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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Subject : Fluid Mechanics

Date of test : 14/04/2019

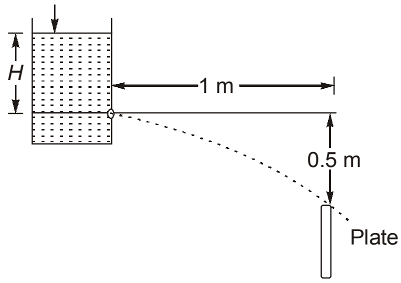
Answer Key

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

Detailed Explanations

1. (b)

For a point on the trajectory.



$$\therefore \quad x = u_1 t$$

$$z = \frac{1}{2} g t^2$$

For, $C_V = 1, \quad u_1 = \sqrt{2gH}$

$$\therefore \quad z = \frac{x^2}{4H} \Rightarrow H = \frac{x^2}{4z} \Rightarrow \frac{(1)^2}{4 \times 0.5} = 0.5\text{m}$$

2. (d)

Let A be the uniform cross-sectional area.
Under the condition of floating equilibrium,
weight of the body = Total buoyant force

$$\therefore \quad A \times (a + b) \times (7850) \times g = (b \times 13.57 + a) \times A \times g \times 10^3$$

$$\therefore \quad \frac{a}{b} = 0.835$$

3. (b)

For the laminar flow through pipes, the ratio of maximum velocity to average velocity is 2.

4. (d)

Here, $\frac{dV}{V} = -22\% = -0.0022$

$$\Delta P = 1400 \text{ kPa}$$

$$K = -\frac{\Delta P}{\frac{dV}{V}} \Rightarrow K = -\frac{1400}{-0.0022}$$

$$\therefore \quad K = 6.36 \times 10^5 \text{ kPa}$$

$$\therefore \quad C = \sqrt{\frac{K}{\rho}}$$

Where, $C \rightarrow$ Velocity of propagation of sound, $\rho \rightarrow$ Density of liquid

$$\therefore \quad C = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{6.36 \times 10^5 \times 10^3}{0.94 \times 1000}}$$

$$\therefore \quad C = 822.55 \text{ m/s}$$

5. (c)

Initially, the boat will be floating

$\therefore$ Let V be the volume of boat inside water

$$\therefore \quad 50 \times 10 = V \times 1000 \times 10$$

$$\therefore \quad V = 0.05 \text{ m}^3$$

$$\Rightarrow \quad V = \frac{1}{20} \text{m}^3$$

The volume to be filled with water before water starts coming in from the sides is $\left(1 - \frac{1}{20}\right) = \frac{19}{20} = 0.95$

= 95%

6. (b)

$$\tau_w = \frac{\Delta PD}{4L}$$

$$\tau_w = \frac{50\times10^3\times1}{4\times100} = 125 \text{ N/m}^2$$

7. (b)

$$\Omega_x = \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}$$

$$\Rightarrow \quad \Omega_x = -18yz - 3y$$

$$\Rightarrow \quad \Omega_{x(1,1,1)} = -21 \text{ units}$$

8. (a)

$$\text{Local acceleration} = \frac{\partial V}{\partial t} = 3\left(1-\frac{x}{3L}\right)^2$$

Given, $L = 1$ m

$$\Rightarrow \quad \left(\frac{\partial V}{\partial t}\right)_{x=0.5\text{ m}} = 3\left(1-\frac{0.5}{3}\right)^2 = 2.0833 \simeq 2.08 \text{ m/s}^2$$

9. (c)

Using Bernoulli's equation at the two points,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$z_1 = z_2$$

$$P_1 - P_2 = (100 \times \rho g)$$

$$\therefore \quad \frac{100\times\rho g}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

Also, $$\alpha = \frac{V_2}{V_1} [\because \alpha > 1]$$

$$100 = \frac{\alpha^2 V_1^2}{2g} - \frac{V_1^2}{2g}$$

$$100 = \frac{V_1^2}{2g}\left(\alpha^2 - 1\right)$$

$$100 = \frac{(10)^2}{2\times9.81}\left(\alpha^2 - 1\right)$$

$$\Rightarrow \quad \alpha = 4.54$$

10. (b)

$$h = \frac{4\sigma\cos\theta}{\rho g d}$$

For water, $\theta = 0°$

$$\therefore \quad h = \frac{4\times0.075\times1}{1000\times9.81\times2.5\times10^{-3}}$$

$$h = 0.012232 \text{ m}$$

$$\Rightarrow \quad h = 12.23 \text{ mm}$$

Rise in manometric reading = 12.23 mm

$\therefore$ correction = –12.23 mm

11. (d)
All the four are correct.

