CLASS TEST

SL. : 01 JP_ME_29062024

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MECHANICAL ENGINEERING

FLUID MECHANICS

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

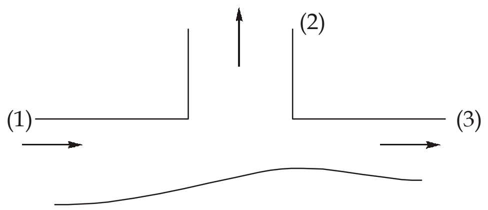
DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q. No. 1 to Q. No. 10 carry 1 mark each

Q.1 If the velocity field is $\vec{V} = xy^2\,\hat{i} + 4xy\,\hat{j}$ m/s, then what is the vorticity of the fluid element in field at point (1, 2)?
(a) $2s^{-1}$ (b) $3s^{-1}$
(c) $4s^{-1}$ (d) $8s^{-1}$

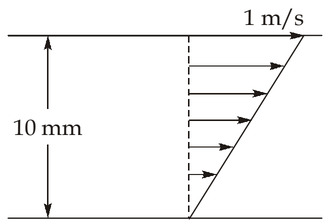
Q.2 A parallelopiped of (2 m × 2 m) square cross-section and 10 m in length, is partially floating in water upto a depth of 1 m, with its longest side being horizontal. The specific gravity, of the block is
(a) 0.8 (b) 0.6
(c) 0.5 (d) 0.4

Q.3 A pipeline system carries crude oil of density 800 kg/m^3. The flow rate at point 1 is 0.3 m^3/s. The cross-sectional areas of the branches 1, 2 and 3 are 0.012, 0.008 and 0.004 m^2 respectively.



If the velocity at point 3 is twice the velocity at point 2 then what is the discharge at point 3?
(a) 0.3 m^3/s (b) 0.2 m^3/s
(c) 0.1 m^3/s (d) 0.15 m^3/s

Q.4 In the parallel plate configuration shown, steady flow of an incompressible Newtonian fluid is established by moving the top plate with a constant speed of 1 m/s. If the force required on the top plate to support this motion is 0.5 N per unit area (in m^2) of the plate then the viscosity of the fluid between the plates is $P \times 10^{-3}$ N-s/m^2. What is the value of P?



(a) 2 (b) 4
(c) 7 (d) 5

Q.5 The Piezometric head in a static liquid
(a) Increases linearly with depth below a free surface.
(b) Decreases linearly with depth below a free surface.
(c) Remains constant only in the horizontal plane.
(d) Remains constant at all points in the liquid.

Q.6 Which one of the following is correct regarding the boundary layer thickness for flow over a flat plate?
(a) it increases with an increase in the free stream velocity.
(b) it decreases with an increase in the free stream velocity.
(c) it does not depend upon the kinematic viscosity.
(d) it decreases with an increase in the kinematic viscosity.

Q.7 A 200 mm diameter nozzle forms venacontracta of diameter 180 mm. If the coefficient of velocity is 0.95, then the coefficient of discharge for nozzle will be
(a) 0.710 (b) 0.743
(c) 0.769 (d) 0.786

Q.8 The average velocity of a one dimensional incompressible fully developed viscous flow in pipe is 2 m/s. The maximum velocity of the flow is
(a) 1.5 m/s (b) 2.5 m/s
(c) 4 m/s (d) 5.2 m/s

Q.9 Navier stokes equation is useful in the analysis of
(a) Non-viscous flows
(b) turbulent flow
(c) viscous flows
(d) both viscous and turbulent flows

Q.10 The nature of velocity profile within the laminar viscous sublayer in a turbulent pipe flow is
(a) Linear (b) Parabolic
(c) Logarithmic (d) Exponential

Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 For 3D flow field, the components of rotation at Point (1, 2, 3) will be

$$V = (x^2 + y^2)\hat{i} + (y^2 + z^2)\hat{j} + (x^2 + z^2)\hat{k}$$

(a) $\omega_x = 3\text{ rad/s}, \omega_y = 1\text{ rad/s}, \omega_z = -1\text{ rad/s}$

(b) $\omega_x = -3\text{ rad/s}, \omega_y = -1\text{ rad/s}, \omega_z = -2\text{ rad/s}$

