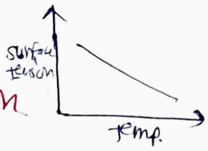
Surface Tension



① surface tension : $(T) = \frac{\text{force}}{\text{length}}$ — scalar quantity

→ $\boxed{\text{Force} = T \times \text{length}}$

② Balancing of needle on liquid surface

$\boxed{2 \times Tl\cos\theta = mg}$

③ max. wt of needle

$\boxed{2Tl = mg}$

$\boxed{\eta = \frac{\text{stress}}{\text{strain rate}}}$

→ Force required to pull needle.

$\boxed{(F_{up})_{min} = mg + 2Tl}$

③ Surface Energy

$\boxed{W = T \times (A_f - A_i)}$

$\boxed{\Delta U = T \times \Delta A}$

- W done in Blowing a liquid drop = 2 × soap bubble

$W = T \times 4\pi(r_2^2 - r_1^2) = 2 \times [T \times 4\pi(r_2^2 - r_1^2)]$

④ Excess pressure

a) multiple layers: $\boxed{\Delta P = 2T\left[\Sigma \frac{1}{R}\right]}$

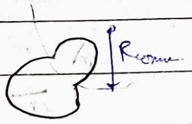
$P_i = P_{inside}$
$P_o = P_{outer}$

b) soap bubble : $\boxed{\Delta P = P_i - P_o = \frac{4T}{R}}$ — P_o = atm. pressure

c) cylindrical liq. surface : $\boxed{\Delta P = T/R}$

⑤ formation of double bubble

$\boxed{R_{common} = \frac{r_1 r_2}{(r_2 - r_1)}}$



⑥ capillarity

$\boxed{h = \frac{2T\cos\theta}{r\rho g} = \frac{2T}{R\rho g}}$

R = radius of meniscus
r = radius of capillary tube

$\boxed{R = \frac{r}{\cos\theta}}$

$\boxed{h_1 r_1 = h_2 r_2}$ $\boxed{h_1 R_1 = h_2 R_2}$

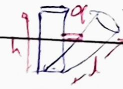
Poise आते ही all units continue करो

(CM)

MKS → Pl (Poiseuille) $\boxed{1\ Pl = 10\ P}$
CGS → P (Poise)

tilting of capillary tube :

$\boxed{h = l\cos\alpha}$



Viscosity

① Newtonian formulae : $\frac{\Delta V}{\Delta x} = \text{const}$ — vel. gradient

② viscous force : $\boxed{F = -\eta A\left(\frac{dv}{dx}\right)}$ or $\boxed{F = \eta A\left[\frac{\Delta V}{\Delta x}\right]}$ → for two layers interacting

10 Poise = 1 poiseuille = 1 decapoise

$\eta_{water} = 0.01$ poise (η = coeff. of viscosity)

④ Stokes law → for sphere & layer interaction

$\boxed{F_V = 6\pi\eta r v_t}$

⑤ Terminal vel. $\boxed{v_t = \frac{2}{9}\frac{r^2 g}{\eta}(\sigma - \rho)}$ — σ: body, ρ: liquid

⑥ Poiseuille's formulae :

$\boxed{I = \frac{V}{R}}$ $\boxed{V = P/R}$ — rate of flow / liquid current

$R = \rho l/A$

liq. resistance ← $\boxed{R = \frac{8\eta l}{\pi r^4}}$ $\boxed{\frac{8\eta l}{r^2 A}}$

a) series comb^n of tubes : $R_{eq} = R_1 + R_2$

Elasticity

① Stress : $\frac{\text{Force}}{\text{Area}} = \frac{F}{A}$

Normal stress — shear | tangential stress

longitudinal — Bulk / volume

a) longitudinal stress = $\frac{\text{Normal / longitudinal force}}{\text{Area}}$

b) Bulk / volumetric stress : ΔP — in case of liq. gas solid

b) shear stress = $\frac{\text{tangential force}}{\text{Area}}$

(3)

$$\Delta P = 4T/R = \rho g h = \frac{B\Delta V}{V}$$

(3) Strain!

1) Linear strain = $\dfrac{\text{change in length } (\Delta l)}{\text{original length } (l)}$

2) Volumetric strain = $\dfrac{\text{change in volume } (\Delta V)}{\text{original volume } (V)}$

3) shearing strain = $\boxed{\phi = \dfrac{x}{L}} = \boxed{\tan\theta}$

If θ much less, then $\boxed{\tan\theta \simeq \theta}$

(4) Hooke's law:

$\boxed{\dfrac{\text{stress}}{\text{strain}} = \text{const}} = (E)$ (modulus of elasticity)

