

FLUID MECHANICS & PROPERTIES OF MATTER

FLUIDS, SURFACE TENSION, VISCOSITY & ELASTICITY :

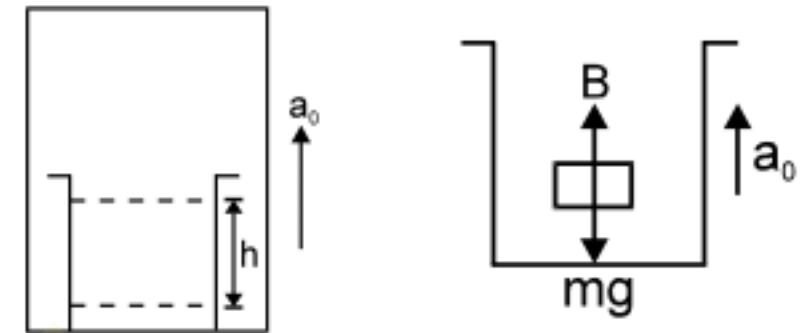
1. Hydraulic press. $p = \frac{f}{a} = \frac{F}{A}$ or $F = \frac{A}{a} \times f$.

Hydrostatic Paradox $P_A = P_B = P_C$

(i) Liquid placed in elevator : When elevator accelerates upward with acceleration a_0 then pressure in the fluid, at depth 'h' may be given by,

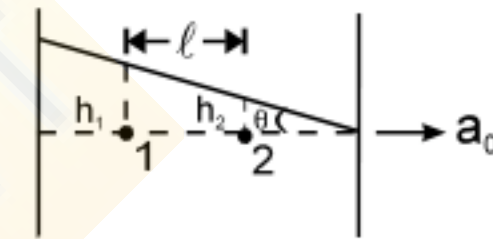
$$p = \rho h [g + a_0]$$

and force of buoyancy, $B = m (g + a_0)$



(ii) Free surface of liquid in horizontal acceleration :

$$\tan \theta = \frac{a_0}{g}$$

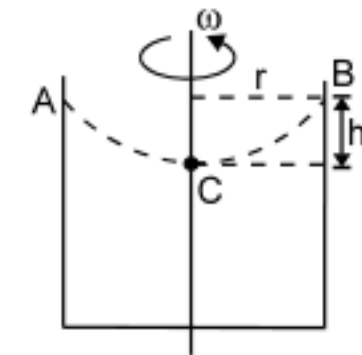


$p_1 - p_2 = \rho l a_0$ where p_1 and p_2 are pressures at points 1 & 2.

Then $h_1 - h_2 = \frac{l a_0}{g}$

(iii) Free surface of liquid in case of rotating cylinder.

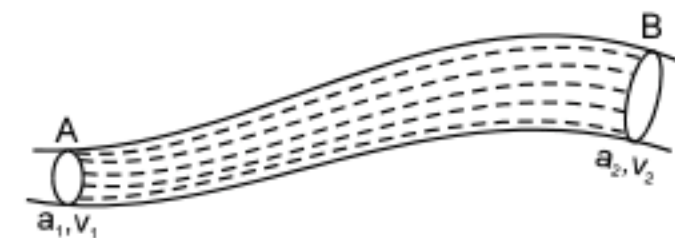
$$h = \frac{v^2}{2g} = \frac{\omega^2 r^2}{2g}$$



Equation of Continuity

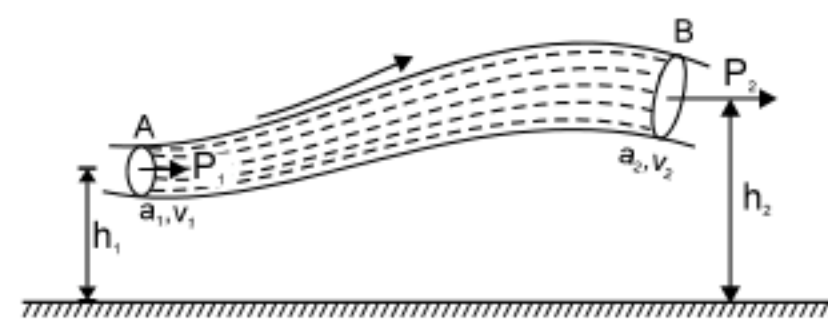
$$a_1 v_1 = a_2 v_2$$

In general $av = \text{constant}$.



Bernoulli's Theorem

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



(vi) Torricelli's theorem – (speed of efflux) $v = \sqrt{1 - \frac{A_2^2}{A_1^2} \cdot 2gh}$, $A_2 = \text{area of hole}$

$A_1 = \text{area of vessel}$.

ELASTICITY & VISCOSITY : stress = $\frac{\text{restoring force}}{\text{area of the body}} = \frac{F}{A}$

Strain, $\epsilon = \frac{\text{change in configuration}}{\text{original configuration}}$

(i) Longitudinal strain = $\frac{\Delta L}{L}$

(ii) $\epsilon_v =$ volume strain = $\frac{\Delta V}{V}$

(iii) **Shear Strain** : $\tan \phi$ or $\phi = \frac{x}{l}$

Young's modulus of elasticity $Y = \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L}$

Potential Energy per unit volume = $\frac{1}{2}$ (stress \times strain) = $\frac{1}{2}$ (Y \times strain²)

Inter-Atomic Force-Constant $k = Yr_0$.

Newton's Law of viscosity, $F \propto A \frac{dv}{dx}$ or $F = -\eta A \frac{dv}{dx}$

Stoke's Law $F = 6\pi\eta r v$. Terminal velocity = $\frac{2}{9} \frac{r^2(\rho - \sigma)g}{\eta}$

SURFACE TENSION

Surface tension (T) = $\frac{\text{Total force on either of the imaginary line (F)}}{\text{Length of the line (l)}}$;

$$T = S = \frac{\Delta W}{A}$$

Thus, surface tension is numerically equal to surface energy or work done per unit increase surface area.

Inside a bubble : $(p - p_a) = \frac{4T}{r} = p_{\text{excess}}$;

Inside the drop : $(p - p_a) = \frac{2T}{r} = p_{\text{excess}}$

Inside air bubble in a liquid : $(p - p_a) = \frac{2T}{r} = p_{\text{excess}}$

Capillary Rise $h = \frac{2T \cos \theta}{r\rho g}$