CLASS TEST

Sl. : 02SKCE_EFGHI_10062025

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FLUID MECHANICS

CIVIL ENGINEERING

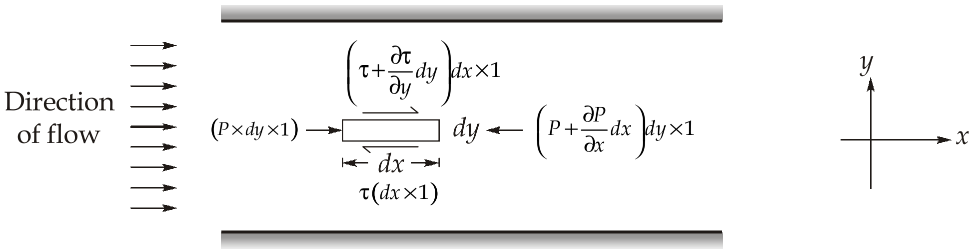
Date of Test : 10/06/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)



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

$$P\times(dy\times 1)-\left(P+\frac{\partial P}{\partial x}dx\right)dy\times 1-\tau(dx\times 1)+\left(\tau+\frac{\partial \tau}{\partial y}dy\right)dx\times 1=0$$

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

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

2. (a)

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

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

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

So, $dQ = |8-2|$

$= 6$ units

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. (b)

Pipe flow is a case of application of Reynold's model law and Weber model law is applicable in capillary rise in narrow passages.

5. (c)

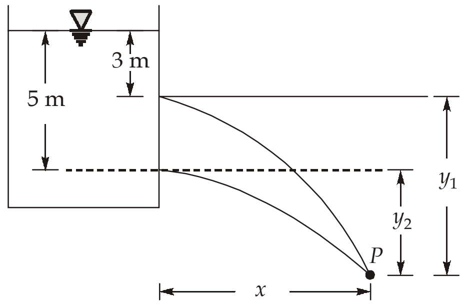
When $\frac{dh}{dx}>0$, it means that depth of water increases in the direction of flow. The profile of water so obtained is called back water curve.

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. (a)

Let P is the point of intersection of the two jets coming from orifice (1) and (2), such that

$$x = \text{Horizontal distance of } P$$
$$y_1 = \text{Vertical distance of P from orifice (1)}$$
$$y = \text{Vertical distance of P from orifice (2)}$$



Then, $$y_1 = y_2 + (5 - 3) = (y_2 + 2) \text{ m} \quad ...(1)$$

The equation of C_V is given by

For orifice (1), $$C_{V_1} = \frac{x}{\sqrt{4y_1H_1}} = \frac{x}{\sqrt{4y_1 \times 3}}$$

For orifice (2), $$C_{V_2} = \frac{x}{\sqrt{4y_2H_2}} = \frac{x}{\sqrt{4 \times y_2 \times 5}}$$

Since, $$C_{V_1} = C_{V_2}$$

Hence, $$\frac{x}{\sqrt{4y_1 \times 3}} = \frac{x}{\sqrt{4y_2 \times 5}}$$

$\Rightarrow$ $$3y_1 = 5y_2 \quad ...(2)$$

From (1) and (2),

$$y_2 = 3.0 \text{ m}$$

So, $$C_{V_2} = \frac{x}{\sqrt{4y_2 \times 5}}$$

$\Rightarrow$ $$x = 0.96 \times \sqrt{4 \times 3 \times 5}$$
$$= 7.436 \text{ m}$$

7. (a)

Since the pipes are connected in series

$\therefore$ $$\frac{L}{d^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \frac{L_3}{d_3^5}$$

$\Rightarrow$ $$\frac{1700}{d^5} = \frac{800}{0.500^5} + \frac{500}{0.4^5} + \frac{400}{0.3^5}$$

$\Rightarrow$ $$d^5 = \frac{1700}{239037.18}$$

$\Rightarrow$ $$d = 0.3719 \text{ m}$$
$$= 371.9 \text{ mm} \simeq 372 \text{ mm}$$

8. (c)

The divergence of the velocity field is

$$\text{div. V} = \nabla.V = \frac{\partial}{\partial x}(3t)+\frac{\partial}{\partial y}(xz)+\frac{\partial}{\partial z}\left(ty^2\right)$$

$$= 0 + 0 + 0$$

$$= 0$$

Therefore the velocity field is incompressible.

The curl of this velocity field is

$$\text{curl. } V = \nabla \times V = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 3t & xz & ty^2 \end{vmatrix}$$

$$= (2ty - x)\hat{i} + z\hat{k} \neq 0$$

Therefore the flow field is rotational.