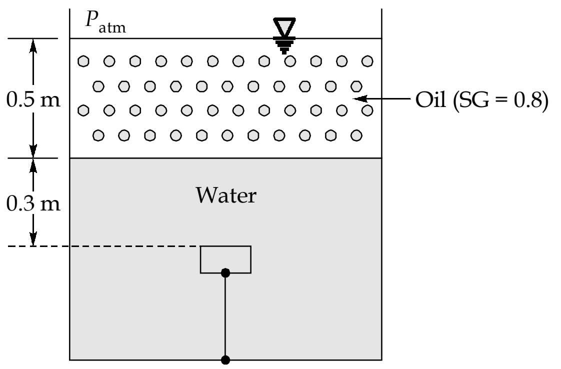
(c) $\omega_x = -3\text{ rad/s}, \omega_y = 1\text{ rad/s}, \omega_z = -2\text{ rad/s}$

(d) $\omega_x = -3\text{ rad/s}, \omega_y = 2\text{ rad/s}, \omega_z = -2\text{ rad/s}$

Q.12 Two pipelines of equal length and diameter of 20 cm and 30 cm are connected in parallel between two reservoirs. If the friction factor (f) is the same for both the pipes, the ratio of discharge in the smaller to the larger size of the pipe is______.

(a) 0.24 (b) 0.72
(c) 0.45 (d) 0.36

Q.13 A 125 ml cube of solid oak is held submerged by a tether as shown. What will be the actual force of water on the bottom surface of the cube? [P_{atm} = 101 kPa]



(a) 263.66 N (b) 270.89 N
(c) 267.74 N (d) 243.67 N

Q.14 A flow in a 2 cm diameter pipe is taking place, the kinematic viscosity of water is 0.0098 stroke. What is boundary shear stress, at the largest distance for which the flow will be laminar?

(a) 0.0384 Pa (b) 0.384 kPa
(c) 3.84 Pa (d) 4.2 Pa

Q.15 In a U-tube manometer, inclined leg 'S' inclination changed from 30° to 60°. Percentage change in the sensitivity of inclined U-tube manometer will be

(a) 43.96% (b) 42.26%
(c) 44.0% (d) 46.1%

Q.16 The velocity field in a two-dimensional, unsteady flow is given by $\vec{V} = 2xy^2\,\hat{i} + 3xyt\,\hat{j}$ m/s. The magnitude of acceleration of a fluid particle located at x = 1 m and y = 1 m at time t = 1 second is

(a) 16.1 m/s^2 (b) 18.1 m/s^2
(c) 24.1 m/s^2 (d) 34.1 m/s^2

Q.17 Water flows through a pipe having an inner radius of 10 mm at the rate of 72 kg/hr at 25°C. The viscosity of water at 25°C is 0.002 kg/ms. The Reynolds number of the flow is _______.

(a) 636.62 (b) 534.68
(c) 2025.43 (d) 5544.25

Q.18 Water at 20°C flows between two large parallel plates which are 2 mm apart. If the maximum velocity is 1.5 m/s, then the magnitude of wall shear stress (τ_w) is [Assume viscosity of water at 20°C as 0.001 Pa.s]

(a) 4 Pa (b) 2 Pa
(c) 3 Pa (d) 7 Pa

Q.19 The workdone in blowing a soap bubble of diameter 14 cm, if the surface tension of soap solution is 0.05 N/m, will be

(a) 0.616 Nm
(b) 4.11×10^{-3} Nm
(c) 6.16×10^{-3} Nm
(d) 8.51 Nm

Q.20 A semicircular plate of radius 1 m is immersed in water vertically such that its base lies downwards at a depth of 4 m. The depth of centre of gravity from the free water surface will be

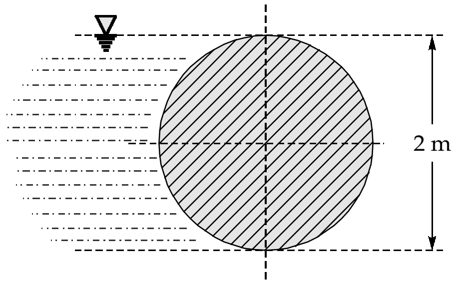
(a) 0.424 m (b) 4.424 m
(c) 3.576 m (d) 4.576 m

Q.21 Which one of the following set of velocity components satisfies the continuity equation?
(a) $u = 4xy + y^2, v = 6xy + 3x$
(b) $u = -cxy, v = cxy$
(c) $u = -\frac{x}{(x^2+y^2)}, v = \frac{-y}{(x^2+y^2)}$
(d) $u = A\sin xy, v = -A\sin xy$

Q.22 Consider the following statements.
1. A velocity potential function exists only for irrotational flow.
2. The velocity potential provides an alternative means of expressing velocity components.
3. Velocity potential is a vector function similar to stream function.
4. Velocity potential does not exist at stagnation points.