$\boxed{\tan\theta = \dfrac{\text{stress}}{\text{strain}} = E}$

(5) Young's modulus

$\boxed{Y = \dfrac{F \cdot l}{A \cdot \Delta l}}$ → $\dfrac{\text{Normal stress}}{\text{longitudinal strain}}$

a) Force

$\boxed{F = \left(\dfrac{YA}{l}\right) x}$ $\boxed{F = kx}$ spring const like

$\boxed{k = \dfrac{YA}{l}}$ → convert wire → spring

b) Energy:

$\boxed{U = \dfrac{1}{2} kx^2 = \dfrac{1}{2}\left(\dfrac{YA}{l}\right) x^2}$

$U = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$

$U = \frac{1}{2}\frac{(\text{stress})^2}{Y} = \frac{1}{2}(\text{strain})^2 Y$

c) Breaking of wire

$\boxed{\text{Breaking force} = P \times A}$

P → Breaking stress

(6) Bulk modulus

$B = \dfrac{\text{Normal stress}}{\text{volumetric strain}} = \boxed{\dfrac{F/A}{-\Delta V/V} = -\dfrac{PV}{\Delta V}}$

$B_{iso} = P$

$B_{ad} = \gamma P$

$\boxed{\dfrac{\Delta V}{V} = 3\dfrac{\Delta r}{r}}$

(7) Modulus of Rigidity

$\eta = \dfrac{\text{shearing stress}}{\text{shearing strain}} = \dfrac{F/A}{\phi} = \boxed{\dfrac{F_T \cdot L}{A \times x}}$

(4)

P_0 = atm. pressure

$W = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$

$W = \frac{1}{2} \times Y \times (\text{strain})^2$

(8) Poisson's ratio (σ)

$\boxed{\sigma = \dfrac{\text{lateral strain}}{\text{longitudinal strain}} = -\dfrac{dr/r}{dL/L}} = \dfrac{\Delta r \times l}{r \times \Delta l}$

* Theoretical value of poisson's ratio.

$\boxed{-1 < \sigma < 0.5}$

* practical value of poisson's ratio.

$\boxed{0 < \sigma < 0.5}$

Pressure & pressure diff

(1) $P = F/A$

(2) → $\boxed{\Delta P = h\rho g}$ → variation with depth

→ $P_1 = P_2$ → ~~variation~~ same level

$\boxed{\Delta P = P_{lower} - P_{higher}}$

or $P_{inner} - P_{outer}$

(3) P_0 for mercury $\rho_{Hg} = 13.6 \text{ gm/cm}^3$

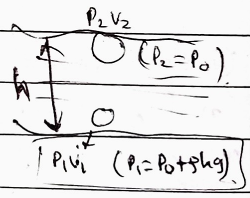
$\boxed{P_0 = 1.01 \times 10^5 \text{ N/m}^2 = 10^5 \text{ pascal} = 1 \text{ atm}}$

$\boxed{= 760 \text{ torr}}$

(4) depth of lake

$\boxed{P_2V_2 = P_1V_1}$

mole conservation   ($nRT = \text{const}$)



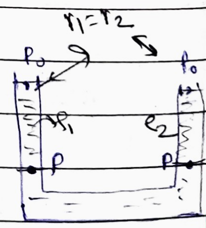
(5) Gas manometer

$\boxed{P_{gas} = P_0 + h_{mercury}\,\rho_{mercury}\, g}$ → $\boxed{\Delta P = h\rho g}$

(6) $\boxed{P_{gauge} = P_{gas} - P_0}$

(7) U-tube

$\boxed{\Sigma h\rho g \text{ (left)} = \Sigma h\rho g \text{ (Right)}}$



(8) working of hydraulic lift

$\boxed{\dfrac{f}{a} = \dfrac{F}{A}}$ $\boxed{f \propto a}$

$P - P_0 = \rho g h$

inner level ; surface level

$P' - P = 2T/R$

P' → pressure inside the bubble.

P → inner level or outside the bubble at bottom

③ Archemedes principle

a) upthrust

$$\boxed{U = \rho V g}$$

(V = vol. of liquid displaced)

→ For accⁿ container in y-dirⁿ.

$$\boxed{U = \rho V \cdot g_{eff}}$$

① Partially immersed body

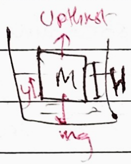
U = weight

$$\rho V_{imm} g = \sigma V_{body} g$$

$$\boxed{\rho V_{imm} = \sigma V_{body}}$$

a) ~~fractional~~ volᵐ of immersed portion

$$\boxed{\frac{V_{imm}}{V_{body}} = \frac{\sigma}{\rho}}$$



b) fraction of body immersed in liq.

$$\boxed{\frac{y}{H} = \frac{\sigma}{\rho}}$$

② Just floatation

$$\boxed{\sigma = \rho}$$

bcz $\boxed{V_{imm} = V_{body}}$

③ sink

$$U = \rho V_{imm} g = \rho V_{body} \times g = \boxed{\rho \frac{M}{\sigma} \times g}$$

$$\boxed{U = \frac{\rho}{\sigma} Mg}$$

a) Apparent wt ⇒ $\boxed{Mg - U}$

④ cavity $\boxed{U = \rho V_{imm} g}$

* Reynold's no.

