MECHANICAL PROP. OF FLUIDS

PRESSURE

: • scalar quantity

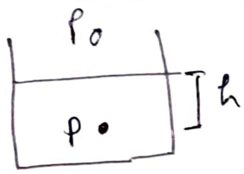
$$P_{av} = \frac{F}{A}$$

Units : 1 atm = 1.01×10^5 Pa

1 bar = 10^5 Pa

1 torr = 133 Pa = 1 mm of Hg.

Variation with depth



$$P = P_0 + \rho g h$$

$P - P_0$ = gauge pressure/ excess pressure.

ARCHIMEDE'S PRINCIPLE

upthrust/ Buoyancy = weight of fluid displaced by body

$U = W_{fluid\ displaced}$

$U = m_{fluid\ disp.} g = \rho_{fluid} V_{disp} g$

$$U = \rho_f V_f g$$

loss of wt of body in fluid = U

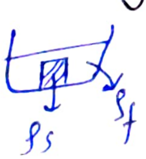
$$W_{app} = W_{air} - U$$

$$\frac{W_{app}}{W} = \frac{\rho_s - \rho_f}{\rho_s}$$

$W_{app} = W\left(1 - \frac{\rho_f}{\rho_s}\right)$ → relative dencity

$$\rho_s = \frac{W}{W - W_{app}} \times \rho_f$$

Floating condition :



① $\rho_s > \rho_f$ ⇒ Sink

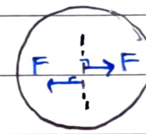
② $\rho_s < \rho_f$ ⇒ Float

③ $\rho_s = \rho_f$ ⇒ Limiting floatath

SURFACE TENSION (T)

- scalar
- liquid surface property due to which attain min surface (E min) → sphere
- depend on : (i) nature of liquid
  (ii) its int. mol. force. (∝)
  (iii) impurities. (soap dec. T)
  (v) temp. ($\propto \frac{1}{T}$) → critical temp when T=0
- surface tension is numerically equal to force acting per unit length on imaginery line (force is ⊥ to line on both sides)

$$T = \frac{F}{l} = \frac{\Delta U}{\Delta A}$$



unit of $T = \frac{N}{m} = \frac{J}{m^2}$

$F_s = T \times l$ [Liquid in beaker]

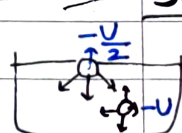
☆ For liquid film — ANY LIQUID

$F = T \times 2l$

Total force ← F ; 2l → ek length aage or ek peeche

Double layer/ Double surface

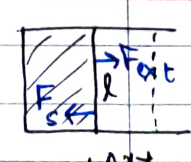
SURFACE ENERGY (U)



surface molecule has extra erg.

- molecule ⇒ force of attractn ⇒ -ve potential energy
- Bulk mol. reach surface on Δ.
- Surface erg = $\frac{1}{2}$ × Heat of vaporisatn

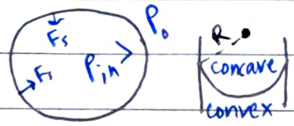
$$W_{ext} = \Delta U = T \Delta A$$ → Total change in area



☆ X2 → ANY liq. film
→ ONLY SOAP BUBBLE/ DROP.

> Soap, detergent, dying substance = wetting agent → dec. contact angle
> water proofing agent inc. θ

⇒ EXCESS PRESSURE in liq drop



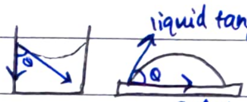
$P_{in} - P_0 \neq P_{concave} - P_{convex}$
(ΔP)

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

soap bubble $\Delta P = \frac{4T}{R}$

⇒ CONTACT ANGLE

- $\theta < 90°$



(I) More wetting
(II) Concave meniscus
(III) $h = +ve$ → capillary rise up
(iv) Adhesive > cohesive (v) eg: Impure water

- $\theta > 90°$ → $\cos\theta$ +ve ∴ h dip

opp. points
eg: Mercury

- $\theta = 0°$

completely wet
eg: Pure H_2O

- $\theta = 90°$ → $\cos\theta = 0$

$h = 0$ (No rise/fall in capillary)
eg: silver

⇒ CAPILLARY RISE/FALL :

$\Delta P = h\rho g \Rightarrow \boxed{\frac{2T}{R} = h\rho g}$

$R\cos\theta = r$
$\Rightarrow \boxed{r = \frac{R}{\cos\theta}}$ — r: radius of capillary tube; R: Radius of meniscus; θ: Angle of contact

∴ $\boxed{h = \frac{2T\cos\theta}{r\rho g} = \frac{2T}{R\rho g}}$ — h: height of capillary rise

Capillary tube of insufficient height :

No fountain (Against energy conservatn)
> liquid will adjust its meniscus radius according to length provided

$h = \frac{2T}{R\rho g}$ → const $\Rightarrow \boxed{h_1 R_1 = h_2 R_2}$

h_1: calculated height; R_1: expected meniscus; h_2: given height/length; R_2: new meniscus

∵ $R = \frac{r}{\cos\theta_1} \Rightarrow \boxed{\frac{h_1}{\cos\theta_1} = \frac{h_2}{\cos\theta_2}}$

If tube is cut ⇒ R↑ ⇒ cos θ↓ ⇒ θ↑

Bernoulli's Principle :

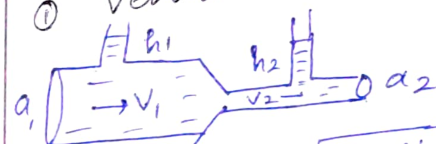
- conservation of energy

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

- various energies per unit mass.

Application :

① Venturimeter



$$Q = a_1 a_2 \sqrt{\frac{2g(h_1 - h_2)}{a_1^2 - a_2^2}}$$

② Hole in tank

$$V_e = \sqrt{2gh}\sqrt{\frac{A^2}{A^2 - a^2}}$$

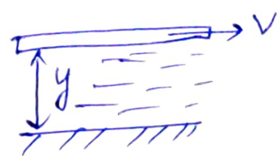
Range ⇒ $R = 2\sqrt{h(H-h)}$
$R_{max} = H$ (when $h = \frac{H}{2}$)

Reynold's no. :

$$N_R = \frac{\rho v D}{\eta} = \frac{\text{Inertial force}}{\text{Viscous force}}$$

Viscous force :

$$\boxed{F = -\eta A \frac{dv}{dy}}$$



SI unit of η = Pa.s

STOKE'S LAW :

$$\boxed{F = 6\pi\eta r v}$$

Imp case : Body released from rest.

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

V_T: Terminal velocity; σ: Body's density; ρ: fluid's density