12. (a)

$$a_x = \frac{du}{dt} + u\frac{\partial u}{dx} + v\frac{\partial u}{\partial y} \Rightarrow 2t + (t^2 + 3y)0 + (4t + 5x)(3)$$

$$a_y = \frac{dv}{dt} + u\frac{\partial v}{dx} + v\frac{\partial v}{\partial y} \Rightarrow 4t + (t^2 + 3y)5 + (4t + 5x)0 = 4 + 5t^2 + 15y$$

At point (5, 3), $a_x = (14 \times 2) + (15 \times 5) = 103$

$$a_y = 4 + (5 \times 2^2) + (15 \times 3) = 69$$

$$a = \sqrt{103^2 + 69^2} = 123.97 \text{ units}$$

13. (d)
Total force on both sides of the plate,

$$C_D = \frac{1.328}{\sqrt{Re_L}} = \frac{1.328}{\sqrt{\frac{10 \times 3}{10^{-4}}}} = 2.424 \times 10^{-3}$$

$$F = C_D \times (area) \times \frac{\rho U^2}{2}$$

$$F = \frac{2.424 \times 10^{-3} \times (2 \times 2 \times 3) \times (0.9 \times 1000) \times 10^2}{2} = 1309.276$$

$$P = F \times V = 1309.276 \times 10 = 13092.76 \text{ W}$$

14. (d)

$$P_{atm} = \rho_m gh = 13600 \times 9.81 \times 0.75 = 100062 \text{ N/m}^2$$

$$P_{guage} = (\rho gh)_{water} = 1000 \times 9.81 \times 5 = 49050 \text{ N/m}^2$$

$$P_{abs} = P_{atm} + P_{guage} = 149112 \text{ N/m}^2$$

$$P_{abs} = 0.149 \text{ N/mm}^2$$

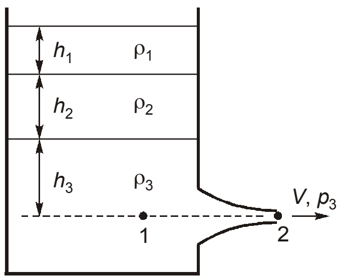
15. (b)

Time ratio, $T_r = \frac{L_r}{V_r} = \frac{L_r}{\sqrt{L_r}} = \sqrt{L_r}$

$\Rightarrow$ $\frac{T_m}{T_p} = \frac{1}{10}$

$T_m = \frac{15}{10} = 1.5 \text{ hrs.}$ (Given, $T_p = 15$ hrs.)

16 (a)



Total pressure at state 1,

$$P_1 = \rho_1 gh_1 + \rho_2 gh_2 + \rho_3 gh_3$$

Total pressure at state 2,

$$P_2 = \frac{\rho_3 V^2}{2}$$

Thus, $P_2 = P_1$

$$\frac{\rho^3 V^2}{2} = \rho_1 gh_1 + \rho_2 gh_2 + \rho_3 gh_3$$

$$V^2 = 2g\left(\frac{\rho_1}{\rho_3}h_1 + \frac{\rho_2}{\rho_3}h_2 + \frac{\rho_1}{\rho_3}h_1\right)$$

$$V = \sqrt{2g\left(h_3 + \frac{\rho_2}{\rho_3}h_2 + \frac{\rho_1}{\rho_3}h_1\right)}$$

$$= \sqrt{2gh_3\left(1 + \frac{\rho_2}{\rho_3}\frac{h_2}{h_3} + \frac{\rho_1}{\rho_3}\frac{h_1}{h_3}\right)}$$

