* **for vertical plane :-**

Total Pressure Force = $\rho g A \bar{h}$

centre of pressure = $h^* = \frac{I_G}{A\bar{h}} + \bar{h}$

Moment of inertia of some important plane surfaces.

Plane	C.G from base	Area	M.O.I from C.G & ∥ to base	M.O.I from base
Rectangle	$x = d/2$	bd	$\frac{bd^3}{12}$	$\frac{bd^3}{3}$
Triangle	$x = \frac{h}{3}$	$\frac{bh}{2}$	$\frac{bh^3}{36}$	$\frac{bh^3}{12}$
circle	$x = d/2$	$\frac{\pi}{4}d^2$	$\frac{\pi d^4}{64}$	—
Trapezium.	$x = \left(\frac{2a+b}{a+b}\right)\frac{h}{3}$	$(a+b)\frac{h}{2}$	$\left(\frac{a^2+b^2+4ab}{a+b}\right)h^3$	—

Unit-3.

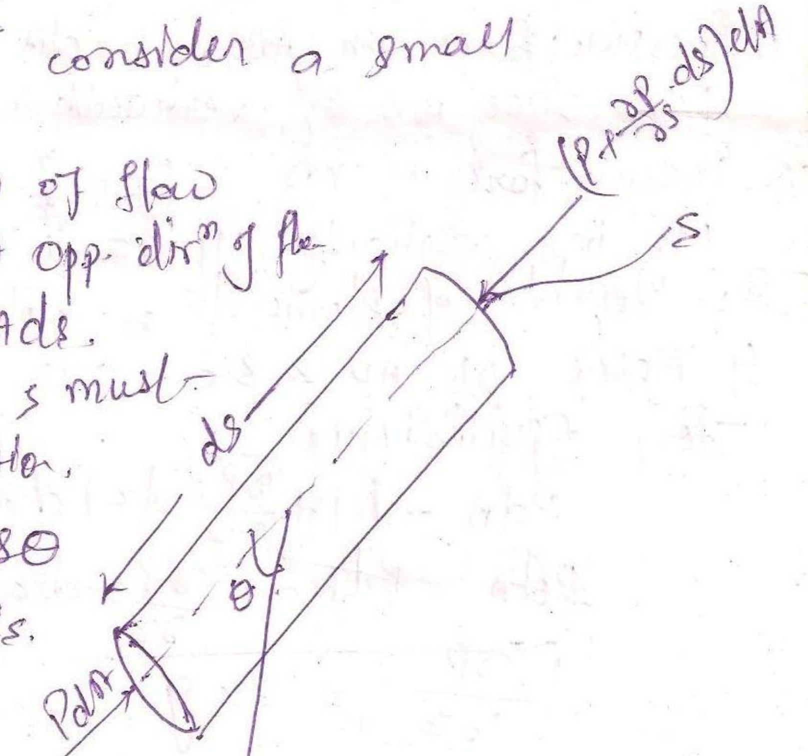
* **Bernaulli's Equation :-** consider a small element of

(i) Pressure force pdA in dirn of flow

(ii) Pressure force $(P + \frac{\partial P}{\partial s} ds)dA$ opp. dirn of flow

(iii) weight of element = $\rho dA ds$.

The resultant force in dirn of s must be equal to mass x acceleration.



$$PdA - (P + \frac{\partial P}{\partial s} ds)dA - \rho g dA ds \cos\theta = \rho dA ds \times a_s.$$

$$a_s = \frac{\partial v}{\partial t} = \frac{\partial v}{\partial s} \cdot \frac{ds}{dt} + \frac{\partial v}{\partial t}.$$

$$= \frac{v \partial v}{\partial s}$$

For steady flow $\frac{\partial v}{\partial t} = 0$

$$\cancel{PdA} - \cancel{PdA} - \frac{\partial P}{\partial s} ds dA - \rho g dA ds \cos\theta = \rho dA ds \cdot \frac{v \partial v}{\partial s}$$

$$\frac{\partial P}{\rho \partial s} + g\cos\theta + \frac{v\partial v}{\partial s} = 0 \qquad \cos\theta = \frac{dz}{ds}$$

$$\frac{\partial P}{\rho \partial s} + g \cdot \frac{dz}{ds} + \frac{v \partial v}{\partial s} = 0$$

$$\frac{\partial P}{\rho} + g dz + v \partial v = 0 \qquad \text{Euler's equation}$$

Integrating Euler's equation

$$\int \frac{dp}{\rho} + g\int dz + \int v\,dv = 0$$

$$\frac{p}{\rho} + gz + \frac{v^2}{2} = 0$$

$$\boxed{\frac{p}{\rho g} + z + \frac{v^2}{2g} = 0}$$ Bernaulli's eqn.

* Venturimeter :-

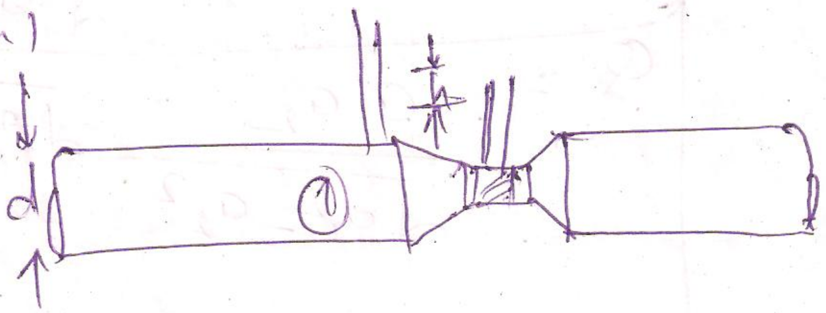
let d_1 = diameter at section 1

P_1 = Intensity of presse

V_1 = velocity at 1

a_1 = Area at 1

$= \frac{\pi}{4} d_1^2$



Similarly P_2, V_2, a_2 & d_2 for section 2

Applying Bernaulli's equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

As pipe is horizontally fitted so $z_1 = z_2$

$$\therefore \frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$$

$$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

But $\frac{P_1 - P_2}{\rho g}$ = Differerence of press. head = h

$$\Rightarrow h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

Using continuity equation,

$$A_1 V_1 = A_2 V_2 \Rightarrow v_1 = \frac{A_2 V_2}{A_1}$$

$$h = \frac{V_2^2}{2g} - \frac{\left(\frac{a_2 V_2}{a}\right)^2}{2g}$$

$$= \frac{V_2^2}{2g}\left[1 - \frac{a_2^2}{a_1^2}\right]$$