9. (b)

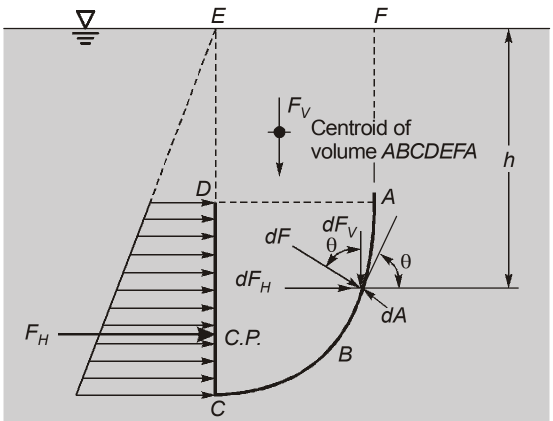
$$\because \quad \bar{h}_p = \bar{h} + \frac{I_G}{A\bar{h}}$$

Also, $\frac{I_G}{A\bar{h}} > 0$

Therefore, $\bar{h}_p > \bar{h}$, i.e. centre of pressure or point of action of total hydrostatic force is always below the centroid of the area.

$$F_H = \int dF_H = \gamma \int hdA\sin\theta$$

$$F_V = \int dF_V = \gamma \int hdA\cos\theta$$



where,

$(dA)\sin\theta$ = vertical projection of elementary area dA

$(dA)\cos\theta$ = horizontal projection of elementary area dA

Thus, F_H is the total hydrostatic force on the projected area of the curved surface on the vertical plane and will act at the centre of pressure of the plane surface.

F_V is the weight of the liquid contained in the portion extending vertically above the curved surface up to the free surface of the liquid.

10. (d)

When surface tension effect predominants in addition to inertia force, then Weber's model is used.

When pressure force controls flow in addition to inertia force, then Euler's model is used.

Mach model law is applicable in case of aerodynamics testing.

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. (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 = $v = wr$

$\therefore$ 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, $$dT = F \times r$$

$$= r\tau dA$$

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

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

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

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

$$\Rightarrow \quad T = \frac{\pi\mu w R^4}{2h}$$

13. (c)

In Venturimeter,

Rate of flow, $\quad Q = \dfrac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2gh}$

Here, $\quad h = 20\left(\dfrac{\rho_{Hg}}{\rho_w} - 1\right) = 20\left(\dfrac{13.6\times 10^3}{10^3} - 1\right) = 20(13.6-1) = 252 \text{ cm}$

$$\therefore \quad Q = \frac{0.98\times\frac{\pi}{4}\times 30^2\times\frac{\pi}{4}\times 15^2}{\sqrt{\left[\frac{\pi}{4}\times 30^2\right]^2 - \left[\frac{\pi}{4}\times 15^2\right]^2}}\times\sqrt{2\times 981\times 252}$$

$$\Rightarrow \quad Q = \frac{0.98\times 30^2\times\frac{\pi}{4}\times 15^2}{\sqrt{30^4 - 15^4}}\times\sqrt{2\times 981\times 252} = 125.76\ l\text{ps}$$

14. (a)

Given, $\quad D = 50 \text{ mm} = 0.05 \text{ m}$

$\quad L = 1.0 \text{ m}$

Projected area, $\quad A = L \times D = 1 \times 0.05 = 0.05 \text{ m}^2$

Velocity of air, $\quad U = 0.1 \text{ m/s}$

Total drag is given by, $F_{DT} = C_{DT}\times A\times\dfrac{\rho U^2}{2}$

Shear drag is given by, $F_{DS} = C_{DS}\times A\times\dfrac{\rho U^2}{2}$

Hence, Pressure drag = Total drag – Shear drag

$$= C_{DT}\times A\times\frac{\rho U^2}{2} - C_{DS}\times A\times\frac{\rho U^2}{2}$$

$$= (C_{DT} - C_{DS})\times A\times\frac{\rho U^2}{2}$$

$$= (1.5-0.2)\times 0.05\times 1.25\times\frac{(0.1)^2}{2}$$

Pressure drag $= 4.0625 \times 10^{-4}$ N

15. (a)

