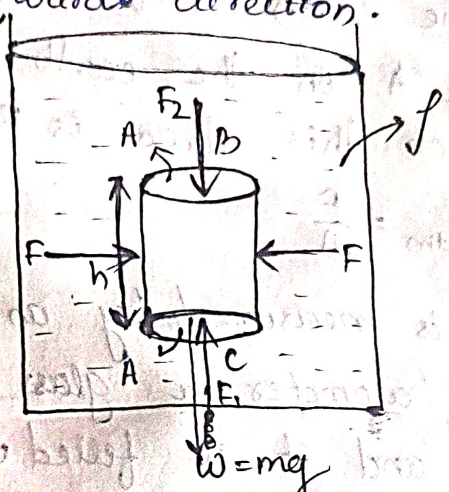
Relation of Fluid pressure with height:

Let us consider a cylinder height 'h', placed inside the liquid of density ρ.

→ Let the area of cross section of the cylinder is 'A'.

→ Let us consider 2 point on the area of cross-section of the cylinder as 'B' and 'C'.

Let forces are exerted on each ~~point~~ part of the fluid normally. Suppose force F_1 is acting vertically upwards at point C and F_2 is the force acting downwards at point B let P_1 is the pressure at point C and P_2 is the pressure at point B. The weight of liquid is acting in downwards direction.



$F_1 = F_2 + \omega$

$\Rightarrow P_1 A = P_2 A + mg$

$\Rightarrow P_1 A = P_2 A + (\rho V) g$

$\Rightarrow P_1 A = P_2 A + \rho (Ah) g$

$\Rightarrow P_1 A = A(P_2 + \rho g h)$

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

$\Rightarrow P_1 - P_2 = \rho g h$

$\Rightarrow -(P_2 - P_1) = \rho g h$

$\Rightarrow P_2 - P_1 = -\rho g h$

$\Rightarrow \Delta P = -\rho g h$

$\Delta P \propto (-h)$

The negative sign shows that when we move up in the liquid by height h then the pressure decreases by the value ρgh.

Atmospheric Pressure:

→ Atmospheric pressure is defined as the force per unit exerted by air column on the earth surface.

let the small area A on the earth surface and force exerted by the air on this area is F. Then the atmospheric pressure $P_{atm} = \frac{F}{A}$

→ Atmospheric pressure is measured by an instrument called as Barometer. In a barometer a glass tube open at one end of height h and it is filled with mercury. The tube is inverted in the vessel of mercury such that its open end dipped into the vessel.

~~Atmospheric pressure is the pressure~~

Atmospheric pressure is equal to the pressure exerted by the height of the mercury column $h = 76\ cm$ raised in a barometer tube.

Atmospheric pressure $P_{atm} = \rho gh$

$$P_{atm} = (13 \cdot 6 \times 10^3)(9.8)(76 \times 10^{-2} m)$$

$$P_{atm} = 1 \cdot 013 \times 10^5\ Pa$$

$\therefore$ $1\ atm = 1.013 \times 10^5\ Pa$

→ Unit of pressure used in the meteorology is called bar and $1\ bar = 10^5\ Pa$,

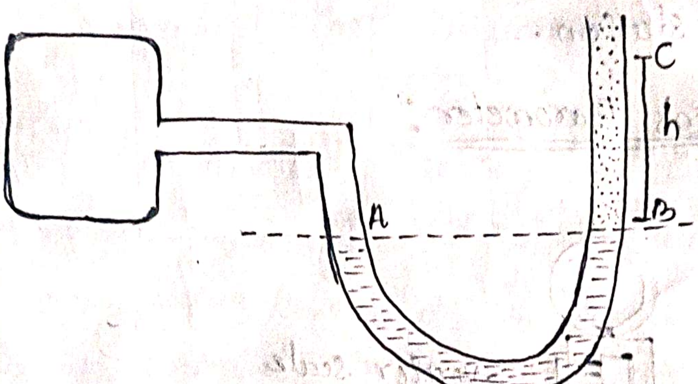
$\therefore$ $1\ atm = 1.013\ bar$

Gauge Pressure and Absolute Pressure :

→ The manometer is a device that is used to find pressure in a closed container it consist of a tube bent in the form of U and contains a ~~liq~~ liquid.

→ One end of the tube is connected to a container of glass and the other end is open to the atmosphere.

Let us consider two points A & B at the same horizontal level.



