FLUID MECHANICS & PROPERTIES OF MATTER

FLUIDS, SURFACE TENSION, VISCOSITY & ELASTICITY :

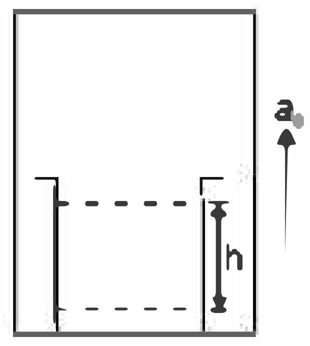
1. Hydraulic press. $p = \frac{f}{a} = \frac{F}{A}$ or $F = \frac{A}{a} \times f$.

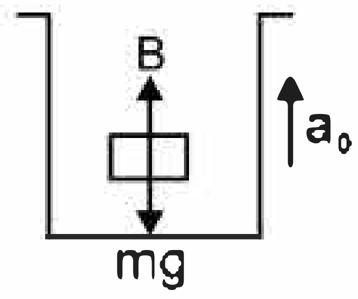
Hydrostatic Paradox $P_A = P_B = P_C$

(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,

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

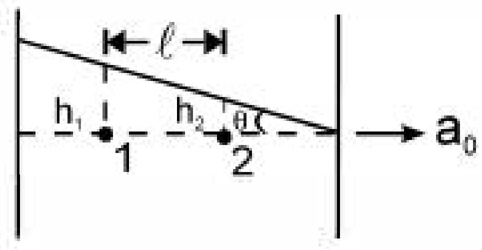
and force of buoyancy, $B = m\,(g + a_0)$





(ii) Free surface of liquid in horizontal acceleration :

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

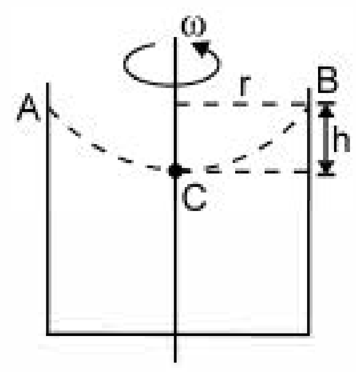


$p_1 - p_2 = \rho \ell a_0$ where p_1 and p_2 are pressures at points 1 & 2.

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

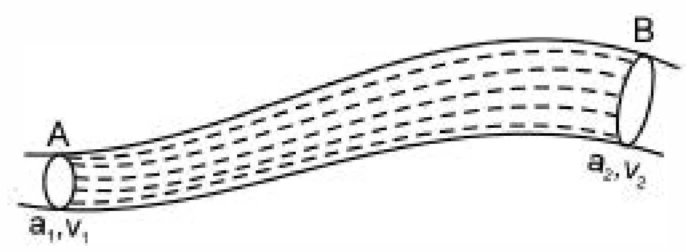
(iii) Free surface of liquid in case of rotating cylinder.

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



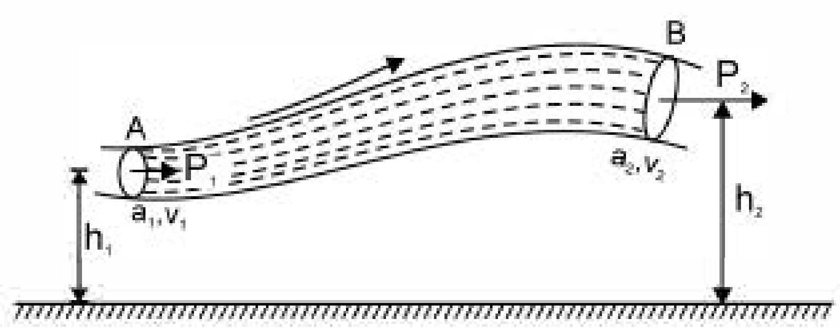
Equation of Continuity

$a_1 v_1 = a_2 v_2$



In general av = constant .

Bernoulli's Theorem



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

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

A_1 = area of vessel.

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

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

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

(ii) $\in_v$ = volume strain = $\dfrac{\Delta V}{V}$

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

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

Potential Energy per unit volume = $\dfrac{1}{2}$(stress × strain) = $\dfrac{1}{2}$ (Y × strain^2)

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

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

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

SURFACE TENSION

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

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

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

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

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

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

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