CLASS TEST

Sl. : 03_SKCE_JKL_14092025

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FLUID MECHANICS

CIVIL ENGINEERING

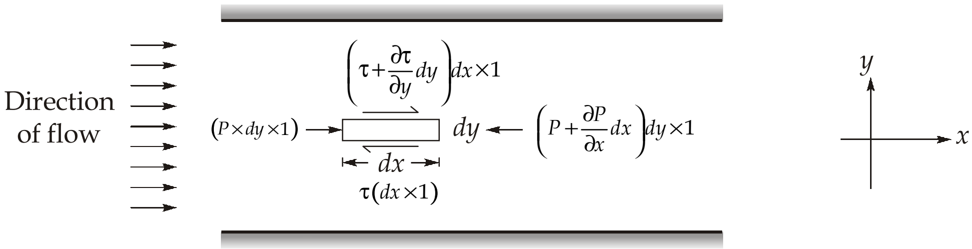
Date of Test : 14/09/2025

ANSWER KEY

1.	(b)	7.	(a)	13.	(b)	19.	(c)	25.	(c)
2.	(d)	8.	(b)	14.	(b)	20.	(d)	26.	(d)
3.	(d)	9.	(b)	15.	(a)	21.	(a)	27.	(d)
4.	(a)	10.	(a)	16.	(d)	22.	(a)	28.	(d)
5.	(c)	11.	(d)	17.	(c)	23.	(b)	29.	(a)
6.	(d)	12.	(b)	18.	(b)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. (b)



For steady and uniform flow, there is no acceleration and hence ressultant force in the direction of flow is zero

$$P\times(dy\times1)-\left(P+\frac{\partial P}{\partial x}dx\right)dy\times1-\tau(dx\times1)+\left(\tau+\frac{\partial\tau}{\partial y}dy\right)dx\times1=0$$

$$\frac{\partial P}{\partial x} = \frac{\partial\tau}{\partial y}$$

The pressure gradient in the direction of flow is equal to the shear gradient normal to the direction of flow.

2. (d)

Given: D_1 = 200 mm, D_2 = 400 mm

Velocity in smaller diameter pipe,

$$V_1 = \frac{Q}{A_1}=\frac{0.250\text{ m}^3/\text{s}}{\frac{\pi}{4}\times(0.2)^2}=7.96\text{ m/s}$$

Velocity in larger diameter pipe,

$$V_2 = \frac{Q}{A_2}=\frac{0.250\text{ m}^3/\text{s}}{\frac{\pi}{4}\times(0.4)^2}=1.99\text{ m/s}$$

Loss of head due to sudden enlargement is given by,

$$h_L = \frac{(V_1-V_2)^2}{2g} = \frac{(7.96-1.99)^2}{2g}=1.817\text{ m of water}$$

3. (d)

Since $\overline{GM}_{\text{rolling}} << \overline{GM}_{\text{pitching}}$

Hence the stability of ship in rolling is more critical compared to pitching.

Higher the period of oscillation, more comfort the passengers will feel.

4. (a)

$$dQ = |d\psi|=|\psi_2-\psi_1|$$

At (1, 1); $\psi_1 = 3\times1^2\times1-1^3 = 2$ units

At ($\sqrt{3}$, 1); $\psi_2 = 3\times\left(\sqrt{3}\right)^2\times1-1^3=8$ units

So, $dQ = |8-2| = 6$ units

5. (c)

When $\frac{dh}{dx} > 0$, it means that depth of water increases in the direction of flow. The profile of water so obtained is called back water curve.

When $\frac{dh}{dx} < 0$, it means that the depth of water decrease in the direction of flow. The profile of the water so obtained is called drop down curve.