17. (d)

We know,

$$V = \sqrt{2gh\left(1 - \frac{\rho_m}{\rho}\right)}$$

$$2 = \sqrt{2 \times 9.81 \times h\left(1 - \frac{0.9 \times 1000}{1000}\right)}$$

$$\Rightarrow \quad h = 2.0387 \text{ m}$$

18. (b)

Hagen–Poiseuille's equation,

$$\Delta p = \frac{32\mu VL}{d^2}$$

where

$$V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}d^2} = \frac{4Q}{\pi d^2}$$

$$\therefore \quad \Delta p = \frac{128\mu QL}{\pi d^4}$$

$$\Delta p \propto \frac{1}{d^4}$$

$$\Delta p \times d^4 = C$$

$$\Delta p_1 d_1^4 = \Delta p_2 d_2^4$$

$$\Delta p_1 \times d_1^4 = \Delta p_2 \times (2d_1)^4$$

or

$$\Delta p_2 = \frac{\Delta p_1}{16}$$

19. (c)

$$D = \frac{4A}{P} = \frac{4\times\sqrt{3}\times(0.025)^2}{4\times 3\times(0.025)}$$

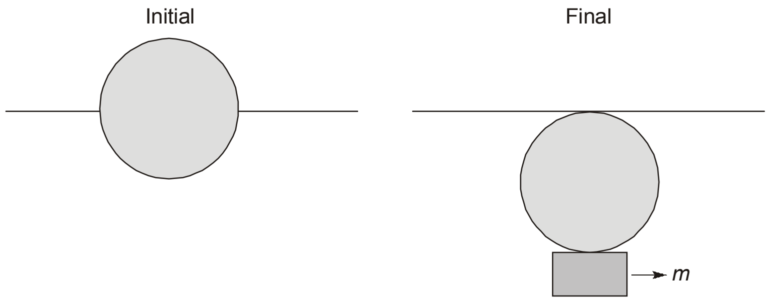
$$D = 0.0144 \text{ m}$$

$$\Delta P = \frac{32\mu \bar{U} L}{D^2}$$

$$\Delta P = \frac{32\times 2\times 10^{-5}\times 1}{0.0144^2}$$

$$\Delta P = 3.086 \text{ Pa}$$

20. (c)



$$R = 0.6095\ m$$

Let m be the mass of concrete anchor.
Initially weight of sphere,

$$W = \frac{1}{2}\left\{\frac{4}{3}\pi\times R^3\times 1025\times g\right\}$$

When mass m is added,
According to question,

$$W + mg = \left[\frac{4}{3}\pi\times R^3 + \frac{m}{2403}\right]\times 1025\times g$$

Where R is the radius of sphere
On solving, $m = 847.10$ Kg

22. (d)
Total pressure on the surface

$$P = wA\bar{x}$$

$$A = \left(\frac{15+12}{2}\right)\times 8 = 108 \text{ m}^2$$

$$\bar{x} = \left(\frac{2\times 12+15}{15+12}\right)\times\frac{8}{3} = 3.85 \text{ m}$$

$$P = 10.055 \times 108 \times 3.85 = 4180.869 \text{ kN} = 4.181 \text{ MN}$$

23. (b)
Boundary layer thickness ∝ Square root of distance from leading edge

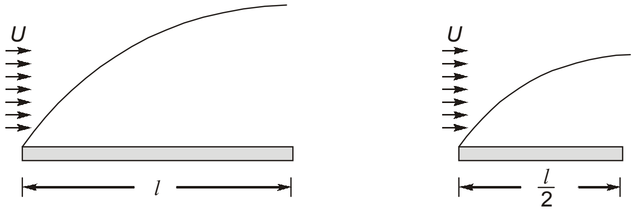
$$\frac{\delta_1}{\delta_2} = \sqrt{\frac{x_1}{x_2}}$$

$$\frac{2}{\delta_2} = \sqrt{\frac{2}{4}}$$

$$\delta_2 = 2\times\sqrt{2} = 2.8284 \text{ mm}$$

24. (c)

