lecture (7) 02/4/19

$\forall = 19.5\ m^3$ Ans

Fluid Static

Pb-(3) $\frac{dP}{dZ} = -\rho . g$ ↑ Z dirⁿ [for Isothermal (T= const) $P = \rho . R . T$, $\rho = \frac{P}{RT}$]

$\frac{dP}{dZ} = -\frac{P}{RT} . g$

$\frac{dP}{P} = \frac{-dZ\, g}{RT}$ → Int. it $\int_{P_0}^{P} \frac{dP}{P} = -\frac{g}{RT} \int_{Z_0}^{Z} dZ$

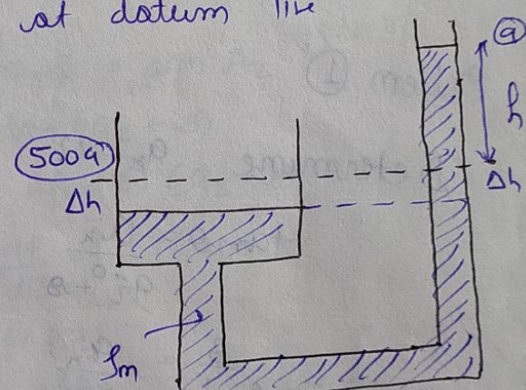
$\ln \frac{P}{P_0} = -\frac{g}{RT}(Z - Z_0)$

taking antilog

$\frac{P}{P_0} = e^{-\frac{gZ}{RT}}$

If datum line taken as Z_0 ($Z_0 = 0$) and P_0 is pressure at datum line

(Pb) - 15 volum conservation



$500\cancel{a} \times \Delta h = \cancel{a} \times h$

$h = 500\,\Delta h$

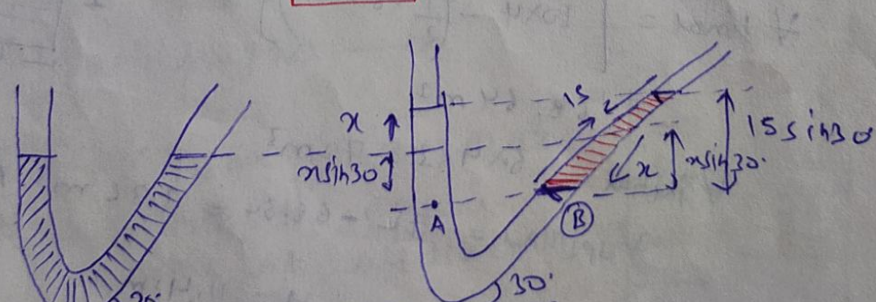
$P = \rho_m\, g\,(500\Delta h)$

$P_{actual} = \rho_m\, g\,(501\Delta h)$

$|\%\ error| = \frac{\cancel{\rho_m}\cancel{g}.\Delta h}{\cancel{\rho_m}\cancel{g}(501)\Delta h} \times 100$

$= \boxed{0.2\ \%}$

(Pb) - (18)



$\forall = 7.5\ cm^3$

$l = \frac{\forall}{a} = \frac{7.5}{0.5} = 15\ cm$

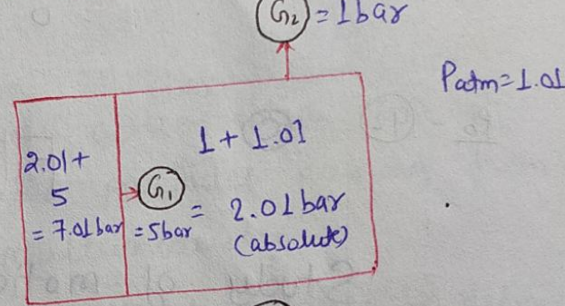
$P_A = P_B$

$(1.25 \times \cancel{10^3}\, \cancel{g})(x + x\sin 30) = \cancel{10^3}\, (\cancel{g}).(15 \sin 30)$