6. (d)

Momentum thickness, θ is given by

$$\theta = \int_0^\delta \frac{u}{U}\left(1 - \frac{u}{U}\right)dy$$

$$\Rightarrow \quad \theta = \int_0^\delta \left\{\left(\frac{2y}{\delta}\right) - \frac{y^2}{\delta^2}\right\}\left\{1 - \frac{2y}{\delta} + \frac{y^2}{\delta^2}\right\}dy$$

$$= \int_0^\delta \left[\frac{2y}{\delta} - \frac{4y^2}{\delta^2} + \frac{2y^3}{\delta^3} - \frac{y^2}{\delta^2} + \frac{2y^3}{\delta^3} - \frac{y^4}{\delta^4}\right]dy$$

$$= \int_0^\delta \left[\frac{2y}{\delta} - \frac{5y^2}{\delta^2} + \frac{4y^3}{\delta^3} - \frac{y^4}{\delta^4}\right]dy$$

$$= \left[\frac{2y^2}{2\delta} - \frac{5y^3}{3\delta^2} + \frac{4y^4}{4\delta^3} - \frac{y^5}{5\delta^4}\right]_0^\delta$$

$$= \left[\delta - \frac{5\delta}{3} + \delta - \frac{\delta}{5}\right] = \frac{2\delta}{15}$$

7. (a)

Equating pressure at interface level,

$$P_A + \rho_0\, g(0.15) = \rho_{Hg}\, g(0.1)$$

where ρ_0 is density of oil and ρ_{Hg} is density of mercury

$\Rightarrow P_A + (0.85 \times 10^3) \times g \times 0.15 = (13.6 \times 10^3) \times g \times 0.10$

$$\Rightarrow \quad P_A = 12090.825 \text{ N/m}^2$$

$$= 12.09 \text{ kN/m}^2$$

8. (b)

Since the pipes are connected in series

$$\therefore \quad \frac{L}{d^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5}$$

$$\Rightarrow \quad \frac{800}{d^5} = \frac{300}{400^5} + \frac{500}{300^5}$$

$$\Rightarrow \quad d^5 = 3.403 \times 10^{12}$$

$$\Rightarrow \quad d = 320.91 \text{ mm}$$

9. **(b)**

Buoyancy force acts through center of gravity of displaced liquid.

A large metacentric height in a vessel improves stability and makes time period of oscillation shorter.

10. **(a)**

Consider an annular ring with thickness dr at radius r. Velocity variation in the gap is given as linear.

Hence the velocity at radius r from centre = $v = wr$

∴ Shear stress on the ring,

$$\tau = \mu\frac{du}{dy} = \mu\left(\frac{wr}{h}\right)$$

Force on the ring, $dF = \tau \times dA$

$$= \left(\frac{\mu wr}{h}\right)\times 2\pi r dr = \left(\frac{2\pi\mu w}{h}\right)r^2 dr$$

Torque on the ring, $dT = F \times r = r\tau dA = \left(\frac{2\pi\mu w}{h}\right)r^2 \cdot rdr$

$$= \left(\frac{2\pi\mu w}{h}\right)r^3 dr$$

∴ Total torque on disc $= \int_0^R dT = \frac{2\pi\mu w}{h}\int_0^R r^3 dr$

$$\Rightarrow \quad T = \frac{2\pi\mu w}{h}\left[\frac{r^4}{4}\right]_0^R = \frac{\pi\mu w R^4}{2h}$$

11. **(d)**

Given, $\theta = 60°$

Distance, $AC = \frac{h}{\sin 60°} = \frac{2h}{\sqrt{3}}$

The gate will start tipping about hinge B if the resultant pressure force acts at B. If the resultant pressure force passes through a point which is lying from B to C anywhere on the gate, the gate will tip over the hinge. Hence for the given position, point B becomes the centre of pressure.

