CLASS TEST

Sl.:01DLSKME_ABCDEFGH_100726

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FLUID MECHANICS

MECHANICAL ENGINEERING

Date of Test : 10/07/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. **(b)**

2. **(c)**

$$\text{Absolute pressure} = \text{Local atmospheric pressure + gauge pressure}$$
$$= 91.52 + 22.48 = 114 \text{ kPa}$$

3. **(d)**

4. **(c)**

$$\text{Radius of pipe, } R = \frac{D}{2} = \frac{250}{2} = 125 \text{ mm}$$
$$U_{max} = 2 \text{ m/s}$$
$$\bar{u} = \frac{u_{max}}{2} = 1 \text{ m/s}$$
$$u = -\frac{1}{4\mu}\frac{dP}{dx}\left(R^2 - r^2\right)$$
$$u = U_{max}\left(1 - \left(\frac{r}{R}\right)^2\right)$$
$$\frac{\bar{u}}{U_{max}} = 1 - \left(\frac{r}{R}\right)^2$$
$$\left(\frac{r}{R}\right)^2 = \sqrt{0.5} = 0.707$$
$$r = 125 \times 0.707 = 88.388 \text{ mm}$$

5. **(a)**

Velocity profile is given by $\frac{u}{V} = \left(\frac{y}{\delta}\right)^{\frac{1}{7}}$

Shear stress for this velocity profile can be found out as,

$$\tau = \frac{\rho U^2}{2} \times \frac{0.0576}{(\mathrm{Re}_x)^{1/5}}$$
$$\tau \propto \frac{1}{x^{0.2}}$$
$$\frac{\tau_1}{\tau_2} = \left(\frac{x_2}{x_1}\right)^{0.2} = (5)^{0.2} = 1.379$$

6. **(c)**

7. **(c)**

$$\tau = \tau_0 \frac{r}{R}$$
$$= 30 \times \frac{40}{45} = 26.67 \text{ Pa}$$

8. (c)

$$w_z = \frac{1}{2}\left[\frac{dv}{dx} - \frac{du}{dy}\right]$$

$$w_z = \frac{1}{2}(2x - 2y) = x - y$$

$$= 4 - 5 = -1 \text{ rad/s}$$

9. (c)

$$\text{Lift force, } F_L = C_L \frac{1}{2}\rho A U^2$$

Should be equal to weight of wing

$$U = 300 \text{ km/hr} = \frac{300 \times 1000}{60 \times 60} = \frac{1000}{12}$$

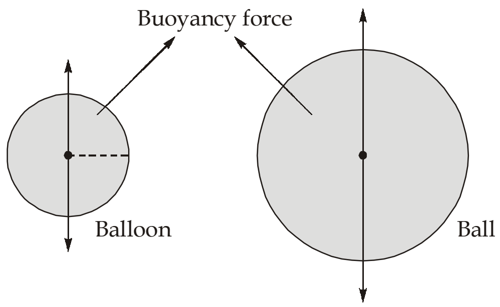
$$110 = C_L \times \frac{1}{2} \times 1.2 \times 16 \times 2.5 \times \left(\frac{1000}{12}\right)^2$$

$$C_L = 0.66$$

10. (a)

11. (b)

Buoyancy force is greater in ball than balloon because buoyancy force depends on the only volume of object and density of fluid.



$$F_B = V \times \rho_{air} \times g$$

$$F_B \propto V$$

and $$V_{ball} > V_{balloon}$$

12. (b)

Since flow is ideal and irrotational Bernoulli's equation can be applied between any two points inside the fluid.

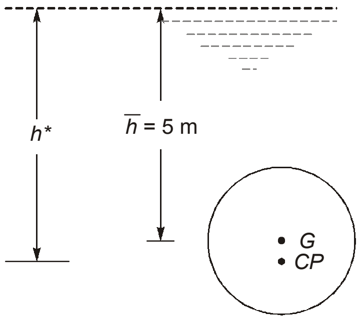
13. (a)

14. (c)

The meniscus of fluid the pressure force is partially balanced by surfaced tension force, so pressure at point (1) is decreased from atmospheric pressure. Since at point (2) pressure is equal to atmospheric pressure. So at point (3) pressure will be intermediate and less than atmospheric pressure. Hole created will cause the high pressure air to rush in the tube.