$(1.25)\left(\frac{3x}{2}\right) = 7.5$

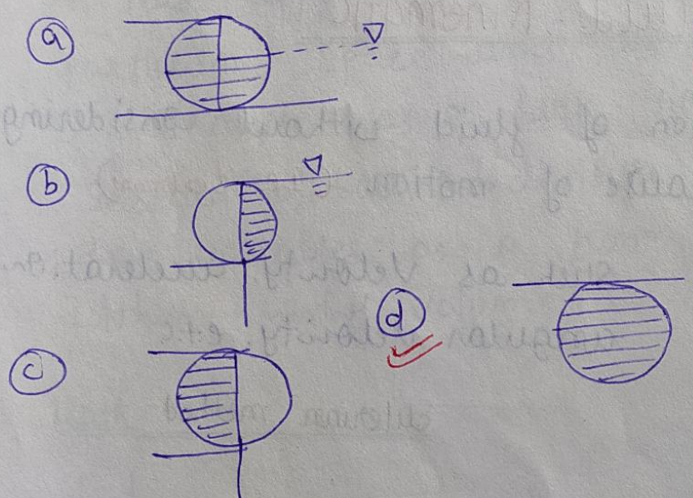
$\boxed{x = 4\,cm}$

(19) (27) W.B.



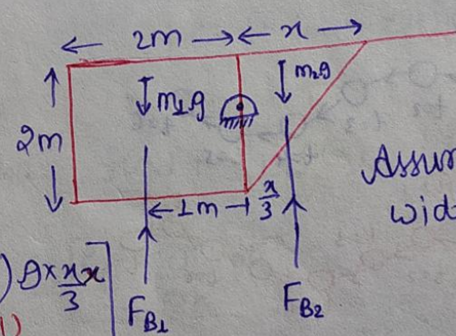
Pb - (17)

(a)



$F_y \rightarrow$ maximum

(34) Taking moment about P



Assume width = 1m

$F_{B_1}(1) = F_{B_2} \times \frac{x}{3}$

$\left[(S-1)\, \rho (2 \times 2 \times 1) . g (1) = \rho \left(\frac{1}{2} \times 2 \times 1\right) g \times \frac{x x}{3} \underset{(S-1)}{} \right]$

$4 = \frac{x^2}{3}$

$\boxed{x = 2\sqrt{3}\,m}$

Extra

$M_1 g - F_{B_1}$

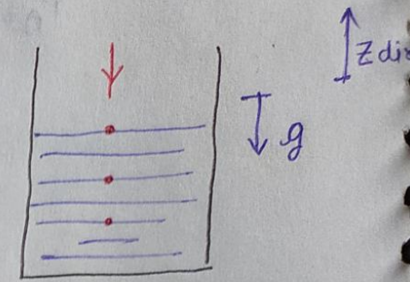
$F_{B_1}\left[\frac{M_1 g}{F_{B_1}} - 1\right] = F_{B_1}\left[\frac{\rho_b . \forall . g}{\rho_w . \forall . g} - 1\right] = F_{B_1}(S-1)$ similarly $F_{B_2}(S-1)$

Pb (40)

$$\frac{dP}{dz} = -\rho(a_z + g)$$

$$= -\rho(-g+g)$$

$$= 0$$



$\boxed{a_z = -g}$

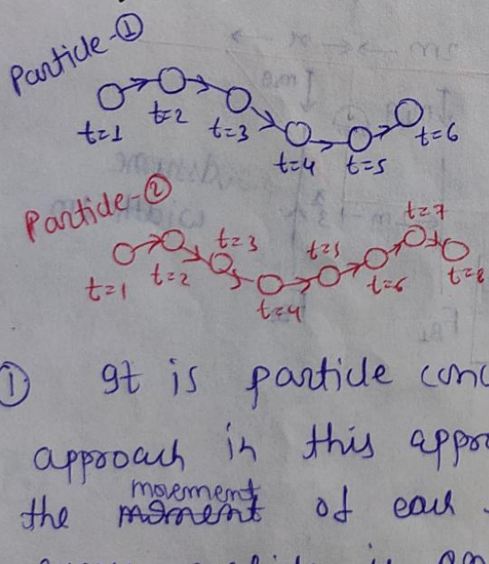
Pb - (42) (c)

Fluid Kinematic

Study of motion of fluid without considering the basic cause of motion (i.e. $F_{external}$)

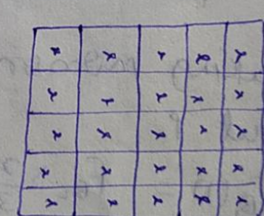
Kinematic parameter: such as velocity, acceleration, angular velocity. e.t.c