Depth of centre of pressure,

$$h^* = (h - 3)\text{ m} \quad \text{...(i)}$$

But h^* is also given by, $h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$

Taking width of gate unity, then

Area, $A = AC \times 1 = \frac{2h}{\sqrt{3}}\times 1;\ \bar{h} = \frac{h}{2}$

$$I_G = \frac{bd^3}{12} = \frac{1\times AC^3}{12} = \frac{1\times\left(\frac{2h}{\sqrt{3}}\right)^3}{12} = \frac{8h^3}{12\times 3\times\sqrt{3}} = \frac{2h^3}{9\times\sqrt{3}}$$

$$h^* = \frac{2h^3}{9\sqrt{3}} \times \frac{\sin^2 60}{\frac{2h}{\sqrt{3}} \times \frac{h}{2}} + \frac{h}{2}$$

$$\Rightarrow \quad h^* = \frac{2h^3 \times \frac{3}{4}}{9h^2} + \frac{h}{2} = \frac{2h}{3} \quad \text{...(ii)}$$

From (i) and (ii)

$$h - 3 = \frac{2h}{3}$$

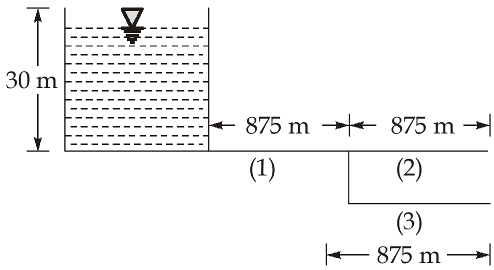
$$\Rightarrow \quad h = 9 \text{ m}$$

$\therefore$ Height of water required for tipping the gate = 9 m

12. (b)

Let Q be the initial discharge.

Diameter, d = 0.55 m, Length, l = 1.75 km = 1750 m



Before addition of pipe, $h_f = \dfrac{8flQ^2}{\pi^2 g D^5}$ ... (i)

$$\Rightarrow \quad 30 = \frac{8(0.04)\times(1750)Q^2}{\pi^2(9.81)\times(0.55)^5}$$

Solving, Q = 0.51 m^3/sec

After addition of pipe, $h_f = h_{f1} + h_{f2}$ ... (ii)

Where, h_{f2} is Head loss in pipe 2, h_{f3} is Head loss in pipe 3

Also, $h_{f2} = h_{f3}$

$$\therefore \quad \frac{f l_2 v_2^2}{2gD_2} = \frac{f l_3 v_3^2}{2gD_3}$$

$$v_2 = v_3$$

Also, let Q' be the final discharge

Now, $Q' = Q_2 + Q_3$ [$\because$ Continuity equation]

$\because$ $Q_2 = Q_3$ [$\because V_2 = V_3, A_2 = A_3$]

$$\Rightarrow \quad Q_2 = Q_3 = \frac{Q'}{2}$$

Substituting values in (ii)

$$h_f = \frac{8fl_1Q'^2}{\pi^2 g D_1^5} + \frac{8fl_2(Q'/2)^2}{\pi^2 g D_2^5}$$

$$30 = \frac{8 \times 0.04 \times 875}{\pi^2 \times 9.81 \times 0.55^5}\left(Q'^2 + \frac{Q'^2}{4}\right)$$

Solving, Q' = 0.65 m^3/s

$$\% \text{ increase} = \frac{Q' - Q}{Q} \times 100 = \frac{0.65 - 0.51}{0.51} \times 100 = 27.45\%$$

13. (b)

Given, $b = 10$ m , $y = 3$ m

$V = 1$ m/s

$$\text{Bed slope, } S_0 = \frac{1}{4000}$$

Slope of energy line, $S_f = 0.00004$

Change of depth flow of flow along the channel,

$$\text{Now,} \quad \frac{dy}{dx} = \frac{S_0 - S_f}{1 - F_r^2}$$

$$\Rightarrow \quad \frac{dy}{dx} = \frac{S_0 - S_f}{1 - \frac{V^2}{gy}} = \frac{0.00025 - 0.00004}{1 - \frac{(1)^2}{9.81 \times 3}} = \frac{0.00021}{0.966} = 2.17 \times 10^{-4}$$

14. (b)

Velocity before expansion, $V_1 = 2.65$ m/s

Velocity after expansion $V_2 = 1.18$ m/s

Loss of load at sudden expansion

$$H_L = \frac{(V_1 - V_2)^2}{2 \times g} = \frac{(2.65 - 1.18)^2}{2 \times 9.81} = 0.11$$