15. (a)

$$d = 3 \text{ m}$$
$$\bar{h} = 5 \text{ m}$$



$$A = \frac{\pi}{4}d^2 = \frac{3.14}{4}\times(3)^2 = 7.065 \text{ m}^2$$
$$I_G = \frac{\pi}{64}d^4 = \frac{3.14}{64}\times(3)^4 = 3.97 \text{ m}^4$$
$$h^* = \bar{h} + \frac{I_G}{A\bar{h}} = 5 + \frac{3.97}{7.065\times 5} = \mathbf{5.112 \text{ m}}$$

16. (a)

Applying Bernoulli's equation between points 1 and 2

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

where $\frac{p_1}{\rho g} = 50 \text{ m}$

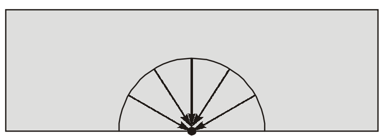
$$V_1 = 5 \text{ m/s}$$
$$z_1 = z_2$$
$$V_2 = 0$$

$\therefore$ $$50 + \frac{(5)^2}{2\times 9.81} = \frac{p_2}{1030\times 9.81}$$

or $p_2 = 518090 \text{ Pa} = 518.09 \text{ kPa}$

17. (c)

Consider the radial velocity



$$V_r = \left(\frac{Q}{A_r}\right) \qquad \text{(Area of hemisphere is } A_r = 2\pi r^2\text{)}$$
$$a_r = V_r\frac{\partial V_r}{\partial r} = \left(\frac{Q}{2\pi r^2}\right)\left(\frac{Q}{2\pi}\times\left(\frac{-2}{r^3}\right)\right) \Rightarrow -\frac{Q^2}{2\pi^2 r^5}$$
$$= \frac{-(2\times 10^{-3})^2}{2\pi^2\times(0.1)^5} = -0.02026 \text{ m/s}^2$$
$$= -20.26 \text{ mm/s}^2 \qquad \text{[-ve sign means flow is inside]}$$

18. (c)

19. (c)

$$u = U\left(\frac{y}{9x} - \frac{y^2}{81x^2}\right)$$

From 2-dimensional continuity equation,

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial}{\partial x}\left[U\left\{\frac{y}{9x} - \frac{y^2}{81x^2}\right\}\right] = -\frac{\partial v}{\partial y}$$

$$U\left\{\frac{y}{9}\frac{(-1)}{x^2} - \frac{y^2}{81}\frac{(-2)}{x^3}\right\} = -\frac{\partial v}{\partial y}$$

$$\frac{\partial v}{\partial y} = -U\left(\frac{2y^2}{81x^3} - \frac{y}{9x^2}\right)$$

$$v = -U\left\{\frac{2y^3}{243x^2} - \frac{y^2}{18x^2}\right\} + f(x)$$

at $y = 0$, $v = 0$; so, $f(x) = 0$

$$v = U\left(\frac{y^2}{18x^2} - \frac{2y^3}{243x^3}\right)$$

20. (b)

$$r = Ae^{-0.0009x}$$

$\therefore$ $$\text{Re} = \frac{\rho VD}{\mu}$$

or, $$\text{Re} \propto VD$$

$$\text{Re} \propto \left(\frac{Q}{R}\right)$$

Since discharge will be constant in the pipeline.

$$\frac{\text{Re}_1}{\text{Re}_2} = \frac{\text{R}_2}{\text{R}_1}$$

at $x = 0$, $R_1 = A$

at $x = 2 \times 10^3$ mm, $R_2 = Ae^{-0.0009 \times 2000}$

$$\frac{\text{Re}_1}{\text{Re}_2} = \frac{Ae^{-1.8}}{A}$$

or, $$\frac{\text{Re}_2}{\text{Re}_1} = e^{1.8}$$

$$= 6.05 \approx 6$$

21. (a)

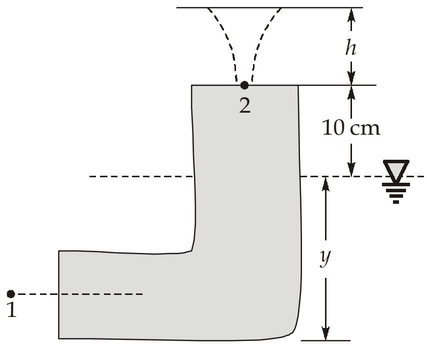
When the bent is sealed at point 2, i.e. no orifice, so applying Bernoulli's equation between (1) and (2)