Manometer

Pressure at A = Atmospheric pressure ~~at C~~ (C) + pressure of liquid column (BC) of height (h).

$$P = P_{atm} + \rho g h$$

The total pressure P is called absolute pressure, ρ is density of liquid of the U tube.

→ The difference in pressure of gas in the container and the atmospheric pressure is called gauge pressure. So the gauge pressure is given as

$$P - P_{atm} = \rho g h$$

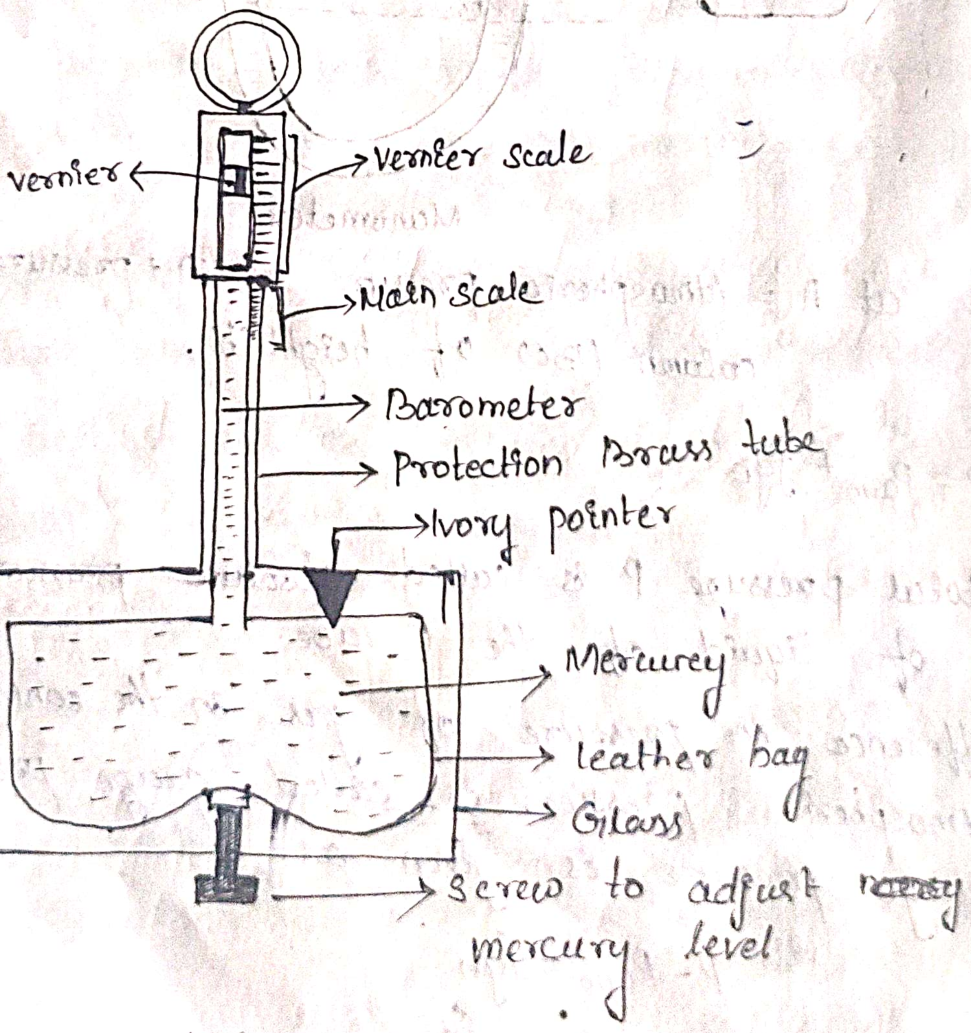
Fortin's Barometer:

→ Fortin's Barometer is a type of barometer that uses mercury to measure atmospheric pressure. It consist of a glass tube inverted in cistern of mercury.

→ The height of mercury column in the tube corresponds to atmospheric pressure.

→ Fortin's barometer is consider to be more accurate type of barometer. It is ~~of~~ often used in scientific laboratories and meteorological station.

Working of Fortin's Barometer:



Fortin's Barometer

1. Mercury Column:

→ The mercury column is a glass tube filled with mercury. inverted in a cistern (Reservoir) containing mercury.

→ The column of mercury in the tube is supported by atmospheric pressure acting on the mercury surface in the reservoir.