By energy equation

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z + H_L$$

$$\Rightarrow \quad \frac{p_2}{\rho g} = \frac{p_1}{\rho g} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - H_L$$

$$\Rightarrow \quad \frac{p_2}{1000 \times 9.81} = \frac{20 \times 1000}{9.81 \times 1000} + \frac{2.65^2}{2 \times 9.81} - \frac{1.18^2}{2 \times 9.81} - 0.11$$

$$p_2 = 21.735 \text{ kN/m}^2$$

$$\simeq 21.74 \text{ kN/m}^2$$

$$\text{Increase in pressure} = (21.74 - 20) \text{ kN/m}^2$$

$$= 1.74 \text{ kN/m}^2$$

15. (a)

Given, $H = 6$ m, $x = 2$ m and $y = 0.18$ m

$$\text{Now, Coefficient of velocity, } C_V = \frac{x}{2\sqrt{y.H}} = \frac{2}{2\sqrt{0.18 \times 6}} = 0.962$$

$$\text{Now,} \quad \text{Discharge, } Q = C_d \times A \times \sqrt{2gH}$$

where 'Q' is 4×10^{-3} m^3/s

$\Rightarrow \quad 4 \times 10^{-3} = C_d \times \frac{\pi \times 0.03^2}{4} \times \sqrt{2 \times 9.81 \times 6}$

$\Rightarrow \quad C_d = 0.522$

Now, $\quad C_d = C_V \times C_C$

where C_C is coefficient of contraction

$\Rightarrow \quad C_C = \frac{C_d}{C_v} = \frac{0.522}{0.962} = 0.543$

16. (d)

On the quadrant part,

Horizontal component of hydrostatic force,

$$F_H = \gamma \text{ (Projected area)} \times \bar{h} = 9.81 \times 10^3 \times 1.2 \times 2.5 \times \left(1.5 + \frac{1.2}{2}\right)$$

$$= 61803 \text{ N} = 61.8 \text{ kN}$$

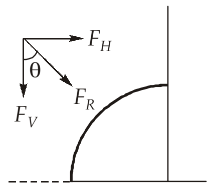
Vertical component of hydrostatic force,

$F_V = \gamma$ [Volume of water above the curved surface upto free surface of water level]

$$= 9.81 \times 10^3 \left[1.2(2.7) - \frac{\pi(1.2)^2}{4}\right] \times 2.5$$

$$= 51723.88 = 51.72 \text{ kN}$$

$$\theta = \tan^{-1}\left(\frac{F_H}{F_V}\right) = \tan^{-1}\left(\frac{61.8}{51.72}\right)$$



$\Rightarrow \quad \theta = 50.07°$

17. (c)

$$u = V_0 \sin\frac{\pi}{2}\left(\frac{y}{\delta}\right)$$

$\therefore \quad \frac{du}{dy} = V_0 \cos\frac{\pi}{2}\left(\frac{y}{\delta}\right) \times \frac{\pi}{2\delta}$

Local shear stress, $\quad \tau_0 = \mu\left(\frac{du}{dy}\right)_{y=0} = \mu \times \frac{V_0 \pi}{2\delta} = 1.02 \times 10^{-3} \times \frac{0.20 \times \pi}{2 \times 8 \times 10^{-3}}$

$$= 0.04 \text{ N/m}^2$$

18. (b)

For rough pipe, $\quad \frac{1}{\sqrt{f}} = 2\log_{10}\left(\frac{R}{k_s}\right) + 1.74 = 2\log_{10}\left(\frac{0.30}{0.20 \times 10^{-3}}\right) + 1.74 = 8.09$