Since for flow of fluids through pipes only viscous and inertia forces predominant, Reynolds model law is the criterion for similarity. Thus

$$\left(\frac{Vd}{\upsilon}\right)_m = \left(\frac{Vd}{\upsilon}\right)_p$$

By substitution, we get

$$\frac{4\times150\times10^{-3}}{1.145\times10^{-6}} = \frac{V\times75\times10^{-3}}{3.0\times10^{-6}}$$

$$\therefore \quad V = 20.96 \text{ m/s}$$

16. (b)

Using Bernoulli's equation

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1 = \frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+h_L \quad ...(i)$$

$$V_1 = \frac{Q}{A_1}=\frac{4.0}{\frac{\pi}{4}\times1.0^2}=5.093 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2}=\frac{4.0}{\frac{\pi}{4}\times2.0^2}=1.273 \text{ m/s}$$

$$h_L = 0 \text{ (Frictionless flow)}$$

From eq. (i)

$$\frac{8.0}{9.81}+\frac{5.093^2}{2\times9.81}+0 = \frac{P_2}{9.81}+\frac{1.273^2}{2\times9.81}+0+0$$

$$P_2 = 20.16 \text{ kPa}$$

17. (c)

Let the height of hydraulic jump in the prototype is h_p

Then, $$\frac{h_p}{h_m} = L_r = 20$$

$$\Rightarrow \quad h_p = 20\times0.2 = 4 \text{ m}$$

If power dissipated is P_p

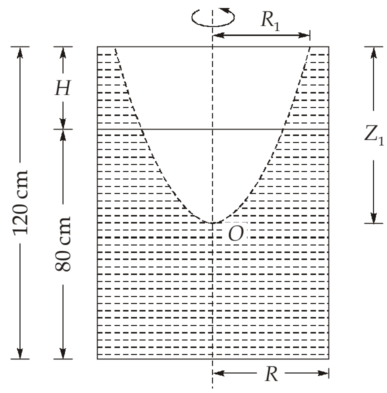
Then, $$\frac{P_p}{P_m} = L_r^{3.5} = 20^{3.5}$$

$$\Rightarrow \quad P_p = P_m\times20^{3.5}$$

$$\Rightarrow \quad P_p = \frac{1}{10}\times20^{3.5}$$

$$\Rightarrow \quad P_p = 3577.71 \text{ kW} \simeq 3578 \text{ kW}$$

18. (c)



Let, Z_1 = Height of paraboloid

R_1 = Radius made by water surface at top of container

Given, N = 400 rpm

$$\therefore \quad \omega = \frac{2\pi N}{60} = 41.89 \text{ rad/sec}$$

$$Z_1 = \frac{\omega^2 R_1^2}{2g} = \frac{41.89^2 \times (R_1)^2}{2 \times 9.81} = 89.438 R_1^2 \quad \text{...(i)}$$

Since,volume of paraboloid so formed = Initial volume of air

$$\Rightarrow \quad \frac{\pi R_1^2 Z_1}{2} = \pi \times R^2 H$$

$$\Rightarrow \quad \frac{\pi \times Z_1}{2 \times 89.438} \times Z_1 = \pi \times 0.1^2 \times 0.4 \text{ [From eq. (i)]}$$

$$\Rightarrow \quad Z_1 = 0.8458 \text{ m}$$

$$Z_1 = 84.58 \text{ cm}$$

19. (b)

Given, $\phi = x\,(2y - 1)$

The velocity components, u and v are

$$u = -\frac{\partial \phi}{\partial x} = -\frac{\partial}{\partial x}\left[x(2y-1)\right] = 1 - 2y$$

$$v = -\frac{\partial \phi}{\partial y} = -\frac{\partial}{\partial y}\left[x(2y-1)\right] = -2x$$

We know that, $$\frac{\partial \psi}{\partial y} = -u = -(1-2y) = 2y - 1$$

and, $$\frac{\partial \psi}{\partial x} = v = -2x$$

Now, $$\int d\psi = \int (2y-1)\,dy$$

$$\Rightarrow \qquad \psi = \frac{2y^2}{2} - y + C$$

$$\Rightarrow \qquad \psi = y^2 - y + C \qquad \text{...(i)}$$

Differentiating eq. (i) w.r.t. x,

$$\frac{\partial \psi}{\partial x} = \frac{\partial C}{\partial x}$$

But,
$$\frac{\partial \psi}{\partial x} = -2x$$

Hence,
$$\frac{\partial \psi}{\partial x} = \frac{\partial C}{\partial x} = -2x$$