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

$$y+\frac{5^2}{2\times 9.81}+0 = \frac{P_2}{\rho g}+0+(0.1+y)$$

$$\frac{P_2}{\rho g} = \frac{5^2}{2\times 9.81}=0.1$$

$$\frac{P_2}{\rho g} = 1.174 \text{ m}$$



When a small hole (orifice) is made at point 2 this excess pressure height will cause to spurt the water upto height h = 1.174 m.

22. (d)

Natural frequency is given by

$$\omega_n = \sqrt{\frac{GM\times g}{k_{min}^2}} \qquad GM = \frac{I}{\forall}-BG$$

$$I = \frac{bh^3}{12}=Ak_{min}^2$$

$$\frac{10\times 10^3}{12} = 10\times 10\times {k_{min}}^2$$

$$k_{min} = 2.887 \text{ cm}$$

$$\forall = 6\times 10\times 10 = 600 \text{ cm}^3$$

$$GM = \frac{10^2\times 2.887^2}{600}-(5-3) = -0.611 \text{ cm}$$

Since metacentric height is –ve i.e. body will not oscillate at all, it will just turn in the direction of applied moment. Body oscillates only when it is in stable equilibrium.

23. (a)

Given: r_2 = 300 mm, r_1 = 250 mm

For laminar flow in the annular space between two pipes, maximum velocity occurs at a radius (r),

$$r = \sqrt{\frac{r_2^2-r_1^2}{2\ln\left(\frac{r_2}{r_1}\right)}}$$

$$\Rightarrow \qquad r = \sqrt{\frac{(300)^2-(250)^2}{2\ln\left(\frac{300}{250}\right)}}$$

$$r = 274.62 \text{ mm}$$

24. (b)

$$\frac{u}{V_\infty} = \left(\frac{y}{\delta}\right)^{1/7},$$

$$V_\infty = 2 \text{ m/s}, \qquad \nu = 10^{-6} \text{ m}^2\text{/s}, l = 1.2 \text{ m}$$

$$\text{Re} = \frac{\rho V_\infty L}{\mu} = \frac{V_\infty L}{v} \Rightarrow \frac{2 \times 1.2}{10^{-6}} = 2.4 \times 10^6$$

Flow is turbulent.

Here, $\tau_w = \mu \left.\frac{du}{dy}\right|_{y=0}$ can't be applied because this velocity profile is invalid near the solid boundary.

Using approximated empirical formula

$$C_{fx} = \frac{\tau_\omega}{\frac{1}{2}\rho V_\infty^2} = \frac{0.0594}{\text{Re}^{1/5}}$$

$$\tau_\omega = \frac{0.0594}{(2.4 \times 10^6)^{1/5}} \times \frac{1}{2} \times 1000 \times 2^2 = 6.29 \text{ Pa}$$

25. (a)

$$\frac{P_{atm}}{\rho g} = 10.2 \text{ m of water or } \frac{10.2 \times 1}{0.85} = 12 \text{ m of oil}$$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} + Z_3 + 0 \qquad [P_1 = P_3 = P_{\text{atm}} = 0 \text{ (Gauge)}]$$

$$0 + 0 + 2 = 0 + \frac{V_3^2}{2g} + 0 + 0$$

$$\sqrt{2 \times 2 \times 9.81} = V_3$$

$$V_3 = 6.26 \text{ m/s} = V_2 \text{ [Incompressible fluid]}$$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + 0$$

$$0 + 0 + 2 = \frac{P_2}{\rho g} + \frac{6.26^2}{2 \times 9.81} + (2 + H) \qquad \text{... (i)}$$

In limiting case $P_2 = P_{\text{sat}}$ at 25°C

Now, $$P_{\text{sat}}@25° = \frac{15 - 10}{30 - 20} \times \{25 - 20\} + 10 = 12.5 \text{ kPa (abs)}$$

$$\frac{P_2}{\rho g} = \frac{12.5}{9.81 \times 0.85} \Rightarrow 1.5 \text{ m(abs)}$$

or, $$\frac{P_2}{\rho g} = 1.5 - 12 \text{ m (gauge)} = -10.5 \text{ m (gauge)}$$