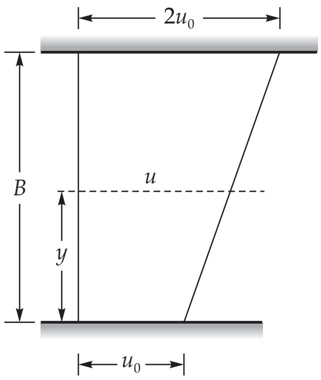
$$f = 0.015$$

$$\tau_{wall} = \rho \frac{f V^2}{8}$$

where, $$V = V_{avg} = \frac{Q}{A} = \frac{0.64}{\frac{\pi}{4}\times 0.6^2} = 2.264 \text{ m/s}$$

$\therefore$ $$\tau_{wall} = \frac{1000\times 0.015\times 2.264^2}{8} = 9.61 \text{ N/m}^2$$

19. (c)



Velocity profile is given by: $$u = u_0\left(1+\frac{y}{B}\right)$$

$$u_{avg} = \frac{\int u\,dA}{A} = \frac{\int_0^B u_0\left(1+\frac{y}{B}\right)(dy\times 1)}{(B\times 1)}$$

Let, $$\left(1+\frac{y}{B}\right) = t$$

$\therefore$ $$dy = B\,dt$$

At $y = 0 \Rightarrow t = 1$

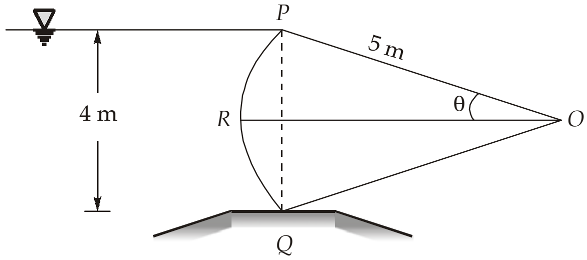
At, $y = \text{B} \Rightarrow t = 2$

$\therefore$ $$u_{avg} = \frac{u_0}{B}\times B\int_1^2 t\,dt = \frac{3u_0}{2} = 1.5u_0$$

$\therefore$ Kinetic energy correction factor, $$\alpha = \frac{\int u^3 dA}{u_{avg}^3 A} = \frac{\int_0^B u_0^3\left(1+\frac{y}{B}\right)^3 (dy\times 1)}{(1.5u_0)^3\times(B\times 1)}$$

$$= \frac{u_0^3 B}{(1.5u_0)^3\times B}\int_1^2 t^3 dt = \frac{1}{(1.5)^3}\times\frac{15}{4} = \frac{10}{9} = 1.11$$

20. (d)



Consider the gate width as 1 m

$$\sin\theta = \frac{2}{5},\ \theta = 23.57°$$

$$F_H = \gamma \times (\text{Projected area}) \times \bar{h} = 9.81 \times (4 \times 1) \times \frac{4}{2} = 78.48 \text{ kN}$$

$$F_V = \gamma \times \forall = \gamma \times \text{Area}[\text{Sector POQR} - \text{Triangle POQ}]$$

$$= 9.81 \times \left[\pi \times 5^2 \times \left(\frac{2 \times 23.57}{360}\right) - \frac{1}{2} \times 4 \times 5 \cos 23.57°\right] = 10.97 \text{ kN}$$

$$F_r = \sqrt{F_H^2 + F_V^2} = \sqrt{(78.48)^2 + (10.97)^2} = 79.24 \text{ kN}$$

21. (a)

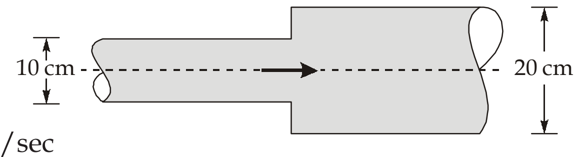
Total head loss, $h_L = \dfrac{(V_1 - V_2)^2}{2g}$

