[ME-2017] [SET-2]

Q-13 (D)- Kaplan turbine is an axial-flow reaction turbine.

Q-16 There can be two scenarios of bodies inside the water

i) Fully submerged

ii) Partially submerged or floating Bodies

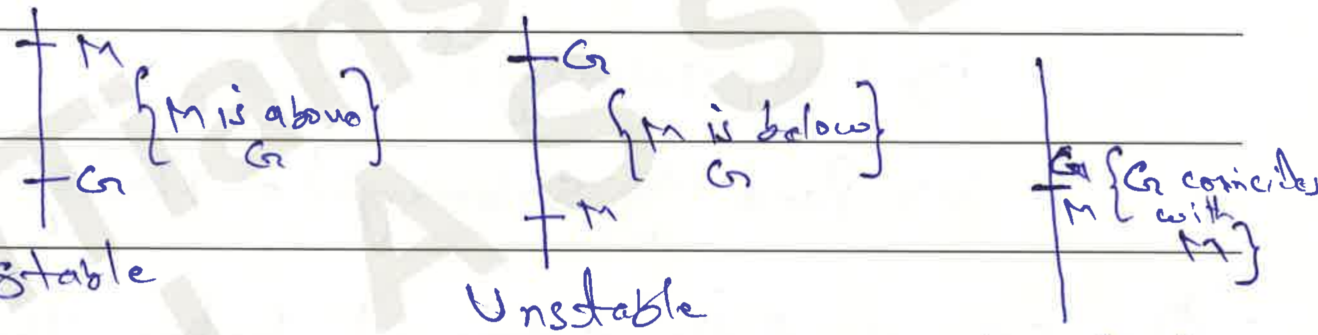
⇒ In case of fully submerged bodies, the stability of the Body is decided based on the relative position of Centre of gravity (G) and Centre of buoyancy (B). So there can be three scenarios,

B, G {B is above G} — Stable

G, B {B is below G} — Unstable

G, B {B coincides with G} — Neutral

⇒ In case of partially submerged bodies or floating bodies the stability is decided based on the position of Metacentre [M] relative to G. It does not matter whether B is below G. In floating case only position of Metacentre decides stability.



Stable — Unstable — Neutral

So for the stability of floating bodies the metacentre must be above the centre of gravity. Correct option [D]

Ans

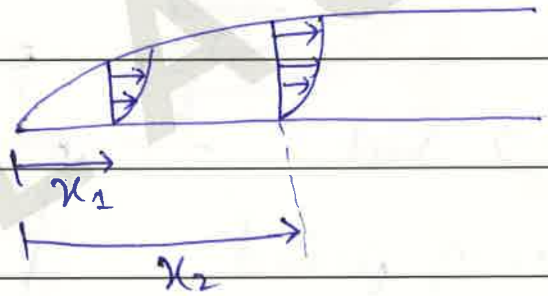
Q-17

Since shear stress at the wall is given as

$$\tau_w = \mu \left.\frac{\partial u}{\partial y}\right|_{y=0} \quad [\text{Newton's law of viscosity}]$$

where $\left.\frac{\partial u}{\partial y}\right|_{y=0}$ is velocity gradient near wall

$\mu \rightarrow$ Dynamic viscosity or viscosity



Since velocity gradient $\left[\frac{\partial u}{\partial y}\right]_{x_1} > \left[\frac{\partial u}{\partial y}\right]_{x_2}$

{velocity gradient will be higher at x_1 as compared to x_2}

So $|\tau_w|_{x_1} > |\tau_w|_{x_2}$ —— [C] Ans.

Q-39 Given

$$\rho = 1 \text{ kg/m}^3 \text{ [flowing fluid]}$$

$$\rho_m = 1000 \text{ kg/m}^3 \text{ [manometric fluid]}$$

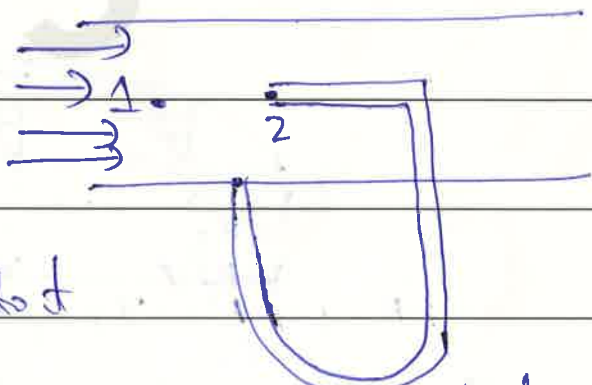
Velocity measured by a pitot of a flowing fluid is given as

$$\boxed{V = \sqrt{2g\, h_{fluid}}}$$ [V – velocity of flowing fluid]

This relation is derived as follows

Taking two point 1 and 2

1 somewhere in upstream and 2 just at the entrance of pitot tube. Now applying Bernoulli's eqn between point 1 and 2.