Drag coefficient for laminar flow,



$$C_D = \frac{0.664}{\sqrt{Re}}$$

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

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

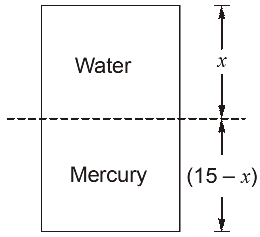
$$C_D \propto \frac{1}{\sqrt{l}}$$

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

$$C_{D1}\sqrt{l_1} = C_{D2}\sqrt{l_2}$$

$$\frac{C_{D1}}{C_{D2}} = \sqrt{\frac{l_2}{l_1}} = \sqrt{\frac{l/2}{l}} = \sqrt{\frac{1}{2}} = 0.707$$

25. (c)



$$15 \times A \times 7.4 = (x \times 1 \times A) + [(15 - x) \times 13.6 \times A]$$

$$x = \frac{15(13.6 - 7.4)}{12.6}$$

$$x = 7.38 \text{ cm}$$

26. (b)

The value of kinetic energy correction factor is given by

$$\alpha = \frac{1}{AV^3}\int_A V^2 dA$$

The actual value of α depends on the velocity distribution at the flow section. The value of α for turbulent flow in pipes lies between 1.03 to 1.06, which is approximately equal to 1, because in turbulent flow the velocity distribution is very close to uniform velocity distribution. However for laminar flow in pipes the value of α is 2.

27. (b)

$$\rho = 1.25 \text{ kg/m}^3$$
$$x = 30 \text{ mm of Hg} = 0.03 \text{ m of Hg}$$
$$\rho_{Hg} = 13600 \text{ kg/m}^3$$
$$g = 10 \text{ m/s}^2$$

Dynamic pressure head: $h = x\left[\frac{\rho_{Hg}}{\rho} - 1\right] = 0.03\left[\frac{13600}{1.25} - 1\right] = 326.37$ m of air

Velocity of air (fluid): $V = \sqrt{2gh} = \sqrt{2 \times 10 \times 326.37} = 80.79$ m/s

28. (c)

The continuity equation is given by

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

Now,

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

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

$$\frac{\partial(\rho u)}{\partial x} = 5\rho$$

$$\frac{\partial(\rho v)}{\partial y} = 5\rho$$

$$\frac{\partial(\rho w)}{\partial z} = \lambda\rho$$

$$\therefore \quad -2\rho + 5\rho + 5\rho + \lambda\rho = 0$$

$$8 + \lambda = 0$$

$$\lambda = -8$$

29. (b)

$$F = \rho g\bar{h} \times A = 1000 \times 9.81 \times \frac{8}{12} \times (8 \times 6)$$

$$= 1883.520 \text{ kN}$$

Centre of pressure

$$h^* = \frac{I_G}{A\bar{h}} + \bar{h} = \frac{6 \times 8^3}{(12 \times 8 \times 6) \times (4)} + 4$$

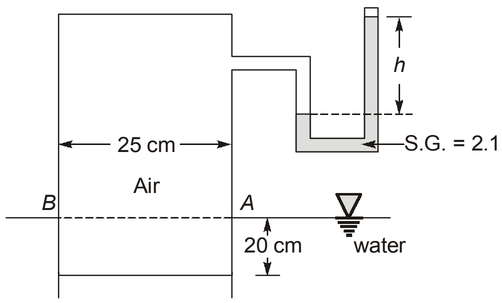
$$= 5.333 \text{ m}$$

$$\text{Moment about bottom} = F \times (8 - 5.333)$$

$$= 5023.34 \text{ kNm}$$

30. (d)

Pressure at *A* and *B* must be same as they fall on the same horizontal line in same fluid.



$$P_{air} = \rho_w g h_w$$

$$= 1000 \times 9.81 \times 0.2 = 1962 \text{ Pa}$$

As pressure variation within the cylinder is given negligible.

$$P_{air} - (\rho g h)_{mano} = 0$$

$$h = \frac{1960}{2100 \times 9.81} = 0.09524 \text{ m}$$

$$h = 9.524 \text{ cm}$$

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