Also $Q = A_1V_1 = A_2V_2$;

$$d_1^2 V_1 = d_2^2 V_2$$

$$10^2 V_1 = 20^2 V_2$$

$$V_1 = 4V_2$$



In series, $Q_1 = Q_2 = Q = 0.1 \text{ m}^3/\text{sec}$

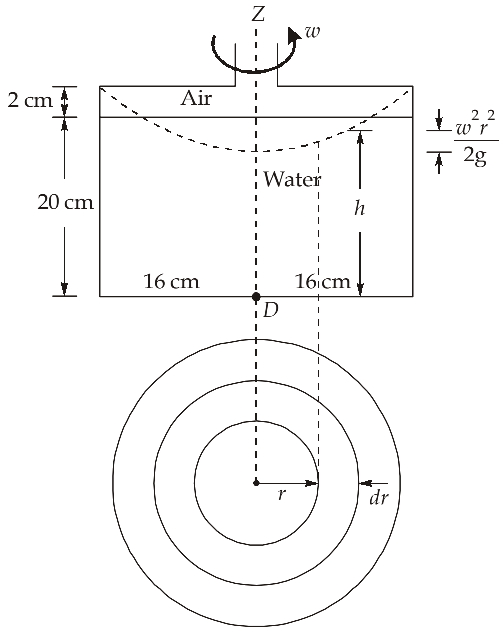
$\because$ $Q = A_1V_1 = A_2V_2$

$\Rightarrow$ $0.1 = \frac{\pi}{4}(0.1)^2 V_1 \Rightarrow V_1 = 12.73 \text{ m/s}$

And, $0.1 = \frac{\pi}{4}(0.2)^2 V_2 \Rightarrow V_2 = 3.18 \text{ m/s}$

$$h_L = \frac{(12.73 - 3.18)^2}{2 \times 9.81} = 4.65 \text{ m}$$

22. (a)



∵ Water just touches point A

$$\therefore \quad 0.04 = \frac{w^2(0.16)^2}{2g}$$

$$dF = \text{Pressure} \times \text{Area} = \rho g h \times 2\pi r dr$$

$$\therefore \quad F = \int dF = \int \rho g\left(0.18 + \frac{w^2 r^2}{2g}\right) \times 2\pi r dr$$

$$\Rightarrow \quad F = 2\pi\rho g \int_0^{0.16} \left(0.18 + \frac{w^2 r^2}{2g}\right) r dr$$

$$= 2\pi\rho g\left[\frac{0.18 r^2}{2} + \frac{w^2}{2g} \times \frac{r^4}{4}\right]_0^{0.16}$$

$$= 2\pi\rho g\left[0.09(0.16)^2 + \frac{w^2(0.16)^2}{2g} + \frac{(0.16)^2}{4}\right] = 157.8 \text{ N}$$

23. (b)

Let x be the distance from the leading edge such that the drag force in distance x is one-third of the total drag force.

$$F_{Dx} = \frac{1}{3}F_{DL} = C_{D_{fx}}(Bx)\left(\frac{\rho U^2}{2}\right)$$

$$F_{DL} = C_{D_{fL}}(BL)\left(\frac{\rho U^2}{2}\right)$$

$$\therefore \quad \frac{C_{Dfx}}{C_{DfL}} \cdot \frac{x}{L} = \frac{F_{Dx}}{F_{DL}} = \frac{1}{3}$$

$$\text{But from } C_{Dfx} = \frac{1.328}{\sqrt{Ux/V}}$$

$$C_{Df\,L} = \frac{1.328}{\sqrt{UL/V}}$$

$$\therefore \quad \left(\frac{L}{x}\right)^{1/2} \frac{x}{L} = \frac{1}{3}$$

$$\Rightarrow \quad \left(\frac{x}{L}\right)^{1/2} = \frac{1}{3}$$

$$\Rightarrow \quad x = \frac{L}{9}$$

24. (c)

For a function to be a valid potential function for incompressible flow, it must satisfy laplace equation i.e., $\nabla^2\phi = 0$.