2. Atmospheric Pressure:

→ Atmospheric pressure pushes ~~down~~ down on the mercury in the reservoir. This pressure is transmitted through the mercury and supports the column of mercury in the tube.

→ The height of the mercury column is directly proportional to the atmospheric pressure. A higher column indicates a high atmospheric pressure and a lower column indicates low atmospheric pressure.

3. Vernier scale and main scale reading:

The height of the mercury column is measured using a main scale.

→ The vernier scale is attached to the barometer to accurately measure the height of mercury column.

→ The vernier scale allows the precise readings in millimeters of mercury (mmHg).

4. Mercury level adjustment:

→ A screw mechanism is used to ~~do~~ adjust the level of mercury in the reservoir.

→ Before taking a reading the screw is adjusted until the tip of an ivory pointer just touches its image on the mercury surface. This ensures that the mercury level is at the reference point.

5. Pressure Measurement:

→ The height of mercury column as measured by the vernier scale is directly proportional to the atmospheric pressure. ~~That~~ Therefore, a fortins barometer measures the height a column of mercury supported by atmospheric pressure.

→ Pressure due to a column of liquid of height h and density ρ is given by

$$P = \rho g h$$

If the variation in the density of mercury with ~~tempera~~ temperature is neglected, we see that the pressure is proportional to the height of mercury column.

Application of Fortin's Barometer:

1. This barometer is commonly used to measure atmospheric pressure in ~~made~~ meteorological station, Laboratories and schools.
2. It is also used for the measurement of the altitude of mountains and in weather forecasting.

Surface Tension

→ Surface tension is the property of a liquid surface that makes it act like a elastic sheet.

Let us consider a molecule A and molecule B in a liquid surface. The molecule A lies inside the liquid and molecule lies on the surface of the liquid. The molecule A experiences force by liquid molecules from all directions. Therefore, the net force on A is zero. But the molecule B is on the is at the reference point.

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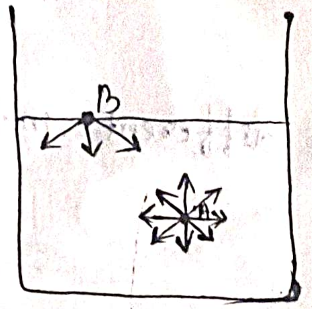


Suppose an imaginary line A B is drawn on the liquid surface and force F acts perpendicular to the line A B along the surface on both side of it.

Let the length of the line is L then the surface tension of the liquid is defined as

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

→ SI unit of Nm^{-1}

→ Dimension $M^1L^1T^{-2}$

The free surface of the liquid behaves like a streched membrane due to surface tension and the surface tense to the acquire the minimum surface area.

Cohesive And Adhesive Force

All types of matter is made up of molecules. These molecules interact with each other with a force called as intermolecular force.

→ The intermolecular forces are divided into 2 categories.

1. Cohesive force

2. Adhesive force.

1. Cohesive force:

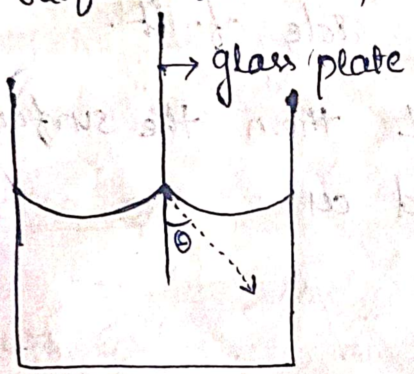
→ The force of attraction between two similar molecules is called as cohesive force.

2. Adhesive force:

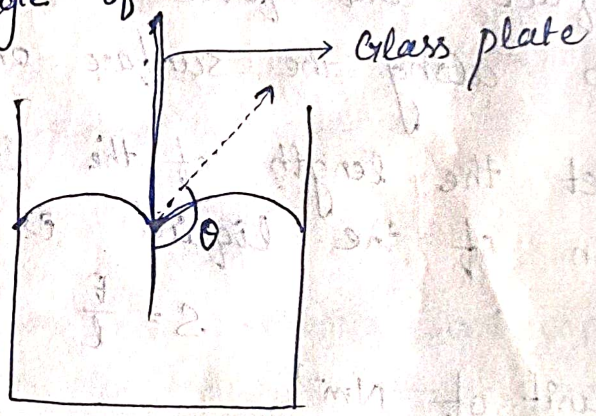
→ The force between two different molecules is called as adhesive force.

Angle of Contact:

→ The angle between the tangent at the liquid surface and solid surface is called as angle of contact.



