S.No. : 08 KS_CE_T_161019

Fluid Mechanics

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 16/10/2019

ANSWER KEY ➤ Fluid Mechanics

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

DETAILED EXPLANATIONS

2. (c)

$$\text{Vorticity} = \frac{\text{Circulation}}{\text{Area}}$$

$$= \frac{\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) \cdot \text{Area}}{\text{Area}}$$

$\Rightarrow$ $$\text{m/s/m} = 1/\text{s}$$

3. (d)

$$\text{Displacement thickness, } \delta^* = \int_0^\delta \left(\frac{u}{U}\right) \cdot dy = \int_0^\delta \left(1 - \frac{y^2}{\delta^2}\right) dy$$

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

6. (a)

$$\psi = 2xy$$

$\because$ $$u = \frac{\partial \psi}{\partial y} = 2x$$

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

At (2, –2), $u = 4$, $v = 4$

$\therefore$ $$|\vec{V}| = \sqrt{u^2 + v^2} = 4\sqrt{2}$$

7. (b)

Change in the piezometric head between the inlet and throat of a venturimeter is measured by a differential u-tube manometer. The piezometric head difference depends upon the gauge reading regardless of the orientation of the venturimeter, weather it is horizontal, vertical or inclined.

8. (b)

$$v = C\sqrt{2g\Delta h}$$

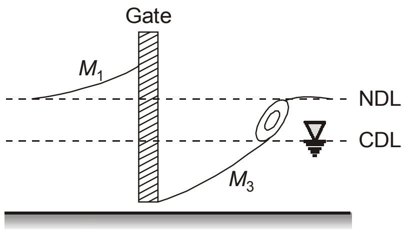
$$\Delta h = X\left(\frac{s_w}{s_{air}} - 1\right) = 0.012\left(\frac{1000}{1.2} - 1\right) = 9.988 \text{ m}$$

$$v = \sqrt{2g \times 9.988}$$

$\therefore$ $$v = 13.99 \simeq 14 \text{ m/s}$$

10. (b)

Mild slope: Flow downstream of a sluice: M_1 is the wrong statement, because it will be M_3



11. (b)

$$N_S = \frac{N\sqrt{P}}{H^{5/4}} = \frac{145\sqrt{7000}}{(25)^{5/4}} = 217$$

Low head ⇒ Francis turbine

12. (b)

Hydraulic jump height in model,

$$h_m = 10 \text{ cm}$$

Given $$\frac{l_p}{l_m} = 36 = \frac{h_p}{h_m}$$

⇒ $$h_p = 36 \times h_m = 36 \times 10$$
$$= 360 \text{ cm}$$
$$= 3.6 \text{ m}$$

13. (b)

Critical time of closure, $t_c = \frac{2L}{c} = \frac{2 \times 3000}{1500} = 4$ sec

Since time of closure, (t) > Critical time of closure (t_c) hence it is a case of slow closure.

15. (a)

$$\text{Angular deformation} = \frac{1}{2}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)$$

Given, $$u = 8x^3y$$

∴ $$\frac{\partial u}{\partial y} = 8x^3 \quad \text{... (i)}$$

$$v = -10x^2y$$

∴ $$\frac{\partial v}{\partial x} = -20xy \quad \text{... (ii)}$$

By equation (i) and (ii)

$$\text{Angular deformation} = \frac{1}{2}(8x^3 - 20xy)$$

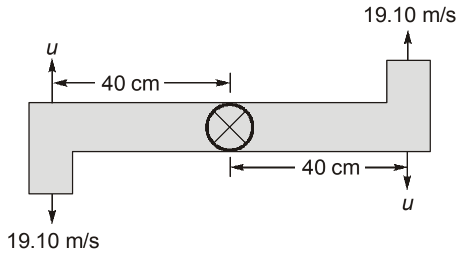
∴ At (1, 1), angular deformation = $\frac{1}{2}(8-20) = -6$ units

16. (c)

Discharge coming out from one side = $\frac{3}{2}$ = 1.5 l/s

$= 1.5 \times 10^{-3}$ m^3/s

$$\text{Velocity at the exit} = \frac{1.5 \times 10^{-3}}{\frac{\pi}{4} \times (0.01)^2} = 19.099 \text{ m/s} \simeq 19.10 \text{ m/s}$$



Velocity of water with respect to ground = (19.10 – u)

Applying angular momentum conservation

$$T = (\dot{m}vr)_{\text{final}} - (\dot{m}vr)_{\text{initial}}$$

Initial angular momentum = 0 (Since flow is radial r = 0)

$$T = \rho Q.(19.10 - u) \times 0.40 \times 2 - 0 \quad \text{[Multiplied by 2 for both side]} \quad \text{... (i)}$$