Checking for option (a):

$$\phi = A\log_e xy = A[\log_e x + \log_e y]$$

$$\therefore \quad \frac{\partial\phi}{\partial x} = \frac{A}{x}; \quad \frac{\partial^2\phi}{\partial x^2} = -\frac{A}{x^2}$$

$$\therefore \quad \frac{\partial\phi}{\partial y} = \frac{A}{y}; \quad \frac{\partial^2\phi}{\partial^2 x} = -\frac{A}{y^2}$$

$$\therefore \quad \nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = \left(-\frac{A}{x^2}\right) + \left(-\frac{A}{y^2}\right) \neq 0 \quad \text{(Not OK)}$$

Checking for option (b):

$$\phi = A(\cos x + \sin y)$$

$$\therefore \quad \frac{\partial\phi}{\partial x} = A(-\sin x); \quad \frac{\partial^2\phi}{\partial x^2} = -A\cos x$$

$$\therefore \quad \frac{\partial\phi}{\partial y} = A\cos y; \quad \frac{\partial^2\phi}{\partial y^2} = -A\sin y$$

$$\therefore \quad \nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = -A(\cos x + \sin y) \neq 0 \quad \text{(Not OK)}$$

Checking for option (c):

$$\phi = \frac{A}{2}\left(x^2 - y^2\right)$$

$$\therefore \quad \frac{\partial\phi}{\partial x} = Ax; \quad \frac{\partial^2\phi}{\partial x^2} = A$$

$$\frac{\partial \phi}{\partial y} = -Ay; \quad \frac{\partial^2 \phi}{\partial y^2} = -A$$

$$\therefore \quad \nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = A + (-A) = 0 \quad \text{(OK)}$$

$\therefore$ Correct option is (c).

25. (c)

$$\text{Re}_L = \frac{v \times L}{\nu} = \frac{12 \times 0.8}{1.47 \times 10^{-5}} = 653061.2245 > 5 \times 10^5$$

$\therefore$ Turbulent flow

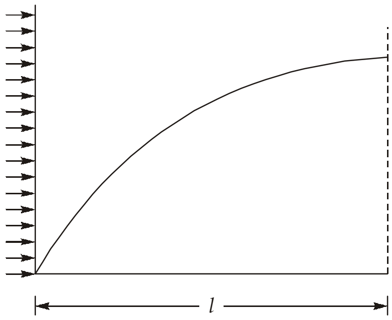
So, for turbulent flow, boundary layer thickness,

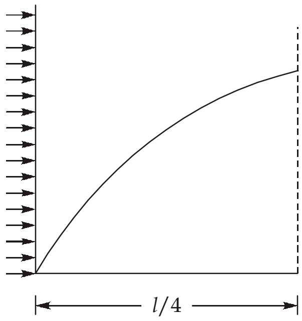
$$\delta = \frac{0.376x}{(\text{Re}_x)^{1/5}} = \frac{0.376 \times L}{(\text{Re}_L)^{1/5}}$$

$$\Rightarrow \quad \delta = \frac{0.376 \times 0.8}{(653061.2245)^{1/5}} = 0.02067 \text{ m}$$

$$\Rightarrow \quad \delta = 2.067 \text{ cm}$$

26. (d)





For laminar flow, $$C_D = \frac{0.664}{\sqrt{\text{Re}}}$$

where, $$Re = \frac{Ul}{\nu}$$

$$C_D = \frac{0.664}{\sqrt{\frac{Ul}{\nu}}}$$

$$C_D \propto \frac{1}{\sqrt{l}}$$

$$C_D \sqrt{l} = \text{Constant}$$

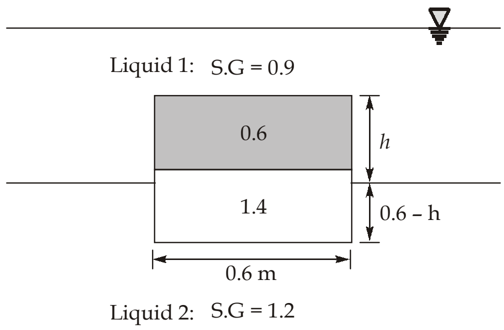
$$C_{D,1}\sqrt{l_1} = C_{D,2}\sqrt{l_2}$$

$$\frac{C_{D,1}}{C_{D,2}} = \sqrt{\frac{l_2}{l_1}}$$

$$\frac{C_{D,1}}{C_{D,2}} = \sqrt{\frac{l/4}{l}}$$

$$\frac{C_{D,1}}{C_{D,2}} = \sqrt{\frac{l}{4}} = 0.5$$

27. (d)