From equation (i) $$2 = -10.5 + \frac{6.26^2}{19.62} + 2 + H$$

or $$H_{\text{max}} = 8.5 \text{ meter}$$

26. **(a)**

Bernoulli's equation for isentropic process.

$$\frac{\gamma}{\gamma-1}\left(\frac{P_1}{\rho_1 g}\right)+\frac{V_1^2}{2g}+Z_1 = \frac{\gamma}{\gamma-1}\left(\frac{P_2}{\rho_2 g}\right)+\frac{V_2^2}{2g}+Z_2$$

$$P_1 v_1^{\gamma} = P_2 v_2^{\gamma}$$

$$400 \times 0.725^{1.4} = 150 \times v_2^{1.4}$$

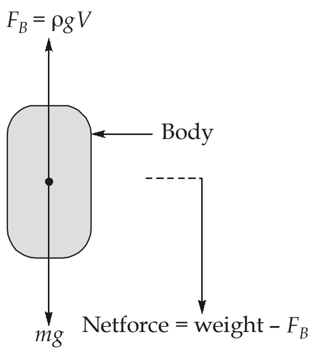
$$v_2 = 1.461 \text{ m}^3/\text{kg}$$

$$\frac{1.4}{0.4}\left(\frac{400\times 0.725}{9.81}\right)+\frac{20^2}{19.62}+0 = \frac{1.4}{0.4}\left(\frac{150\times 1.461}{9.81}\right)+\frac{V_2^2}{19.62}+20$$

$$V_2^2 = 503.55$$

$$V_2 = 22.44 \text{ m/s}$$

27. **(b)**

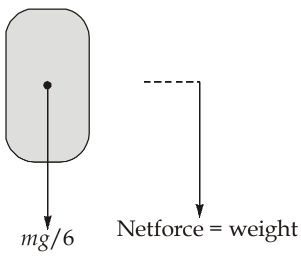


On earth

$$mg - \rho g V = 700 \qquad \text{... (i)}$$

$$mg = 700 + 1.1 \times 9.81 \times 1.2$$

$$= 712.95 \text{ N}$$

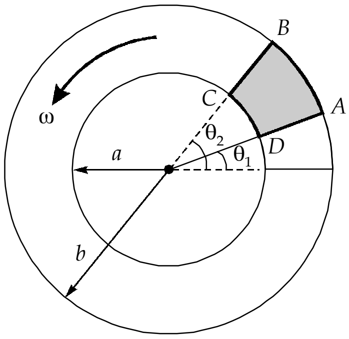


On moon no buoyancy because no air

$$\frac{mg}{6} = \text{Weight on moon}$$

$$\text{Weight on moon} = 118.82 \text{ N}$$

28. **(b)**



$$\Gamma = \oint_{ABCD} V.ds$$

$$= \int_{AB} V_\theta\, b d\theta + \int_{BC} V_r\, dr + \int_{BC} V_\theta\, a d\theta + \int_{DA} V_r dr$$

Since, $V_r = 0$, and $V_\theta = r\omega$

$$= \int_{\theta_1}^{\theta_2} (\omega b) b d\theta + 0 + \int_{\theta_2}^{\theta_1} (\omega a) a d\theta + 0$$

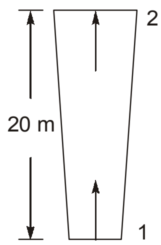
$$= \omega b^2 (\theta_2 - \theta_1) + \omega a^2 (\theta_1 - \theta_2)$$

$$r = \omega(\theta_2 - \theta_1)(b^2 - a^2) = \omega \Delta\theta (b^2 - a^2)$$

29. (a)

30. (c)

$$u = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20} = 19.81 \text{ m/s}$$



$$v^2 - u^2 = 2as$$

$$v^2 - 19.81^2 = -2 \times 9.81 \times 10$$

or $$v = 14 \text{ m/s}$$

$$A_1 v_1 = A_2 v_2$$

$$D_2^2 = \frac{12^2 \times 19.81}{14}$$

or $$D_2 = \mathbf{14.27 \text{ cm}}$$

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