# Physics Notes

BY

Er. Lalit Sharma
B.Tech (Electrical)
Ex. Lecturer Govt. Engg. College Bathinda
Physics Faculty Ranker's Point, Bathinda

Arun Garg
M.Sc. Physics
Gold Medalist
Physics Faculty Ranker's Point, Bathinda

Class:10+1

Unit: VII-B

Topic: Properties of Bulk Matter

*SYLLABUS*: UNIT-VII

| | |
|---|---|
| Elastic behavior, Stress-stain relationship, Hooke's law, Young's modulus, bulk modulus, shear, modulus of rigidity. | *7A* |
| Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes). Effect of gravity on fluid pressure. Surface energy and surface tension, angle of contact, application of surface tension ideas to drops, bubbles and capillary rise. | *7B* |
| Viscosity, Stokes law, terminal velocity, Reynolds's number, streamline and turbulent flow, Bernoulli's theorem and its applications. | *7C* |
| Heat, temperatures, thermal expansion; specific heat-calorimetry; change of state- latent heat. | *7D* |
| Heat transfer-conduction, convection and radiation, thermal conductivity, Newton's law of cooling. | *7E* |

**Q.1. What is Fluid? Hydrostatics? Hydrodynamics?**

Ans. **Fluid**:- Fluid is a name given to a substance which begins to flow when external force is applied on it.

Eg. Water and air.

**Hydrostatics**:- The branch of physics which deals with study of fluids at rest, is called *hydrostatics*.

Eg. Water is at rest in bucket.

**Hydrodynamics**:- The branch of physics which deals with study of fluids in motion, is called *hydrodynamics*.

Eg. Water flowing in the pipe.

**Q.2. Explain How Fluid exert normal force/pressure on Walls of Container?**

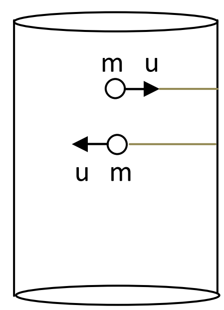
Ans. 1. $\vec{P}_i = m.u.\hat{L}$

$\vec{P}_f = m.u.(-\hat{L})$

$\overrightarrow{\Delta p} = \vec{P}_f - \vec{P}_L$

$= m.u.(-\hat{L}) - m.u.\hat{L}$

$$\boxed{\overrightarrow{\Delta p} = -2.m.u.\hat{L}}$$




2. Force $= \frac{\Delta p}{\Delta t}$

$= \frac{2m.u}{\Delta t}$

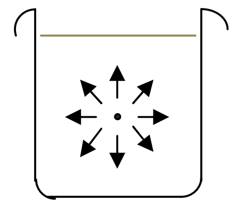
" Normal change in momentum transferred to the per unit time by molecules of fluid, is called normal force or thrust"

3. Pressure is force exerted per unit area.

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

**Q.3. a) Define Pressure? Units? Dimensions? Scalar or Vector?**
**b) How do you measure pressure in a lake?**
**c) Applications of Concept of pressure?**

Ans.a) **Pressure**:- Force per unit area for liquid at rest is *" hydrostatic pressure"*.



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

**Units**:- $\frac{N}{M^2}$ or Pascal

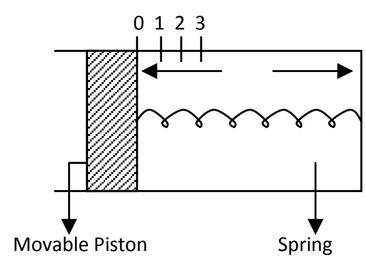
**Dimensions**:- $[P] = \frac{[F]}{[A]}$

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

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

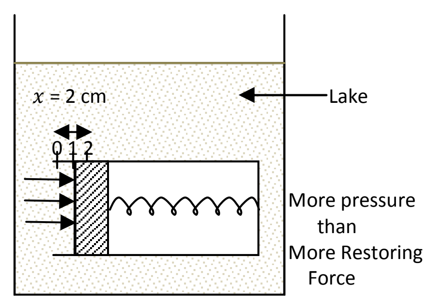
**Scalar**:- Because at one level inside the liquid, the pressure due to liquid, is exerted equally in all directions.