Here hinge is provided so T = 0, in equation (i)

$$19.10 - u = 0$$

$$u = 19.10$$

$$u = \omega r$$

$$\Rightarrow \quad \omega = \frac{19.10}{0.4} = 47.75 \text{ radian/sec} = \frac{47.75 \times 60}{2 \times \pi}$$

$= 455.98$ rpm $\simeq 456$ rpm

17. (b)

$$a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t} \quad \text{... (i)}$$

In given problem, $u = 6xt + yz^2$ ... (ii)

$v = 3t + xy^2$

$w = xy - 2xyz - 6tz$ ... (iii)

$\frac{\partial u}{\partial t} = 6x$; $\quad \frac{\partial u}{\partial x} = 6t$;

$\frac{\partial u}{\partial y} = z^2$; $\quad \frac{\partial u}{\partial z} = 2yz$ ... (iv)

By equation (i), (ii), (iii), (iv)

a_x at (1, 1, 1) and t = 1 unit

$= (6 + 1) \times 6 + (4 \times 1) + (1 - 2 - 6) \times 2 + 6$

$= 38$ units

18. (c)

$$P = \dot{m}gh_L = \rho Qgh_L$$

Now $$h_L = \frac{fLQ^2}{12 \times D^5}$$

$\therefore \quad P \propto Q^2$

$$\Rightarrow \quad P_2 = \left(\frac{Q_2}{Q_1}\right)^2 \times P_1$$

$$P_2 = (1.44\, P_1)$$

$\therefore$ Power will increase by 44%.

19. (a)

Froude number will be same for dynamic similarity,

So, $F_m = F_p$

$$\frac{V_m}{\sqrt{gD_m}} = \frac{V_p}{\sqrt{gD_p}}$$

$$\Rightarrow \quad \frac{V_p}{V_m} = \sqrt{\frac{D_p}{D_m}}$$

$$\Rightarrow \quad V_r = \sqrt{L_r}$$

Also $\quad V_r = \frac{L_r}{T_r} = \sqrt{L_r}$

$$\therefore \quad T_r = \sqrt{L_r}$$

$$\text{Power} = \text{Force} \times \text{Velocity} = ma \times v$$

$$= \left(\rho V \cdot \frac{v}{T}\right) v = \rho L^3 . \frac{v^2}{T}$$

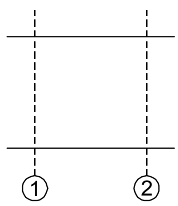
$$\Rightarrow \quad P_r = \rho_r \cdot L_r^3 \cdot \frac{L_r}{T_r^2} \cdot \frac{L_r}{T_r}$$

Here, $\rho_r = 1$, since water is in both case and $T_r = \sqrt{L_r}$ $\quad \because L_r = 50$ (given)

So, $\quad P_r = L_r^{3.5} \Rightarrow \frac{P_p}{0.5} = (50)^{3.5}$ $\quad \left(P_r = \frac{P_p}{P_m}\right)$

$$P_p = 441.94 \text{ MW}$$

20. (b)



$$\tau_0 L\pi D = (p_1 - p_2)\frac{\pi}{4}D^2$$

$$\Rightarrow \quad \tau_0 = (p_1 - p_2)\frac{D}{4L}$$

21. (b)

$$Q = C_d \frac{8}{15}\sqrt{2g}\tan\left(\frac{\theta}{2}\right)H^{5/2}$$

$$\therefore \quad \frac{\partial Q}{Q} = \frac{5}{2}\frac{\partial H}{H} = \frac{5}{2} \times 4 = 10\%$$

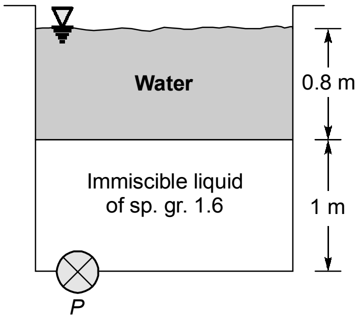
22. (b)

Moment of Inertia is less for rolling as compared to pitching.

23. (b)

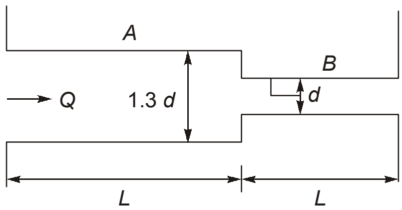
The values of k/δ' representing the boundary in transition are $0.25 < k/\delta' < 6$. Therefore, a pipe will behave as hydro dynamically smooth pipe if k/δ' is less than 0.25 and it will behave as hydrodynamically rough pipe when k/δ' greater than 6.0.