Glass water



Glass mercury

Glass water	Glass mercury
Cohesive force < Adhesive force	Cohesive force > Adhesive force
→ The angle of contact θ is less than 90°	→ The angle of contact θ is greater than 90°.
→ The shape of the liquid surface is concave	→ The shape of the liquid surface is convex.
→ The liquid wets the solid surface.	→ The liquid does not wets the solid surface.
→ Adhesive force is greater than cohesive force.	→ Cohesive force is greater than adhesive force.
→ Liquid rising capillary tube dipped in it.	→ Liquid depresses in capillary tube dipped in it.
→ E.g. – water and glass	→ E.g. – Mercury & glass.

Ascent formula of liquid in capillary tube

→ when a glass tube of very small diameter open at both ends are dipped in a liquid then either liquid is raised or depressed in this capillary tube. The rise or depression of liquid in a capillary tube is called capillarity.

The formula of height raised in a capillary tube is given as $h = \frac{2S\cos\theta}{r\rho g}$

here, S is surface tension ρ is density of the liquid,
θ is angle of contact,
r is radius of capillary tube
and g is acceleration due to gravity.

If θ = 0°, cos θ = 1

$$h = \frac{2S}{r\rho g}$$

If S, ρ, and g is considered as constant.

$$h \propto \frac{1}{r}$$

Therefore, smaller the radius of capillary tube higher is the rise of liquid inside the tube.

Factors affecting surface tension:-

1. Temperature:- The surface tension of a liquid decreases with the rise in temperature.
2. Effect of contamination: If the contaminants like dust, grease or oil spread over the water surface then surface tension reduces.

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3. Impurity:- If any salt is dissolved completely in a liquid its surface tension increases.

Viscosity:-

Viscosity is a measure of fluid's resistance to flow. It is like the thickness of a fluid. Viscosity is caused by the friction between the molecules of the fluid. The stronger the force between the molecules the higher is the viscosity. Viscosity is an internal resistance to flow due to tensile or shear stress. It is a tendency to resist the flow of flow of fluid. For example - A honey is more viscous than water since it experiences more resistance to flow.

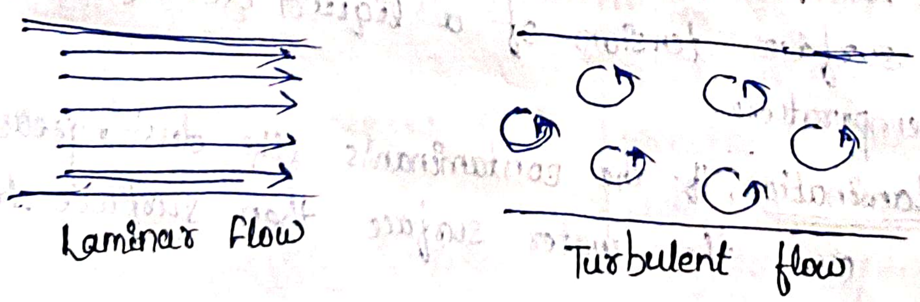
Co-efficient of Viscosity:-

→ Co-efficient of viscosity is the physical property of fluid that shows a fluids resistance to flow it is denoted as the symbol = η(eta)

Types of Flow:

a) Laminar Flow:- Generally it occurs in small diameter pipes and flow velocity form.

b) Turbulent flow:- If the fluid layers do not move in parallel and cross each other, then the flow is called turbulent flow.



Velocity Distribution of Fluid in Laminar Flow :-

→ In a laminar flow the layers of the liquid flow in a uniform and parallel motion. In the laminar flow to consecutive layers move parallelly with different velocity without mixing over a horizontal surface for ~~two~~ low velocity and high velocity of a fluid the laminar flow occurs at constant temperature the viscous force (F) acting in a laminar fluid depends on, area on which ~~visco~~ viscous force act (A).

Velocity gradient

Therefore, mathematically we can write

$$F \propto A \frac{V_2 - V_1}{d}$$

$$F = \eta A \frac{V_2 - V_1}{d}$$

A is the area on which the viscous force act

$\frac{V_2 - V_1}{d}$ is the velocity gradient

η is the coefficient of viscosity

d is the distance between two parallel layers.

$$F = \eta A \frac{V_2 - V_1}{d}$$

$$\Rightarrow \frac{F}{A} = \eta \frac{V_2 - V_1}{d}$$

$$\Rightarrow \frac{\left(\frac{F}{A}\right)}{\left(\frac{V_2 - V_1}{d}\right)} = \eta = \frac{\text{shear stress on fluid}}{\text{velocity gradient}}$$

This is known as Newton's law of viscosity.