b) **Measurement of pressure in a lake**:-




Force exerted by liquid = K.x

| F = K.x |
|---|

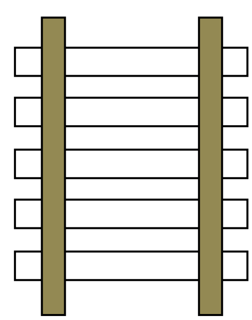



$$\text{Pressure, } P = \frac{Force}{Area\ of\ piston}$$

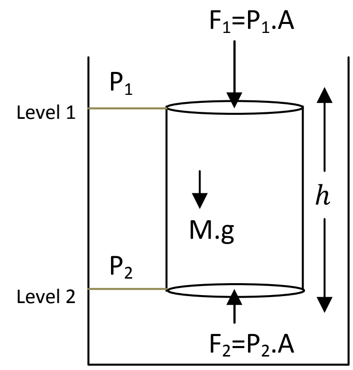
$$= \frac{k.x}{A}$$

c) **Applications of concept of pressure**:-

1. The bags and suitcase are provided with broad handles so that small pressure is exerted on the hand while carrying them.
2. Railway tracks are laid on large sized wooden, iron or cement sleepers so that the thrust due to weight of train is spread over a large area. Thus pressure is reduced on ground.
3. It is painful to walk bare footed on a road covered with edge pebbles.
4. It is difficult to walk bare footed on a sandy ground as the sand yields under our weight.
5. Pins and nails are made to have pointed ends.



**Q.4. a) Prove pressure due to height $h$ of a liquid is $h.\rho.g$.**
**b) Explain "Absolute pressure" and "Gauge Pressure".**




Ans.a) Force on upper face, $F_1 = P_1.A$
Force on lower face, $F_2 = P_2.A$

$Wt = m.g$

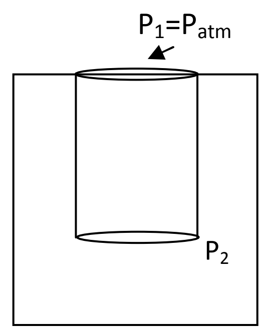
$F_{up} = F_{down}$ as liquid is at rest

$P_2.A = P_1.A + M.g.$

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

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

$$\boxed{P_2 - P_1 = h.\rho.g}$$

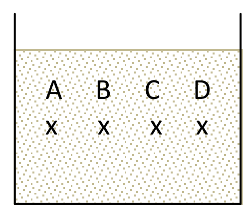



b) $P_2 - P_{atm} = h.\rho.g$ in Gauge Pressure

$P_2 = P_{atm} + h.\rho.g.$ in Absolute Pressure

**Q.5. a) Explain Pascal's Law.**
**b) Application of Pascal's Law:**
**i) Hydraulic Lift**
**ii) Hydraulic Brakes**

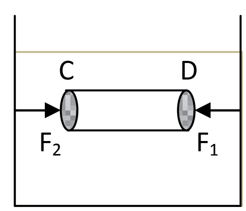
Ans.a) **Pascal's Law**:- It states that pressure at every point on a liquid in equilibrium of rest is same, neglecting effect of gravity.




Eg. Pressure at all points $A$,$B$,$C$ & $D$ is same

Proof Imagine a liquid cylinder with
Forces on face $C$ and $D$
Force on face $D$ $= F_1$
Force on face $C$ $= F_2$
As cylinder is in equilibrium
So, $F_{net} = 0$
$F_1 = F_2$
$P_1.\cancel{A} = P_2.\cancel{A}$

$$\boxed{P_1 = P_2}$$



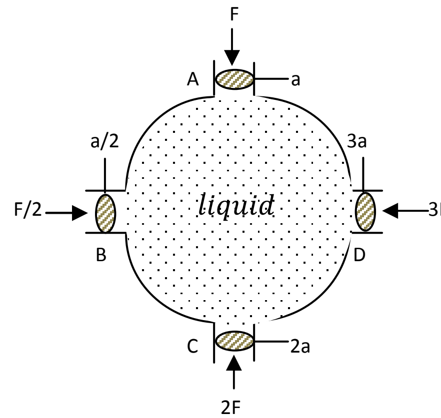
Experimental proof:-

$P_A \quad = \frac{F}{a}$

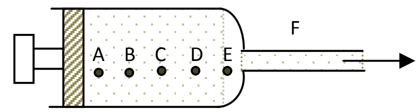
$P_B \quad = \frac{F/2}{a/2} \quad = \frac{F}{a}$