On integrating, $C = -x^2 + C_1$

Hence, $\psi = y^2 - y - x^2 + C_1$

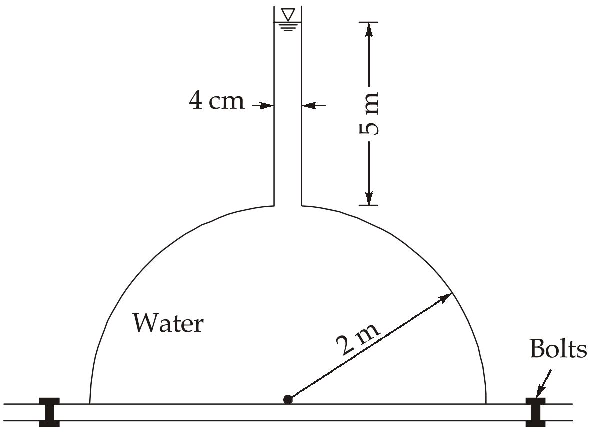
ψ at $(0, 0) = 0 = C_1$

Hence, $\psi = y^2 - y - x^2$

$\therefore$ Value of ψ at point P (4, 5) is, $\psi = 5^2 - 5 - 4^2 = 4$ units

20. (d)

The force in the bolts is equal to the weight of imaginary water above the container upto the height of the water level.



$$F_V = \rho g V$$

$$\Rightarrow \qquad F_V = 1000 \times 9.81 \times \left[\left\{(5+2) \times \pi \times 2^2\right\} - \left\{5 \times \pi \times \frac{(0.04)^2}{4}\right\} - \left\{\frac{1}{2} \times \frac{4}{3} \times \pi \times 2^3\right\}\right]$$

$$\Rightarrow \qquad F_V = 698.5 \text{ kN (upwards)}$$

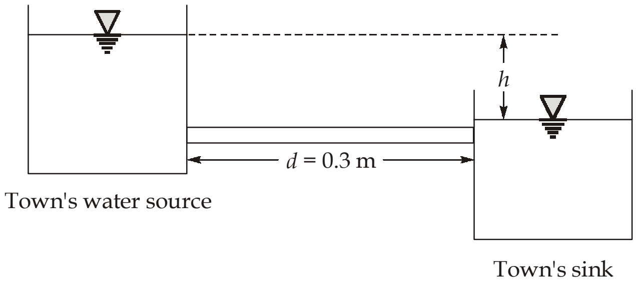
Net upward force on dome

$$= 698.5 - 125 = 573.5 \text{ kN}$$

$$\therefore \qquad \text{Force per bolt} = \frac{573.5}{2} = 286.75 \text{ kN} \simeq 287 \text{ kN}$$

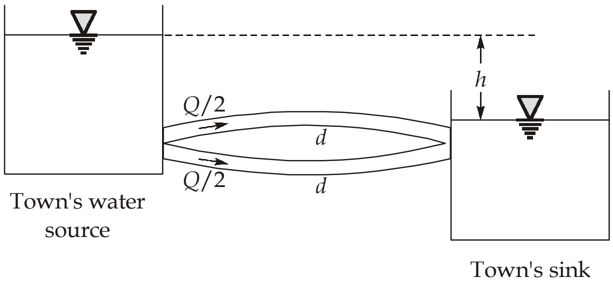
21. **(d)**

Case 1: Single pipe connection



$$h = \frac{flQ^2}{12(0.3)^5} \quad \text{... (i)}$$

Case 2: Dual pipe connection



$$h = \frac{fl(Q/2)^2}{12d^5} \quad \text{... (ii)}$$

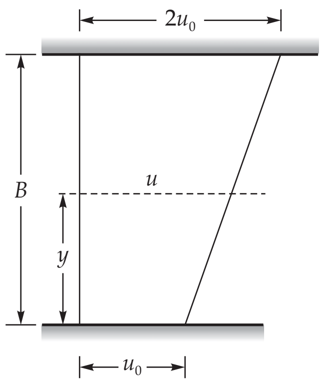
Using (i) and (ii)

$$\frac{flQ^2}{12(0.3)^5} = \frac{fl(Q/2)^2}{12d^5}$$

$\Rightarrow$ $d = 0.2274 \text{ m} = 22.74 \text{ cm}$

$\Rightarrow$ $\text{d} = 227.4 \text{ mm} \simeq 227 \text{ mm}$

22. **(a)**



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

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

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

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

At $y = 0 \Rightarrow t = 1$

At, $y = B \Rightarrow t = 2$

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

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

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

23. (c)

Area of each nozzle, $A = \frac{\pi}{4} \times \left(15 \times 10^{-3}\right)^2 = 1.767 \times 10^{-4}\ \text{m}^2$