Buoyant force, F_B = Weight of fluid displaced

$\Rightarrow$ $F_B = [(0.9 \times 9.81) \times 0.6 \times 0.6 \times h] + [(1.2 \times 9.81) \times 0.6 \times 0.6 \times (0.6 - h)]$

Now, $F_B = (-1.0595h + 2.5428)$ kN

Weight of block $= (1.4 \times 9.81 \times 0.6 \times 0.6 \times 0.3) + (0.6 \times 9.81 \times 0.6 \times 0.6 \times 0.3)$
$= 2.11896$ kN

For stable equilibrium,

Weight of block = Buoyant force

$\Rightarrow$ $2.11896 = -1.0595h + 2.5428$

$\Rightarrow$ $$h = \frac{2.5428 - 2.1189}{1.0595}$$

$\Rightarrow$ $h = 0.4$ m $= 40$ cm

28. (d)

Given: $L_r = \frac{L_m}{L_p} = \frac{1}{3}$, $V_p = 900$ kmph,

$\rho_p = 1.582$ kg/m^3

$\mu_p = 1.474 \times 10^{-5}$ kg/m.s

$\rho_m = 999.7$ kg/m^3, $\mu_m = 1.307 \times 10^{-3}$ kg/m.s

Since, in the given condition viscous forces are predominant.

$\therefore$ For dynamic similarity, $(Re)_m = (Re)_p$

$\Rightarrow$ $$\frac{\rho_m V_m L_m}{\mu_m} = \frac{\rho_p V_p L_p}{\mu_p}$$

$\Rightarrow$ $$V_m = \frac{\mu_r \cdot V_p}{L_r \cdot \rho_r} = \left(\frac{\rho_p V_p L_p}{\mu_p}\right) \times \left(\frac{\mu_m}{L_m \rho_m}\right)$$

$\Rightarrow \quad V_m = \left(\dfrac{1.582 \times 900 \times 3L_m}{1.474 \times 10^{-5}}\right) \times \left(\dfrac{1.307 \times 10^{-3}}{999.7 \times L_m}\right)$

$\Rightarrow \quad V_m = 378.86 \text{ kmph} \simeq 379 \text{ kmph}$

29. (a)

According to principle of manometry,

$P_1 + \rho_1 g(2 + 0.5) - \rho_{Hg} \times g \times 0.5 - \rho_1 g(2) = P_2$

$\Rightarrow \quad P_1 - P_2 = \rho_{Hg} \times g \times 0.5 - \rho_1 g(0.5)$

$\Rightarrow \quad P_1 - P_2 = 0.5 \times g\,(\rho_{Hg} - \rho_1) = 0.5 \times g \times (S_{Hg} - S_1)\rho_w$

$\Rightarrow \quad P_1 - P_2 = 0.5 \times 9.81\,(13.6 - 0.8) \times 1000 \text{ Pa}$

$\Rightarrow \quad P_1 - P_2 = 62784 \text{ Pa} \simeq 62.78 \text{ kPa}$

30. (c)

Applying Bernoulli's equation between 1 and 2

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

As $\quad p_1 = p_2 = P_{atm}$

and $\quad V_1 = 0 \quad$ (Free surface of reservoir)

$$Z_1 = \frac{V_2^2}{2g} + Z_2$$

$\Rightarrow \quad \dfrac{V_2^2}{2g} = Z_1 - Z_2 = 0.6 - (-0.25) = 0.85$

$\Rightarrow \quad V_2^2 = 2g \times 0.85$

$\Rightarrow \quad V_2 = \sqrt{2 \times 9.81 \times 0.85}$

$\Rightarrow \quad V_2 = 4.08 \text{ m/s} \simeq 4.1 \text{ m/s}$

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