$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

Since $Z_1 = Z_2$ and $V_2 = 0$ (stagnation point).

So

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

or $\frac{V_1^2}{2g} = \frac{P_2 - P_1}{\rho g}$ [where ρ is the flowing fluid density]

and $\frac{P_2 - P_1}{\rho g}$ — head difference between point 1 and 2 = h_{fluid}

So $\frac{P_2 - P_1}{\rho g} = h_{fluid}$

$$\Rightarrow \therefore \frac{V_1^2}{2g} = \frac{P_2 - P_1}{\rho g} = h_{fluid}$$

or $$\boxed{V_1 = \sqrt{2 g h_{fluid}}}$$

If pressure difference $P_2 - P_1$ is measured with the help of a manometer filled with manometric fluid of density ρ_m than →

$$\frac{P_2 - P_1}{\rho_m g} = h_m \text{ [manometric column height]}$$

and in terms of head of fluid

$$\frac{P_2 - P_1}{\rho g} = h_{fluid} \quad [\rho \rightarrow \text{flowing fluid density}]$$

So $\frac{P_2 - P_1}{\rho_m g} = h_m$ or $P_2 - P_1 = \rho_m g h_m$ —— (A)

and $\frac{P_2 - P_1}{\rho g} = h_{fluid}$ or $P_2 - P_1 = \rho g h_{fluid}$ —— (B)

Comparing eqn (A) and (B)

$$\rho_m g h_m = \rho g h_{fluid}$$

or $\boxed{\rho_m h_m = \rho h_{fluid}}$

From the given ~~data~~ data

$V = V_1 = 20$ m/s and $g = 9.81$ m/s^2

So $V = \sqrt{2 g h_{fluid}} \Rightarrow (20)^2 = 2 \times 9.81 \times h_{fluid}$

$h_{fluid} = 20.39$ m ⟶

P.T.O

Now $\rho_m = 1000 \text{ kg/m}^3$ (Given)

So

$$\rho_m h_m = \rho \, h_{fluid}$$

$$\Rightarrow \quad 1000 \times h_m = 1 \times 20.39$$

So $h_m = \frac{20.39}{1000} \text{ m} = 20.39 \text{ mm}$

So $\boxed{h_m = 20.39 \text{ mm}}$

Differential head is 20.39 mm

Ans.

Alternatively

$V = \sqrt{2gH}$ where $H = h\left(\frac{\rho_m}{\rho} - 1\right)$

where h is difference in the two limbs of manometer

So $(20)^2 = 2 \times 9.81 \times h\left(\frac{1000}{1} - 1\right)$

$h = 0.0204 \text{ m} = 20.4 \text{ mm}$

Ans.

Q-40 As per Newton's Second law of motion Rate of change of momentum is particular direction is equal to force in that direction

Force in Horizontal direction = Rate of change of momentum in Horizontal direction

$$F_H = \left(\underbrace{\dot{m}_1 V_1}_{\text{momentum}} - \dot{m}_2 V_2\right)_{\text{Horizontal direction}}$$

$$F_H = (\rho_1 A_1 V_1)V_1 - (\rho_2 A_2 V_2)V_2$$

$$F_H = \rho V^2 [A_1 - A_2] \quad \left\{ \begin{array}{l} \text{Since } V_1 = V_2 \\ \text{and } \rho_1 = \rho_2 \end{array} \right.$$

$$F_H = 1000 \times 20^2 \left[\frac{\pi}{4}(0.06)^2 - \frac{\pi}{4}(0.04)^2\right]$$

$$F_H = 628.32\,N$$

Ans

Q-41 For the given Scenario dynamic similarity must satisfy. Moreover Inertial and viscous forces plays a major role in the given Condition So the Raynold's number should be equal for both prototype and model.

or $(Re)_1 = (Re)_2$

$V_1 = 2 m/s$, $D_1 = 100 mm$, $\rho_1 = 1000 kg/m^3$

and $V_2 = ? m/s$, $D_2 = 200 mm$, $\rho_2 = 1000 kg/m^3$

So $\dfrac{\rho_1 V_1 D_1}{\mu_1} = \dfrac{\rho_2 V_2 D_2}{\mu_2}$

for both scenario water is flowing fluid

So $\mu_1 = \mu_2$ and $\rho_1 = \rho_2$

or $V_1 D_1 = V_2 D_2 \Rightarrow 2 \times 100 = V_2 \times 200$

$V_2 = 1 m/s$

So drag force $F_2 = C_F \rho_2 V_2^2 D_2^2 = 0.5 \times 1000 \times 1^2 \times (0.2)^2$

$\boxed{F_2 = 20N}$ Ans