$P_C \quad = \frac{2F}{2a} \quad = \frac{F}{a}$

$P_o \quad = \frac{3F}{3a} \quad = \frac{F}{A}$




Eg. When pressure is exerted on the liquid then pressure is transmitted from one point to the other.




b)i) **Hydraulic Lift**:-

$P_1 \quad = \frac{f}{a} \rightarrow$ (1)

$P_2 \quad = \frac{F}{A} \rightarrow$ (2)

As per Pascal's Law

$P_1 = P_2$

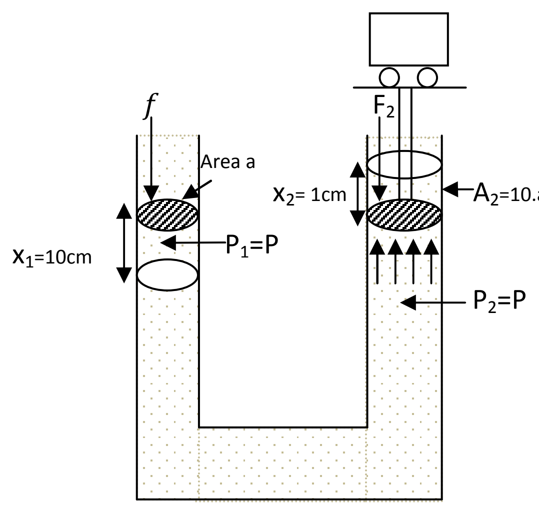
$$\boxed{\frac{f}{a} = \frac{F}{A}}$$

$F \quad = \frac{f}{a} A$

$= f \left(\frac{A}{a}\right)$

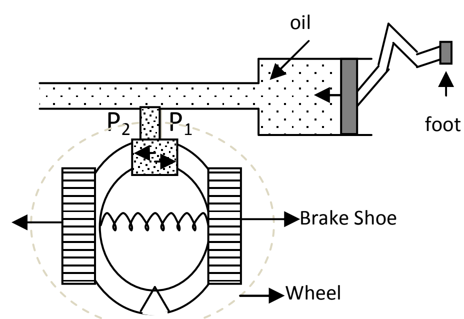
$= f$ (10) (say)

$= 10 f$




However work done remains same.

ii) **Hydraulic Brakes**-

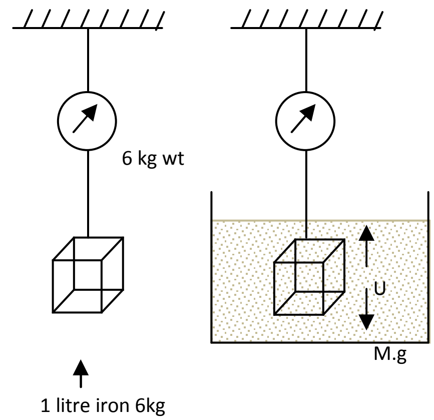



Driver applies force at foot operated paddle. The pressure is transferred to oil. As per Pascal's Law, oil pressure gets transmitted to piston $P_1$ and $P_2$ Because of oil pressure $P_1$ and $P_2$ move outward. Brake shoe also move radically outward as shown. Brake shoe press against the moving wheel. Brake shoe cause friction and vehicle stops.

**Q.6. Explain Archimedes's Principle.**

Ans. **<u>Archimedes's Law/Principle</u>**:-

The loss in weight in the liquid is equal to the weight of the liquid displaced by the immersed part of the body.