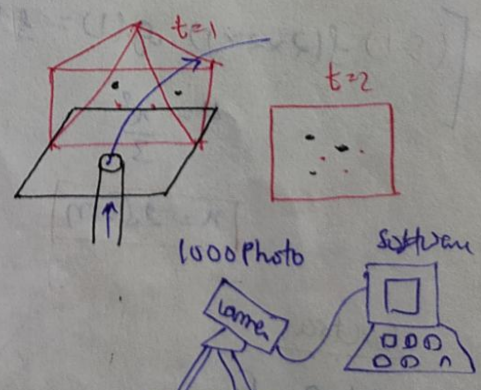
Lagrangian method



1. It is particle concentration approach in this approach the ~~moment~~ movement of each and every particle is analyzed to see the displacement of particle, it velocity and accⁿ can be calculated in the same way the velocity of accⁿ of other calculated in a same way

Eulerian method





(PIV) (Particle Image velocinetry)

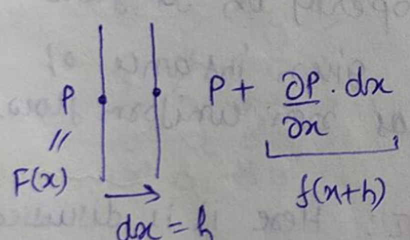
Advantage
→ Very very correct information relative of motion of

Disadvange
→ Huge time consumption to solve a no. of equation

Eulerian Method
(cluster) Form (झुंड)
- In this approach one should concentration on a particular space and all the particles passing from i is analyse as a bulk simultaneously,
- Instead of tacking indivisible of fluid particle be define flow variables as a funⁿ of space and time within control volume

velocity field
$[\vec{V} = f^n(x, y, z, t)]$
pressure field
$[P = f^n(x, y, z, t)]$

Math



Taylor's series →

$$f(x+h) = f(x) + \frac{h}{\lfloor 1}.f'(x) + \frac{h^2}{\lfloor 2} f''(x) + \cdots$$

$$= \boxed{P + \frac{\partial P}{\partial x}.dx}$$

$F = f^n(x, y, z, t)$

$$\boxed{dF = \frac{\partial F}{\partial x}.dx + \frac{\partial F}{\partial y}.dy + \frac{\partial F}{\partial z}.dz + \frac{\partial F}{\partial t}.dt}$$

Different type of flow in the fluid flow system

① Steady flow - If the property in the flow don't change W.R.T. time at a fixed space, the flow are known as steady flows.

$$\boxed{\left.\frac{\partial R}{\partial t}\right|_s = 0}$$ R → properties in flow

② <u>Unsteady flow</u> → If the property in a flow change W.R.T time at a fixed space. flows are known as unsteady flow.

$$\boxed{\left.\frac{\partial R}{\partial t}\right|_s \neq 0}$$

Note :
जो जैसा है वो वैसा रहेगा
जो जहाँ जहाँ है वहाँ वहाँ रहेगा

③ <u>Uniform flow</u> → If the property in a flow don't change W.R.T. space at any given instance of time, the flow is known as "uniform flow"

$$\boxed{\left.\frac{\partial R}{\partial t}\right|_t = 0} \qquad \boxed{\left.\frac{\partial \vec{V}}{\partial s}\right|_t = 0}$$

④ <u>Non-uniform flow</u> → If the property in a flow change W.R.T space at any given instance of time, the flow's are known as non-uniform flow.

$$\boxed{\left.\frac{\partial R}{\partial t}\right|_t \neq 0} \qquad \boxed{\left.\frac{\partial \vec{V}}{\partial s}\right|_t \neq 0}$$

नोट : Here it is discussed W.R.T velocity

[Example of uniform]

At t=1, Red T-Shirt in class
At t=2, Green T. Shirt in class
At t=3, Black T-Shirt in class

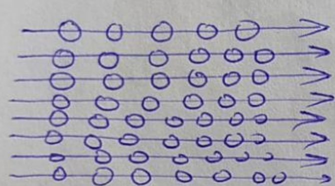
[Uniform, and unsteady]

⑤ <u>Rotational</u> :- When a fluid particle rotate about it's center of mass while moving a direction of flow "rotational flow" Ex. Forces vortex flow

Irrotational FLOW → WHEN A FLUID PARTCLES DOES NOT ROTATE ABOUT IT'S CENTER OF MASS WHILE MOVING IN A DIRECTION OF FLOW THE FLOWS ARE KNOWN AS IRROTATIONAL FLOW. eg. FREE VORTEX FLOW