24. (d)



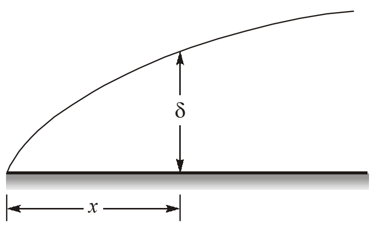
$$\text{Total pressure at } P = \gamma_w \times 0.8 + 1.6\,\gamma_w \times 1$$
$$= 2.4\,\gamma_w = 2.4 \times \rho_w \cdot g$$
$$= 2.4 \times 10000$$
$$= 24 \text{ kPa}$$

25. (d)



$$h_{f_A} = \frac{fLQ^2}{12.1(1.3d)^5}$$
$$h_{f_B} = \frac{fLQ^2}{12.1(d)^5}$$
$$\therefore \quad \frac{h_{f_A}}{h_{f_B}} = \frac{d^5}{(1.3d)^5}$$
$$= \frac{1}{1.3^5} = 0.2693 \simeq 0.27$$

26. (d)



For a laminar boundary layer

$$\frac{\delta}{x} = \frac{5}{\sqrt{\text{Re}_x}}$$
$$\Rightarrow \quad \frac{\delta}{x} = \frac{5}{\sqrt{\dfrac{\rho V x}{\mu}}}$$

$\therefore \quad \delta \propto \sqrt{x}$

$\therefore \quad \dfrac{\delta_1}{\delta_2} = \sqrt{\dfrac{x_1}{x_2}} \Rightarrow \delta_2 = \delta_1\sqrt{\dfrac{2x_1}{x_1}} = \sqrt{2}\,\delta_1$

27. (a)

$$L_1 = L_2$$

$$D_1 = 20 \text{ cm} \qquad D_2 = 30 \text{ cm}$$

$$f_1 = f_2$$

$$h_{L_1} = h_{L_2}$$

$$h_L = \frac{fLV^2}{2gD} = \frac{fLQ^2}{12.1D^5} \qquad (\because \text{ Pipes are in parallel})$$

$$\Rightarrow \quad \frac{f_1L_1Q_1^2}{12.1(0.2)^5} = \frac{f_2L_2Q_2^2}{12.1(0.3)^2}$$

$$\Rightarrow \quad \frac{Q_1^2}{Q_2^2} = \frac{(0.2)^5}{(0.3)^5}$$

$$\Rightarrow \quad \frac{Q_1}{Q_2} = 0.3629$$

28. (d)

$$h_L = \frac{fLQ^2}{12.1D^5}$$

$$Q^2 = \frac{12.1h_LD^5}{fL}$$

$$Q = \sqrt{\frac{12.1h_LD^5}{L}} \times f^{-\frac{1}{2}}$$

$$\therefore \quad \frac{dQ}{df} = \sqrt{\frac{12.1h_LD^5}{L}} \times \left(-\frac{1}{2}f^{-\frac{3}{2}}\right)$$

$$dQ = \sqrt{\frac{12.1h_LD^5}{L}}\left(-\frac{1}{2}f^{-\frac{3}{2}}\right)df$$

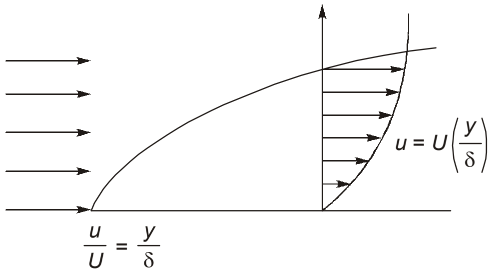
$$\Rightarrow \quad \frac{dQ}{Q} = \frac{\left(-\frac{1}{2}f^{-\frac{3}{2}}\right)df}{f^{-\frac{1}{2}}}$$

$$\Rightarrow \quad \frac{dQ}{Q} = -\frac{1}{2}\frac{df}{f}$$

Percentage error in discharge $= -\dfrac{1}{2} \times 25\% = -12.5\%$

29. (d)

Momentum thickness of boundary layer



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

$$= \int_0^{\delta} \frac{y}{\delta}\left(1-\frac{y}{\delta}\right) dy = \frac{\delta}{2} - \frac{\delta}{3} = \frac{\delta}{6}$$

Displacement thickness of boundary layer

$$\delta^* = \int_0^{\delta}\left(1-\frac{u}{U}\right) dy = \int_0^{\delta}\left(1-\frac{y}{\delta}\right) dy = \frac{\delta}{2}$$

$$\therefore \qquad \frac{\theta}{\delta^*} = \frac{\frac{\delta}{6}}{\frac{\delta}{2}} = \frac{1}{3}$$

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