<u>Ex-1</u> U = wt. of liquid displaced

$= (V_{lig} . \rho_{Lig}).g$

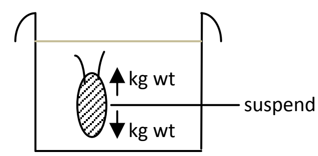
$= (1\,lit)\left(\frac{1\,kg}{1\,lit}\right).g$

$$U = 1kgwt$$

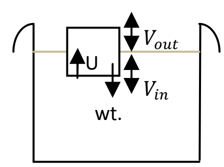
W' = W - U

= 6 kg wt – 1 kg wt

= 5 kg wt.




<u>Ex-2</u> Fraction of volume inside liquids for material having density less than that of liquid.




$\rho_{ice}$ = 90%of water

$\rho_{ice} = 0.9\,\frac{gm}{c.c}$

<u>In equilibrium</u>:-

Wt. = v

$\frac{V_{in}}{V} = \frac{\rho_{ice}}{\rho_{liq}}$

$= \frac{\rho}{\rho_{water}}$

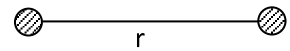
$\frac{V_{in}}{V} = \frac{0.9}{1.0} = 0.90$

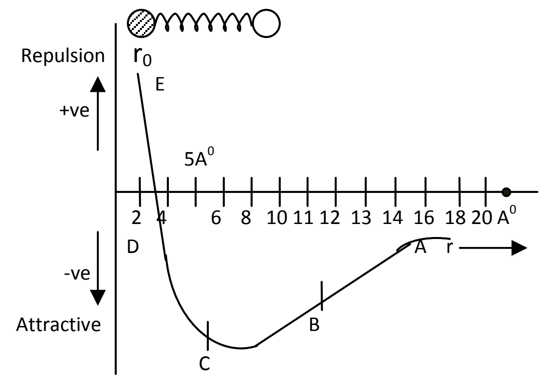
= 90%

**Q.7. Explain:**

**a) Plot $F$ v/s $r$ graph where $r$ is distance between molecules and $F$ is the force between two.**

**b) "*Adhesive*" and "*Cohesive*" force with example.**




Ans. a) (1) As distance decreases from 16A$^0$ to 5A$^0$, $F_{attractive}$ increases and becomes maximum at *C*.

(2) As distance further decreases from 5A$^0$ to 3.5A$^0$ $F_{attractive}$ decreases.

(3) At D, i.e r = 3.5 A$^0$, F = 0 neither attractive nor repulsive. It is in "equilibrium".

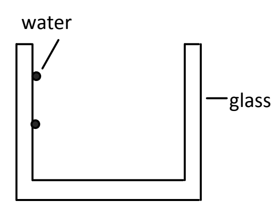
(4) As distance decreases from 3.5A$^0$ to 2A$^0$ force is "repulsive" as a distance decreases. F $\propto \frac{1}{r^n}$
Where n=9 for Part DE.

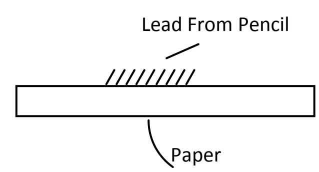
(5) Range:- Order is 10A$^0$

Short Range forces:- Since intermolecular forces act over short distances between the molecules.

b) (i) **Adhesive force**:- The force of attraction acting between the molecules of different substances.

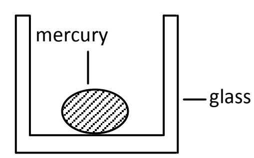
Ex-1:- Glass & water.



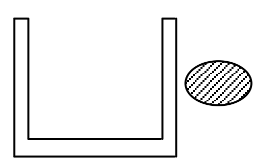

Ex-2:- Piece of paper & lead

(ii) **Cohesive Forces**:- Force of attraction amongst the molecules of same material.




Ex-1:- Force within two molecules of mercury. Force between molecules of mercury is very strong in comparison to mercury glass adhesive force.