N_R = Inertial force/Area / Viscous force/Area $= \boxed{\frac{\rho V D}{\eta}}$

diameter of pipe through which fluid is moving

critical velocity

⇒ 0 – 2000 streamline (or) laminar

⇒ 2000 – 3000 streamline to turbulent

⇒ > 3000 turbulent

* Eqⁿ of continuity (Principle of conservation of mass)

$$\boxed{a_1 V_1 = a_2 V_2}$$

aV = rate of flow

a) tap

$$a_1 V_1 = a_2 V_2$$

$$V_2^2 = V_0^2 + 2gh$$

initial

⑥ Bernoulli's theorem.

$$\boxed{\frac{P}{\rho} + \frac{V^2}{2} + gh = \text{const}}$$

– for incompressible and viscous fluid.

→ applications of Bernoulli's theorem

a) working of aeroplane $\boxed{P \propto \frac{1}{V}}$

b) action of atomiser

c) Blowing of roofs by wind storms

$$\boxed{\frac{P_{high}}{\rho} + \frac{V_{low}^2}{2} = \frac{P_{low}}{\rho} + \frac{V_{high}^2}{2}}$$ → at same ht.

$$\boxed{\Delta P = \frac{(V_{large}^2 - V_{small}^2)}{2} \times \rho}$$

$$\boxed{F = \frac{(V_{large}^2 - V_{small}^2)}{2} \rho \times A}$$

⑦ magnus effect. eg. spinning dirⁿ of ball,

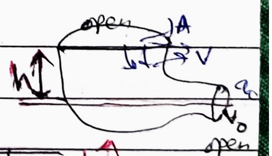
⑧ tappered pipe having cross section at diff. level

$$\boxed{AV = a V_0}$$ final

$$V^2 = V_0^2 + 2gh$$

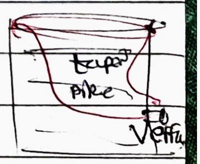
final

$$\boxed{V_0 = \sqrt{\frac{2gh}{1 - \left(\frac{a}{A}\right)^2}}}$$



⑨ Tank

small hole. $\boxed{A >> a}$



$$\boxed{V_0 = \sqrt{2gh}}$$

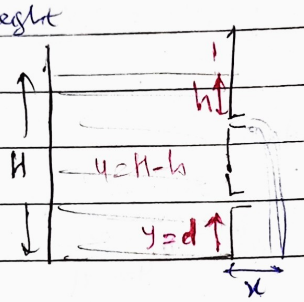
$$\boxed{a V_{efflux} = \text{Rate of flow}}$$

hole = reference point

h = depth upto hole or reference point

a) Range:

$x = \sqrt{4 \times \text{depth} \times \text{height}}$



b) same range

$\boxed{\text{Height} = \text{depth}}$

$(h) = (d)$

c) max. Range

$\boxed{\text{Height} = H/2}$

$h = H/2$

d) Recoil force

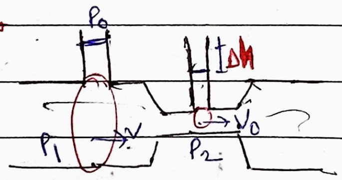
$$\boxed{F_{recoil} = \frac{\Delta p}{\Delta t} = 2\rho a g h}$$

e) time taken to change ht from H_1 to H_2

$$\boxed{t = \frac{A}{a}\sqrt{\frac{2}{g}}\left(\sqrt{H_1} - \sqrt{H_2}\right)}$$

Venturimeter

$$\boxed{V_0 = \sqrt{\frac{2gh}{1-\left(\frac{a}{A}\right)^2}}}$$



→ The Venturimeter is a device to measure the flow speed of incompressible fluid.

→ Shearing stress of fluids is about million times smaller than that of solids.

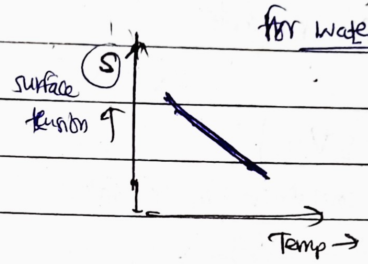
* Pressure is equal to.

⇒ It is ratio of the component of force normal to area.

if, Relative density 1.2 then

$\boxed{\text{density is } 1.2 \times 10^3\ kg/m^3}$

for water



if temp. ↑es, solubility decreases

* when temp ↑ses, the viscosity of
→ Gases ↑ses & liq. decreases

* streamline flow is more likely for liq. with
→ Low density and high ~~density~~ viscosity

* Blood is more viscous than water.

* The blood pressure in humans is greater at the feet that at the brain.

* The energy required for having a molecule at the surface of liq. is
⇒ Roughly half the heat of evaporation.