Terminal Velocity:-

→ It is the highest constant velocity with which an object falls through a fluid when the sum of viscous force and force of buoyancy becomes equal to the force of gravity.

→ The terminal velocity of a spherical body can be gives as

$$V_t = \frac{2}{9} \cdot \frac{r^2 g}{\eta} (\rho - \rho_f),$$

Here, r is the radius of the spherical body.

g is acceleration due to gravity.

ρ is density of the body.

ρ_f is density of the fluid

η is coefficient of viscosity of the fluid.

→ If ρ is greater than ρ_f, then the terminal velocity is positive and spherical body moves downwards in the fluid.

→ If ρ is less than ρ_f, then the terminal velocity is negative and the spherical body moves upwards in the fluid.

Stoke's Law:-

Stoke's Law states that the force that opposes a sphere moving through a viscous fluid is directly proportional to the velocity and radius of the sphere, and the viscosity of the fluid.

Mathematically it is given as

$$F_V = 6\pi\eta r V$$

Here, F_v is viscous force

r is radius of the sphere

v is velocity of the sphere

and η is coefficient of viscosity of the fluid.

→ Stoke's law is valid for small size body. This law does not apply to the particles that are lighter than the fluid medium.

Effect of Temperature on viscosity

For Liquid viscosity decreases with increase in temperature. This is ~~become~~ because the cohesive force ~~[illegible]~~ binding of the liquid reduces and movement of the molecules of molecules increases.

The temperature dependence of viscosity in liquid is given by

$$\eta = \frac{\eta_0}{1+\alpha t+\beta t^2}$$

Here, η_0 is viscosity of liquid at 0°C

α and β are constants

t is temperature of liquid

NOTE:- For gases viscosity increases with increase in temperature. It is given as

$$\eta = \eta_0 + \alpha t + \beta t^2$$

Hydraulic System

→ Hydraulic system are the one in which force applied at one point are transmitted to another point throw incompressible viscous fluid. For example hydraulic breaks. The viscosity of hydraulic fluid is effected by a change in temperature. With increase in temperature viscosity of the fluid decreases and with decrease in temperature viscosity increases. Therefore the hydraulic fluids must have proper viscosity with respect to temperature change to maximise life time. Performance and maintainance of components of hydraulic system.

HydroDynamics

→ Hydrodynamics is a sub discipline of fluid dynamics and a branch of physics in which the motion of liquid is studied at a microscopic level in terms of viscosity and mass density.

Types of fluids depending on density and viscosity change upon action of external force.

1. Ideal Fluid :- Ideal fluid is an imaginary incompressible fluid.

2. Real Fluid :- All fluids are real fluid. Real fluid possesses viscosity and it is compressible.

3. Incompressible Fluid :- If the ~~fluid~~ density of the fluid does not change when external force are applied then the fluid is called incompressible.

4. Compressible Fluid :- In compressible fluid the density changes with application of external force.

5. Ideal Plastic Fluid:- Ideal plastic fluid is a type of fluid in which shear stress is proportional to velocity gradient and it is more than the yield value.

6. Newtonian Fluid:- Newtonian fluid ~~obey's~~ obey's Newton laws of viscosity.

7. Non-Newtonian Fluid:- It does not obey Newton's law of viscosity.

Types of Flow Fluid:-

a) Steady Flow: A flow is said to be a steady flow when the velocity of the fluid is constant at any point.

b) Unsteady Flow: A flow is said to be unsteady flow if the velocity of the fluid is constant at any point in the fluid flow.

c) Compressible Flow:- If the density of the fluid does not changes with the application of external force, then the flow is called compressible flow.

d) Incompressible Flow: ~~In com~~ If the density of the fluid does not changes with the application of external force then the flow is called compressible flow.

e) Viscous Flow: When the effect of inertia and pressure gradient in the fluid are balanced by the effect of fluid viscosity then the flow is called viscous flow.

f) Non-viscous Flow:- In non-viscous fluid flow the forces remain unbalanced due to high velocity of the fluid.

Reynolds Number:-

→ Reynolds number is defined as the ratio of inertia forces to the viscous forces. It can be also be determined as the ratio of dynamic pressure to shear stress.