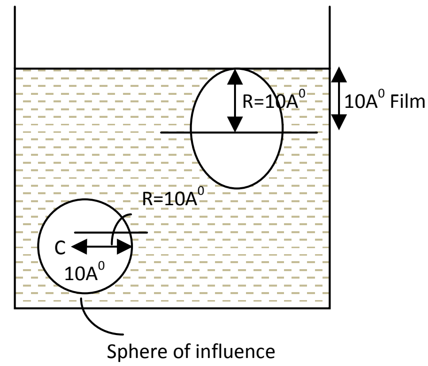
Once we remove mercury from glass, there is no residual of mercury in glass.



Reason:- "Cohesive Force" within mercury molecules is very strong.

**Q.8. Draw diagram to explain:**

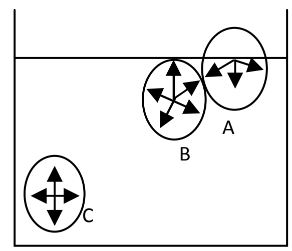
**a) Molecular Range**
**b) Sphere of influence**
**c) Surface film or fluid film**




Ans.a) **Range**:- Maximum distance upto which molecule can exert some measurable attraction on other molecules.
$R = 10A^0$

b) **Sphere**:- It is an imaginary sphere drawn with a molecules as centre and molecules range as Radius.

c) **Surface film**:- It is top most layer of liquid at rest with thickness equal to the molecular range.




Net force on different molecules in liquid:-

Molecule C:- Resultant force an *C* is "zero".

Molecule B:- Resultant force on *B* is downward.

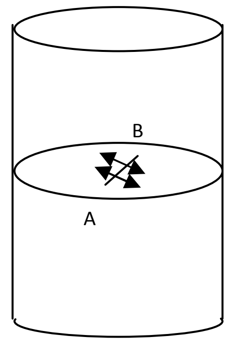
Molecule A:- Resultant force on *A* is downward and more in comparison to *B*.

**Q.9. Explain:**

**a) Surface Tension? Units? Dimensions?**

**b) Examples.**

Ans.a) **Surface Tension**:- Surface Tension is the property of the liquid by virtue of which the free surface of liquid at rest tends to have minimum area and as such it behaves as if stretched membrane.




Measurement of surface Tension:-

$$S \rightarrow \frac{Force}{length}$$

Surface tension of a liquid is measured as the force acting on unit length of a line margined to be drawn tangentially anywhere on the free surface of the liquid at rest. It acts at right angles to this line on both the sides and along tangent to the liquid surface.

Units:- N/m or dyne/cm

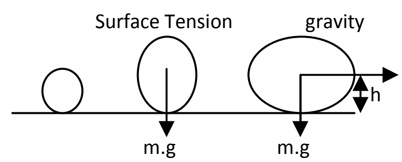
Dimension:- $[s] = \frac{[F]}{[L]}$

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

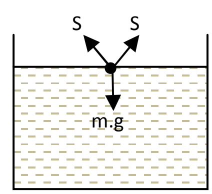
$$= [M^1 L^0 T^{-2}]$$

b) **Examples**:-

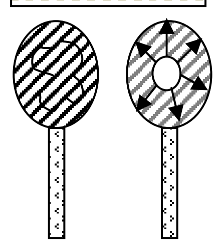
(1) Rain drops are spherical in shape because each drop tends to acquire minimum surface area due to surface tension. For a given volume, the surface area of sphere is minimum.




(2) When mercury is splint on a clean glass plate it forms globules. Tiny globules are spherical on account of surface tension because force of gravity is negligible. The bigger globules get flattened from the middle but round shape near the edges.




(3) The weight of the needle is balanced by the vertical components of the forces of surface Tension. If the water surface is pricked by one end of the needle, the needle sinks down.



(4) Soap film tries to have minimum surface due to surface tension and for a given perimeter, the area of the circle is maximum.

(5) Oil drops spreads on cold water. It may remain as drop on hot water. This is due to the fact that the surface tension of oil is less than that of cold water and is more than that of hot water.