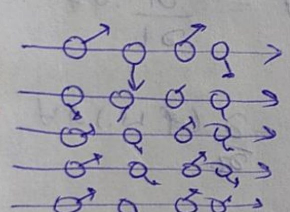
Incompressible flow → If the density is nt changing W.R.T Pressure is known as Incompressible flow. $[d\rho_p = 0]$

Laminar flow



A flow is said to be laminar when the various fluid particles move in layers. when one layer of fluid sliding smoothly over an adjacent layer

turbulant flow



A fluid motion is said to be turbulent when the fluid particle move in an entirely haphazad manner, that result in a rapidly continous mixing of the fluid. in such a flow eddies of different sizes and shape are present.

continuity-

$$\frac{kg}{m^3} \cdot m^2 \times \frac{m}{s} = \frac{kg}{s}$$

Mass flow rate $(\dot{m}) = \rho . A . V$

(kg/s)

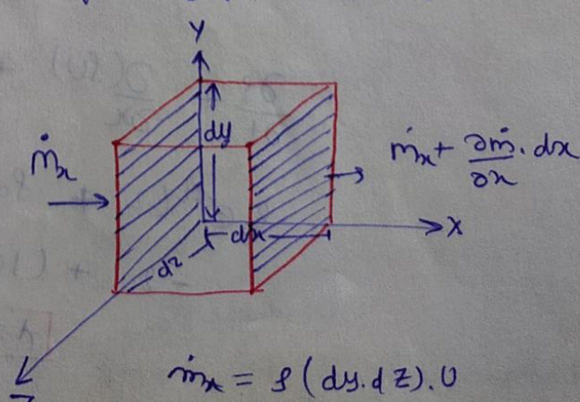
Discharge $(Q) = A.V$

(m^3/s)

$m^2 \times \frac{m}{s}$

$\dot{m}_{in} - \dot{m}_{out} = \dot{m}_{storage}$

$$\vec{V} = u\hat{i} + v\hat{j} + w\hat{k}$$

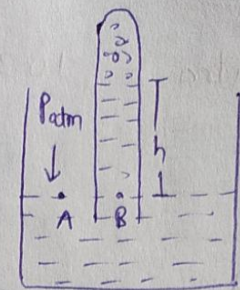


$\dot{m}_x = \rho (dy . dz) . u$

- Constructional details

$P_A = P_A$

$P_{atm} = \rho_{Hg} \cdot g \cdot h + \cancel{P_{Hg\text{-vapour}}}$ neglect

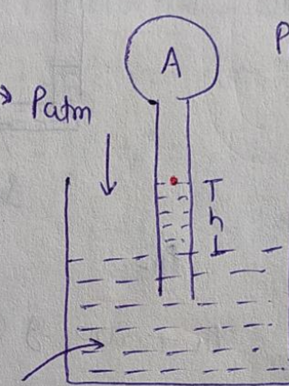


Uses Hg because -

① It's low vapour pressure

② It's high density

(Pb) $h = ?$



76cm of Hg

Hg

P_A = 50cm of Hg vacuum

① 26cm
② 50cm
③ 76cm
④ 126cm

(Pb) - 12

In gauge

$P_1 = P_2$

$0 = \rho_{Hg} \cdot g \cdot h + P_A$

$0 = h - 50$

$\boxed{h = 50\text{cm}}$

In absolute pressure

$P_A(abs) = P_A(gauge) + P_{atm}$

$= (-50) + 76$

$= 26\text{cm of Hg}$

Or

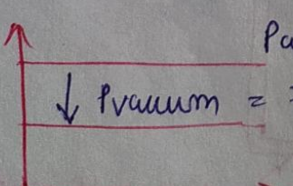
$P_1 = P_2$

$76 = h + P_A(abs)$

$76 = h + 26$

$\boxed{h = 50\text{cm of Hg}}$

(Pb)-13



Patm local = 700 mm of Hg

↓ Pvacuum = 700 - 380 = 320 mm of Hg

Zero pressure level

② Simple Manometer → It uses to measure the Pressure at a Point

[Free surface → the surface of fluid that is subjected to zero Parallel shear stress]