Which of the above statements are correct?
(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4

Q.23 A cylindrical gate of 2 m diameter holds water on one side as shown in figure. The resultant vertical component of force of water per metre width of gate, by taking $\gamma = 10$ kN/m^3 for water, is

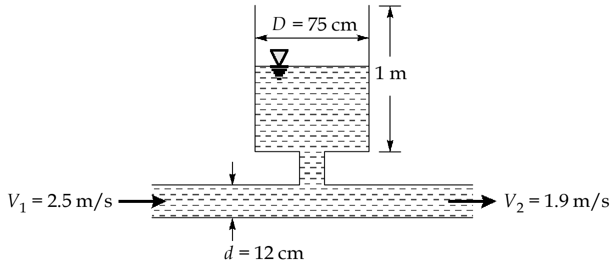


(a) zero (b) 15.71 kN/m
(c) 20 kN/m (d) 31.42 kN/m

Q.24 In the model of a highway bridge constructed to a scale of 1 : 25, the force of water on the pier was measured to be 0.5 kg. The force on the prototype pier will be
(a) 7916.5 kg (b) 7812.5 kg
(c) 7622. kg (d) 7501.5 kg

Q.25 In an air flow, the velocity is measured by a Pitot tube. The mass density of air can be taken as 1.2 kg/m^3. If the head difference in a vertical U-tube holding water is 12 mm, what is the velocity of air?
(a) 10 m/s (b) 14 m/s
(c) 17 m/s (d) 20 m/s

Q.26 The pipe flow shown in the figure fills a cylindrical surge tank as shown. At time t = 0, the water depth in the tank is 30 cm, the time required to fill the remaining tank is



(a) 34.24 sec (b) 45.57 sec
(c) 27.32 sec (d) 55.55 sec

Q.27 The minor loss in a sudden expansion from 6 cm diameter pipe to 12 cm diameter pipe in terms of V_1 is
(a) $\frac{15}{16}\left(\frac{V_1^2}{2g}\right)$ (b) $\frac{3}{4}\left(\frac{V_1^2}{2g}\right)$
(c) $\frac{9}{16}\left(\frac{V_1^2}{2g}\right)$ (d) $\frac{1}{4}\left(\frac{V_1^2}{2g}\right)$

Q.28 Air blows over a cylinder of 5 cm diameter with velocity of 0.2 m/sec. If length of cylinder is 1 m and total and shear drag coefficient are 1.25 and 0.18 respectively. Pressure drag at cylinder will be [ρ_{air} = 1.2 kg/m^3]
(a) 1.5×10^{-3} N (b) 0.216×10^{-3} N
(c) 1.7×10^{-3} N (d) 1.284×10^{-3} N

Q.29 What will be the density of box which weighs 500 N in air and 200 N in water? (Assume ρ_{air} = 1 kg/m^3)
(a) 1690 kg/m^3 (b) 1680 kg/m^3
(c) 1666 kg/m^3 (d) 1650 kg/m^3

Q.30 Pressure in a point in a Hg column is 6.8 N/cm^2. What is the corresponding height of water column?
(a) 8.0 m (b) 7.5 m
(c) 6.10 m (d) 6.93 m

■■■■

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FLUID MECHANICS

MECHANICAL ENGINEERING

Date of Test : 29/06/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Vorticity, $$\Omega = 2\omega_z = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) = \frac{\partial}{\partial x}(4xy) - \frac{\partial}{\partial y}(xy^2)$$

$$\Omega = 4y - 2xy$$

At (1, 2), $$\Omega_{(1,2)} = 4 \times 2 - 2 \times 1 \times 2 = 8 - 4 = 4\text{s}^{-1}$$

2. (c)

For floating bodies, $W = F_B \Rightarrow \rho_s . V . g = \rho_w . \not{v} . g$

$$(\text{SG}) \times 1000 \times (2 \times 2 \times 10)g = 1000 \times 2 \times 1 \times 10 \times g$$

$$\text{SG} = \frac{1}{2} = 0.5$$

3. (d)

Continuity equation, $Q_1 = Q_2 + Q_3$

Now, $Q_2 = A_2V_2 = 0.008V_2$

$Q_3 = A_3V_3 = 0.004V_3 = 0.004 \times 2V_2$ [Given, $V_3 = 2V_2$]

$= 0.008V_2$

Now, $Q_2 = Q_3$

∴ Discharge at point 3, $Q_3 = \frac{Q_1}{2} = \frac{0.3}{2} = 0.15\ \text{m}^3/\text{s}$

4. (d)

By Newton's law of viscosity,

$$\tau = \mu \frac{du}{dy}$$

$$0.5 = \mu \times \frac{1-0}{(0.010-0)}$$

$$\mu = 0.005 = 5 \times 10^{-3}\ \text{Ns/m}^2.$$

5. (d)

Total energy of a flowing fluid can be represented in terms of head which is given by $\left(\frac{P}{\rho g} + \frac{V^2}{2g} + Z = \text{Constant}\right)$.