Velocity of flow, $V_A = V_B = 20$ m/s

Discharge through each nozzle, $Q = AV = 1.767 \times 10^{-4} \times 20\ \text{m}^3/\text{s} = 3.534\ l/\text{sec}$

Torque exerted by water coming through nozzle A

$$T_A = \rho Q V_A r_A$$

$$= 1000 \times \frac{3.534}{1000} \times 20 \times 0.4 = 28.272\ \text{N-m}$$

Torque exerted by water coming through nozzle B,

$$T_B = 1000 \times \frac{3.534}{1000} \times 20 \times 0.45 = 31.806\ \text{N-m}$$

$\therefore$ Torque required to hold the arm stationary

= Torque exerted by water on sprinkler

$= T_A + T_B = 28.272 + 31.806$

$= 60.078$ N-m $\simeq 60.1$ N-m

24. (a)

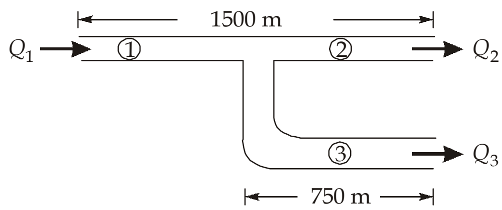
$$h_f = \frac{fLV^2}{2gd} \Rightarrow 30 = 0.04 \times \frac{1.5 \times 10^3}{0.6} \times \frac{V^2}{2 \times 9.81}$$

$\Rightarrow$ $V = 2.426$ m/s

Discharge, $Q = A \times V$

$$= \frac{\pi}{4} \times (0.6)^2 \times 2.426$$

$= 0.686\ \text{m}^3/\text{s}$



$$Q_1 = Q_2 + Q_3 \quad \text{...(i)}$$

$$h_f = h_{f_1} + h_{f_2} \quad \text{...(ii)}$$

$$h_{f_2} = h_{f_3}$$

$$\Rightarrow \quad \frac{f\left(\frac{L}{2}\right)V_2^2}{2gd} = \frac{f\left(\frac{L}{2}\right)V_3^2}{2gd}$$

$$\Rightarrow \quad V_2 = V_3 \quad \text{...(iii)}$$

From (ii),

$$30 = \frac{f\left(\frac{L}{2}\right)V_1^2}{2gd} + \frac{f\left(\frac{L}{2}\right)V_2^2}{2gd}$$

$$30 = \frac{0.04 \times 750}{2 \times 9.81 \times 0.6} \times \left[V_1^2 + V_2^2\right] \quad \text{...(iv)}$$

From (i),

$$\frac{\pi}{4}d^2 \times V_1 = \frac{\pi}{4}d^2 \times V_2 + \frac{\pi}{4}d^2 V_3 \quad (\because \; V_2 = V_3)$$

$$\therefore \quad V_1 = 2V_2$$

From equation (iv), $V_2 = 1.534$ m/s

$$\therefore \quad Q_1 = 2Q_2 = 2 \times \frac{\pi}{4}(0.6)^2 \times 1.534$$

$$= 0.867 \text{ m}^3/\text{s}$$

$$\therefore \text{ \%increase in discharge} = \frac{0.867 - 0.686}{0.686} \times 100 = 26.38\%$$

25. (b)

$$\text{Shape factor, } (H) = \frac{\delta^*}{\theta}$$

$$\delta^* = \int_0^\delta \left(1 - \frac{u}{U}\right) dy = \int_0^\delta \left(1 - \left(\frac{y}{\delta}\right)^{1/7}\right) dy$$

$$= \left[y - \frac{7}{\delta^{1/7}} \times \frac{y^{8/7}}{8}\right]_0^\delta = \left(\delta - \frac{7}{8} \times \delta\right) = \frac{\delta}{8} = 0.125\,\delta$$

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

$$\theta = \int_0^\delta \left(\frac{y}{\delta}\right)^{1/7}\left(1-\left(\frac{y}{\delta}\right)^{1/7}\right)dy$$

$$\theta = \left[\frac{7}{\delta^{1/7}}\times\frac{y^{8/7}}{8}-\frac{7}{\delta^{2/7}}\times\frac{y^{9/7}}{9}\right]_0^\delta$$