**Q.10. a) Explain Surface Energy? Units? Dimensions?**
**b) Prove surface energy magnitude is equal to surface tension.**

Ans.a) **<u>Surface Energy</u>**:- Surface energy of liquid surface is defined as the amount of work done against the force of surface Tension, is forming the liquid surface.

$$\begin{bmatrix} Units \rightarrow J \\ Dimensions \rightarrow [M^1 L^2 T^{-2}] \end{bmatrix}$$

Surface Energy $\rightarrow \frac{work\ done}{Area}$

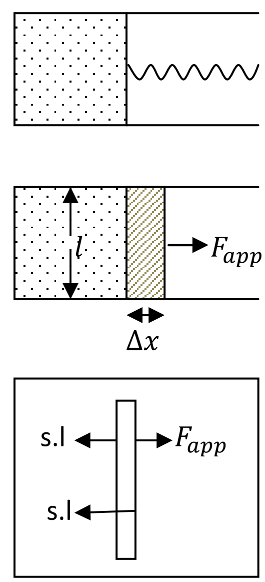
Units $\rightarrow \frac{J}{M^2} \rightarrow \frac{N-m}{m-m} \left(\frac{N}{m}\right)$

$J/m^2$ or N/m

<u>Dimensions</u> $\rightarrow \frac{M^1\, L^2\, T^{-2}}{L^2}$

$$\boxed{[S] \rightarrow [M^1 L^0 T^{-2}]}$$

b) **<u>Surface energy</u>** $= \frac{work\ done}{Area}$

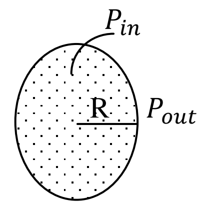



$$= \frac{F_{app}.\Delta x}{2.(l\Delta x)}$$

$$= \frac{(\cancel{2}.s.\cancel{l}).\cancel{\Delta x}}{\cancel{2}.(\cancel{l}\cancel{\Delta x})}$$

= Surface Tension, $s$

**Q.11. Prove excess pressure inside a liquid drop is $\frac{2S}{R}$.**



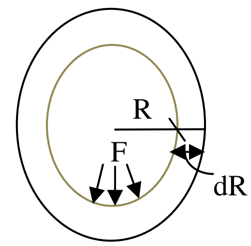

Ans. Radius of drop → R

Surface Tension → S

Excess pressure → $\Delta P$ →?

$(\Delta p = P_{in} - P_{out})$

1. Let us assume the drop expands slightly by distance dR




Work done = F.dR

W = $(\Delta P.4\pi R^2)$.dR

$$W = \Delta P.4\pi R^2.dr \quad \text{——} (1)$$

2. Increase in surface energy

=(S) (Increase in Area)

=(S) $[4\pi(R+dR)^2 - 4\pi R^2]$

=(S) $[4\pi(R^2+dR^2+2dR^2 R) - 4\pi R^2]$

=(S) $[4\pi R^2 + 4\pi dR^2 + 8\pi RdR - 4\pi R^2)$

=(S) $[4\pi dR^2 + 8\pi RdR]$

= $S.4\pi dR^2 + S.8\pi R.dR$ $\quad [(dR)^2 \simeq 0]$

$$E \simeq 8\pi R.dR.S \quad \text{——} (2)$$

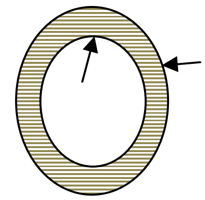
3. As per Law of conservation of Energy

Work done = Increase in Energy

$\Delta P.4\pi R^2.dR = 8\pi RdR.S$

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

**Q.12. Prove excess pressure inside a soap bubble is = $\frac{4S}{R}$ .**



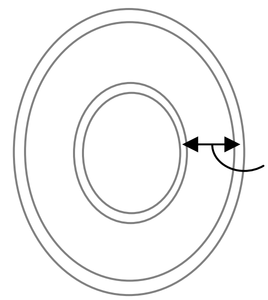
Ans. Radius of soap bubble $= R$

Surface tension $= S$

Excess Pressure → $\Delta P$ → ?