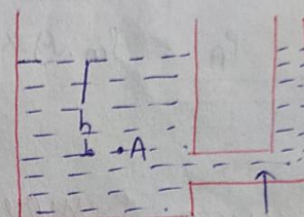
ⓐ Piezometer

ⓑ U-tube manometer

ⓒ Single column manometer

ⓐ Piezometer

$$P_A = \rho . g . h$$



Dia sufficiently large to neglect capillary effect

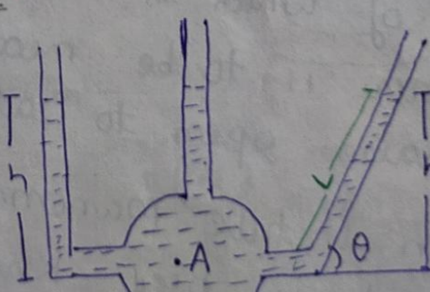
It is a single vertical tube, One end is open in atmosphere and the 2nd end is connected to that placed where the Pressure as to measure

Limitations

① Uses to measure moderate (+ve) gauge pressure of liquid.

Sensitivity of manometer :-

For a small gauge Pressure it is better to use inclined single tube the reading L recorded on a scale of incline tube manometer is ~~Hise th~~ higher than vertical tube manometer by a factor of



$L = \frac{h}{\sin\theta}$

$\boxed{P_A = \rho g h}$

$$(\dot{m}_{in} - \dot{m}_{out})_x + (\dot{m}_{in} + \dot{m}_{out})_y + (\dot{m}_{in} - \dot{m}_{out})_z = \dot{m}_{storage} \quad \text{--- (1)}$$

$$(\dot{m}_{in} - \dot{m}_{out})_x = \dot{m}_x - \left[\dot{m}_x + \frac{\partial \dot{m}_x}{\partial x} dx\right]$$

$$= -\frac{\partial \dot{m}_x}{\partial x} . dx$$

$$= -\frac{\partial}{\partial x}(\rho . dx\, dz) u . d\cancel{x} = -\frac{\partial (\rho u)}{\partial x} d\forall$$

<u>similarly</u>

$$(\dot{m}_{in} - \dot{m}_{out})_y = -\frac{\partial}{\partial y}(\rho V) . d\forall$$

$$(\dot{m}_{in} - \dot{m}_{out})_z = -\frac{\partial}{\partial z}(\rho . W) . d\forall$$

By eq (1)

$$-\frac{\partial}{\partial x}(\rho u) d\forall) - \frac{\partial}{\partial y}(\rho V) d\forall) - \frac{\partial}{\partial z}(\rho . W) d\forall = \frac{\partial \rho}{\partial t} . d\forall$$

$$-\frac{\partial}{\partial t} . dV . \frac{\partial}{\partial x}(\rho u . d\forall) - \frac{\partial}{\partial y}(\rho v . d\forall) \quad -\frac{\partial}{\partial z}(\rho . w .) d\forall$$

$$\boxed{\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} . (\rho u) + \frac{\partial}{\partial y}(\rho V) + \frac{\partial}{\partial z} . (\rho . W)} = 0$$

(Pb) $\vec{V} = (5x + 6y + 7z) i + (6x + 5y + 9z) j + (3x + 2y + \lambda z) \hat{k}$

$$\rho = \rho_0 e^{-2t}$$

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho u)}{\partial x} + \frac{\partial (\rho v)}{\partial y} + \frac{\partial (\rho w)}{\partial z} = 0$$

$$\rho_0 e^{-2t}(-2) + \rho_0 e^{-2t}(5 + 5 + \lambda) = 0$$

$$-2 + (10 + \lambda) = 0$$

$$\boxed{\lambda = -8}$$

continuity eqn another form :-

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho . u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho . w) = 0$$

$$\frac{\partial \rho}{\partial t} + \rho \frac{\partial u}{\partial x} + u \frac{\partial \rho}{\partial x} + \rho . \frac{\partial v}{\partial y} + v \frac{\partial \rho}{\partial y} + \rho \frac{\partial w}{\partial z} + w \frac{\partial \rho}{\partial z} = 0$$

$$\frac{D\rho}{Dt} + \rho\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) = 0$$

$$\frac{D\rho}{Dt} + \rho(\vec{\nabla} . \vec{V}) = 0$$

Pb - 5 $\quad 2.4 + 1.2(\vec{\nabla} . \vec{V}) = 0$

$$\boxed{\vec{\nabla} . \vec{V} = -2}$$