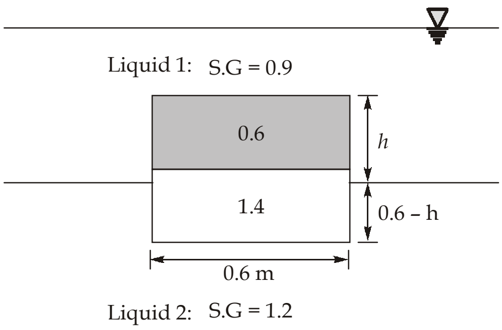
$$\theta = \left(\frac{7}{8}-\frac{7}{9}\right)\delta = 0.0972\delta$$

$$\therefore \qquad H = \frac{\delta^*}{\theta} = \frac{0.125\delta}{0.0972\delta} = 1.286 \simeq 1.29$$

Alternatively,

If $\frac{U}{U_0} = \left(\frac{y}{\delta}\right)^{1/m}$ is velocity profile than shape factor $\frac{\delta^*}{\theta} = \frac{m+2}{7} = \frac{7+2}{7} = 1.284 \simeq 1.29$

26. (b)



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

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

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

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

27. (b)

Velocity, $V = 3$ m/s

Kinematic viscosity, $\nu = 0.9$ centistokes $= 0.9 \times 10^{-6}$ m^2/s

$$\text{Reynolds number, } Re = \frac{Vd}{\nu} = \frac{3\times 0.5}{0.9\times 10^{-6}} = 1.67\times 10^6$$

Since Re > 4000,

$\therefore$ Flow is turbulent

$$\therefore \quad \frac{1}{\sqrt{f}} = 2\log_{10}\frac{r_0}{k_s} + 1.74$$

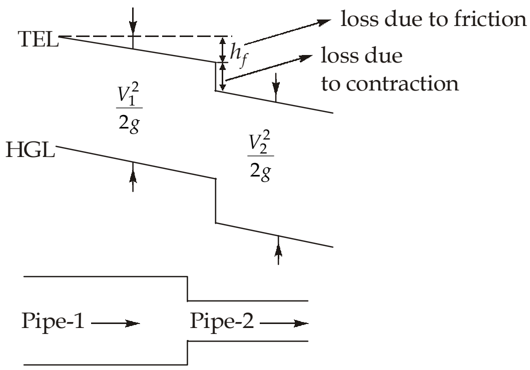
$$\Rightarrow \quad \frac{1}{\sqrt{f}} = 2\log_{10}\frac{0.25}{0.25\times 10^{-3}} + 1.74$$

$$\Rightarrow \quad \frac{1}{\sqrt{f}} = 7.74$$

$$\Rightarrow \quad f = 0.0167$$

$$\therefore \quad h_L = \frac{fLV^2}{2gd} = \frac{0.0167\times 300\times (3)^2}{2\times 9.81\times 0.5} = 4.596 \text{ m} \simeq 4.6 \text{ m}$$

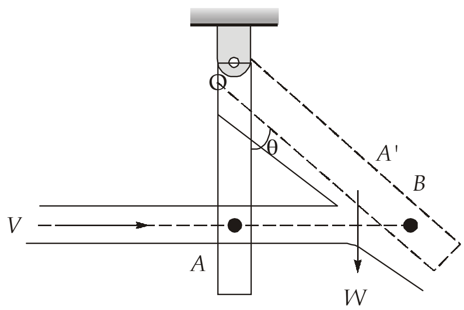
28. (b)



- As pipe contracts, pressure decreases and velocity increases.
- HGL is always lower and parallel to TEL.

29. (c)

30. (a)



$$\text{Area} = 10 \text{ cm}^2$$
$$= 10^{-3} \text{ m}^2$$
$$\text{Velocity of jet} = 50 \text{ m/s}$$

Force on an inclined stationary plate in normal direction to the plate,

$$F_n = \rho a v^2 \cdot \sin\theta$$
$$\text{Here } \theta' = 90 - \theta$$
$$\text{So, } F_n = \rho a v^2 \cos\theta$$
$$\text{Moment of } F_n \text{ about } 0 = F_n \times OB$$
$$= \rho a v^2 \times \frac{OA}{\cos\theta}$$
$$= \rho a v^2 (OA)$$

For equilibrium position, $\Sigma M_0 = 0$

$$W \times \sin\theta \times OA = \rho a v^2 (OA)$$

$$\sin\theta = \frac{\rho a v^2}{W} \quad \text{(Since, } OA = OA'\text{)}$$

$$\sin\theta = \frac{10^3 \times 10^{-3} \times (50)^2}{5 \times 10^3}$$

$$\sin\theta = \frac{1}{2}$$

$$\theta = 30°$$

■■■■