$$(\Delta p = P_{in} - P_{out})$$

1. Let us assume the soap bubble expands slightly by distance dR.




Work done = F.dR

$= \Delta P\ (4\pi R^2).dR$

$$\boxed{W = \Delta P.4\pi R^2.dR} \quad \text{——— (1)}$$

2. Increase in surface energy

$= (S)$ (increase in Area) × 2

$= (S)\ (4\pi\ (R + dR)^2 - 4\pi R^2) \times 2$

$= (S)\ (4\pi dR^2 + 8\pi R.dR) \times 2$

$= 2.S.4\pi dR^2 + 2.S.8\ \pi\ R.dR$

$$\boxed{E \sim 2.S.8\pi R.dR} \quad \text{——— (2)}$$

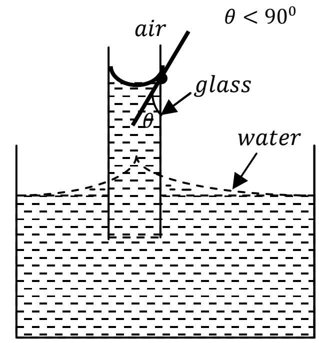
3. As per Law of conservation of Energy

Work done = Increase in Energy

$\Delta P.4\pi R^2.dR = 2.S.8.\pi.R.dR$

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

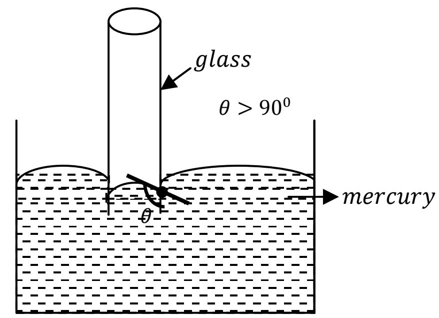
**Q13.** **a) Angle of Contact.**
**b) Factors on which angle of contact depends.**
**c) Phenomenon of capillarity? Examples and Applications.**




Ans.

a) **Angle of Contact**:

The angle of contact between a liquid and solid is defined as the angle enclosed between the tangents to the liquid surface at pt. of contact and the solid surface inside the liquid.

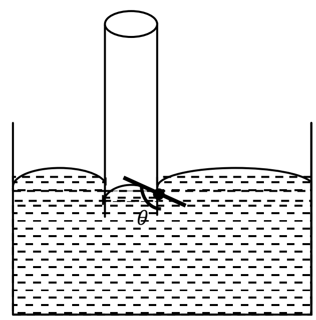


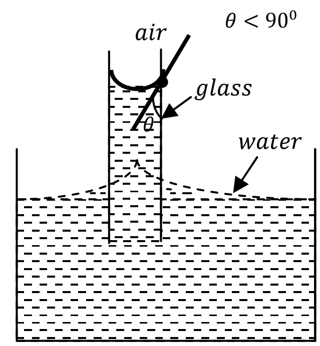

b) **Factors on which Angle of Contact depends**:

1. It depends upon the nature of the liquid and solid in contact.
2. It depends upon the medium which exist above the free surface of liquid.
3. It is independent of the inclination of the solid to liquid surface.
4. It is fixed for a given pair of solid and liquid and surrounding medium.

c) **Capillarity**:

A tube with a fine and uniform bore throughout its length is called a *Capillary Tube*.




**Examples & Applications**:

1. The fine pores of a blotting paper act like capillary tubes. Ink rises in them leaving the paper dry.
2. A towel soaks water on account of capillary action.
3. Oil rises in the long narrow spaces between the threads of a wick, because they act as fine capillaries.
4. Swelling of wood in rainy season is due to rise of moisture from air, in the pores of wood.
5. Ploughing of fields is essential for preserving moisture in the soil. By ploughing the fine capillaries in the soil are broken. Water from within the soil shall not rise and evaporate off.
6. Sand is drier soil than clay. This is because holes between the sand particles are not so fine as compared to that of clay, as to draw up water by capillary action.