→ It is denoted as (Re)

Mathematically, $Re = \frac{\rho V D}{\eta} = \frac{VD}{\mu}$ (for a circular pipe)

where, ρ is the density of the fluid.
V is the velocity of the fluid.
D is diameter of the pipe.
η is the coefficient of viscosity of the fluid.
and $\mu = \frac{\eta}{\rho}$ = coefficient of kinematic viscosity.

For non-circular pipes,

The geometrical equivalent of diameter is replaced by hydraulic diameter. (D_h)

Where, $D_h = \frac{4A}{P}$

A is area of cross section of pipe
P is perimeter of pipe.

Case-I : $Re < 2300$

The flow is laminar

Case-II : $2300 < Re < 4000$

The flow is transient flow

Case-III : $Re > 4000$

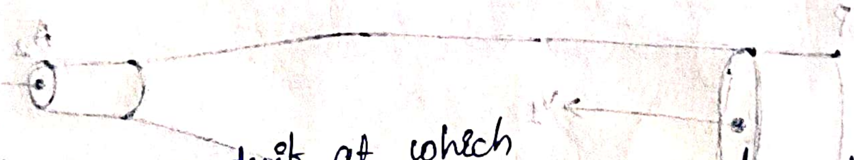
The flow is turbulent flow

Equation of Continuity.

→ It states that the mass flow rate (mass per unit time) remains constant along a stream line motion.

→ The equation of continuity in ~~field~~ fluid dynamics is a mathematical expression that describes the conservation of mass in a fluid flow. It is defined as the product of area of cross section of a conduit (tube) and velocity of the incompressible fluid at any given point along the tube is constant.

Let us consider a steady, incompressible and non-viscous fluid flow in conduit of different area of cross section.



→ Let area of the conduit at which the fluid enter $= A_1$

Let the velocity of the fluid while entering the conduit $= V_1$

→ Let the density of the fluid while entering the conduit $= \rho_1$

→ The mass of the fluid entering the conduit per second $= A_1 V_1 \rho_1$ - - - - - -

Similarly, let the area of the conduit at which the fluid leaves $= A_2$

→ Let the velocity of the fluid while leaving the conduit $= V_2$

→ Let the density of the fluid while leaving the conduit $= \rho_2$

→ The mass of the fluid leaving per ~~unit~~ second $= A_2 V_2 \rho_2$

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

For an incompressible fluid the density remains ~~constant~~ the same.

Therefore, $\rho_1 = \rho_2$

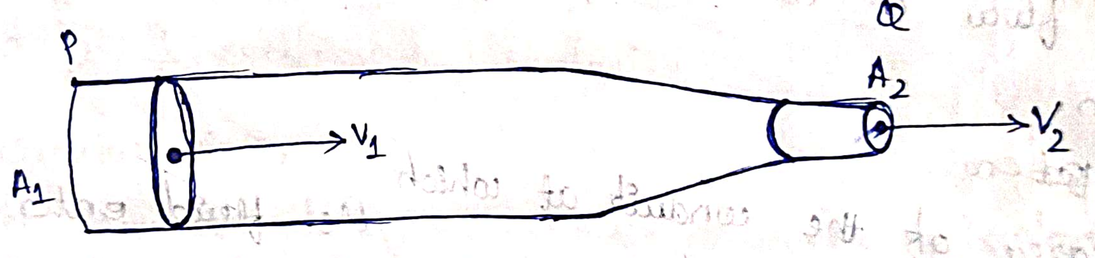
$\Rightarrow A_1V_1 = A_2V_2$

$\Rightarrow AV = \text{constant}$

This is called equation of continuity.

And $AV = R = \text{constant}$ = volume flow rate.

→ this equation states that if the area of cross section of the conduit becomes larger, the velocity of the ~~the~~ fluid becomes smaller and vice-versa.



Steady flow of fluid through a conduit of a different area of cross-sections.

Bernoulli's Theorum:

→ Bernoulli's Theorum states that the total mechanical energy of a non-viscous and incompressible fluid in a stream line motion from one point to another remains constant at every point of its path through out its flow.

Therefore, $\left(P\frac{m}{\rho}\right) + mgh + \frac{1}{2}mv^2 = \text{constant}$

Since mass is constant, we can write the above equation as

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

Multiplying ρ on both sides

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

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

$$\left[\because \rho = \frac{\text{mass of fluid}}{\text{volume of fluid}} \right]$$