**Q.14. Prove rise of liquid in a tube is** $h = \dfrac{2S\cos\theta}{r\,\rho\,g}$ **.**

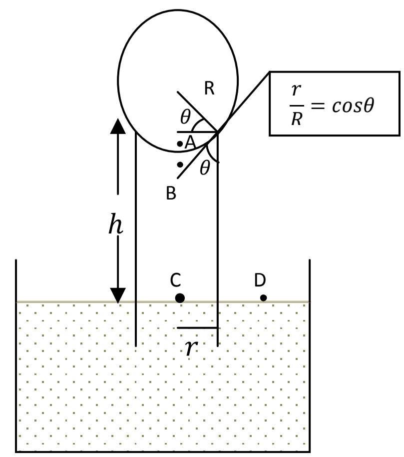
Ans. r → radius of Tube

R → Radius of curvature of surface

$P_D$ = 1atm

$P_A$ = 1atm

$P_c$ = $P_D$ = 1 atm (same level)




1. $P_A - P_B = \frac{2S}{R}$ ——— (1)

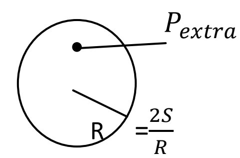
(concave side has extra pressure due to surface tension)

2. $P_c = P_B + h.\rho.g$ ——— (2)

From (1) & (2)

$P_A - \frac{2S}{R} = P_C - h.\rho.g$

$1atm - \frac{2S}{R} = 1\ atm - h\ .\ \rho.\ g$




$$h = \frac{2S}{R.\rho.g}$$

$$h = \frac{2.S.cos\theta}{r.\rho.g}$$ $\left(Because\ R = \frac{r}{cos\theta}\right)$

**Q15. Define Density, Relative Density, S.I. units?**

Ans. **Density**:

Density of a substance is defined as mass per unit volume of a substance.

Density, $\rho = \frac{Mass}{Volume} = \frac{M}{V}$

**S.I. Units**: ${}^{Kg}/_{m^3}$

**Dimensions**: $[\rho] = [M^1 L^{-3}]$

**Relative Density**:

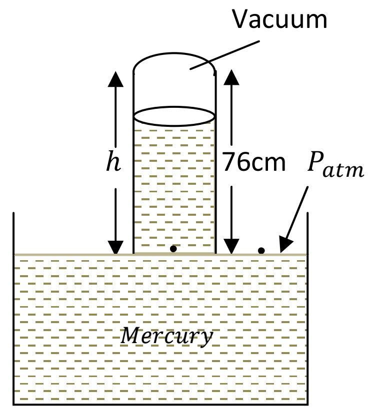
Relative density of a substance is defined as the ratio of its density to the density of water.

Relative Density $= \frac{Density\ of\ substance}{Density\ of\ water}$

(Example: R.D. of iron is 6)

**Q.16. Explain:**

**a) Atm Pressure.**
**b) Tooricell's experiment.**




Ans. $P_B = 1$ atm

$P_A = 1$ atm

$P_A = h.\rho.g$

$= (0.76)\ (13.6 \times 10^3)\ (10)$

$= \frac{76}{100} \times \frac{136}{10} \times 10^3 \times 10$

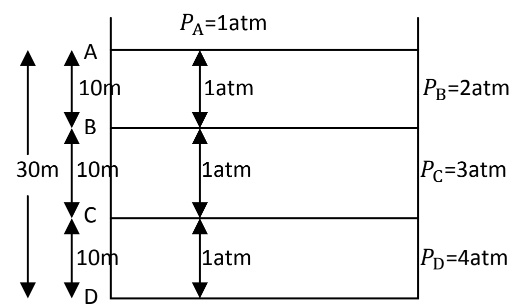
$= \frac{10416}{1000} \times 10^4$

$= \frac{10416}{1000} \times 10^5$

$= 1.0416 \times 10^5\ N/m^2$ (if $g \simeq 10$)

| $P_A = 1.01 \times 10^5\ N/m^2$, when $g = 9.8$ |
|---|

<u>For water</u>




$P_{atm} = h_w.\rho_w.g$

$h_m.\rho_m.\cancel{g} = h_w.\rho_w.\cancel{g}$

$h_m(13.6) = h_w(1)$

$(76cm)\ (13.6) = h_w$

$h_w = 10.3m$

$\simeq = 10m$

| $h_{water} = 10m$ |
|---|