Piezometric head is the sum of pressure head and datum head and it is given by $\left(\frac{P}{\rho g} + Z\right)$.

The pressure at any point in a static fluid is obtained by hydrostatic law which is given by $P = -\rho g h$, where h is the height of the point from the free surface. As we go down h is negative so the pressure gets increased and datum gets decreased.

Therefore, Piezometric head remains constant at all points in the liquid.

6. (b)

As for laminar flow,

Boundary layer thickness $(\delta) \propto \frac{1}{\sqrt{\text{Re}}}$

As the free stream, Speed ↑↑, δ↓↓ $\because \text{Re} = \frac{\rho VD}{\mu}$

For turbulent flow,

Boundary layer thickness $(\delta) \propto \frac{1}{(\text{Re})^{1/5}}$

As the free stream velocity ↑↑, δ↓↓ and it also depending on the kinematic viscosity δ↑↑ as kinematic viscosity (ν) ↑.

7. (c)

We know,
$$C_d = C_C \times C_V$$
$$= 0.95 \times \left[\frac{0.180}{0.200}\right]^2 = 0.7695$$

8. (c)

As we know, the average velocity in fully developed laminar pipe flow is
$$V_{avg} = \frac{1}{2} V_{max}$$
$$V_{max} = 2V_{avg} = 2 \times 2 = 4.0 \text{ m/s}$$

9. (c)

10. (a)

11. (b)

We have, $u = x^2 + y^2, v = y^2 + z^2, \omega = x^2 + z^2$

then, in x-direction,
$$\omega_x = \frac{1}{2}\left[\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right]$$
$$= \frac{1}{2}[0 - 2z] = -3 \text{ rad/s}$$

y-direction,
$$\omega_y = -\frac{1}{2}\left[\frac{\partial w}{\partial x} - \frac{\partial u}{\partial z}\right]$$
$$= -\frac{1}{2}[2x - 0] = -1 \text{ rad/s}$$

z-direction,
$$\omega_z = \frac{1}{2}\left[\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right]$$
$$= \frac{1}{2}[0 - 2y] = -2 \text{ rad/s}$$

12. (d)

In parallel pipe head loss is equal,

$$\therefore \qquad h_{f1} = h_{f2}$$

$$h = \frac{fLv^2}{2gD} = \frac{fLQ^2}{\left(\frac{\pi}{4}d^2\right)^2 \times 2gD}$$

$$\Rightarrow \qquad h \propto \frac{Q^2}{D^5}$$

$$\Rightarrow \qquad \left(\frac{Q^2}{D^5}\right)_{\text{small}} = \left(\frac{Q^2}{D^5}\right)_{\text{large}}$$

$$\Rightarrow \qquad \frac{Q_S}{Q_L} = \left(\frac{D_S}{D_L}\right)^{5/2} = \left(\frac{20}{30}\right)^{2.5} = 0.36$$

13. (b)

Volume of the cube, $V = 125$ mL

$$a^3 = 125 \times 10^{-3} \times 10^{-3} \text{ m}^3$$

$$a = 0.05 \text{ m}$$

Pressure at bottom surface,

$$P_{\text{bottom}} = P_{\text{atm}} + (\rho g h)_{\text{oil}} + [\rho g(h + a)]_{\text{water}}$$

$$= 101 \times 10^3 + (800 \times 9.81 \times 0.5) + [1000 \times 9.81 \times (0.3 + 0.05)]$$

$$P_{\text{bottom}} = 108357.5 \text{ Pa}$$

$$F_{\text{bottom}} = P_{\text{bottom}} \times A$$

$$= 108357.5 \times 0.05^2 = 270.89 \text{ N}$$

14. (a)

At largest distance, we have

$$(\text{Re})_{\text{critical}} = 2000 = \frac{VD}{\nu}$$

$$\Rightarrow \qquad V = \frac{2000 \times 0.0098 \times 10^{-4}}{0.02} = 0.098 \text{ m/s}$$

Now, $$f = \frac{64}{\text{Re}} = \frac{64}{2000} = 0.032$$

$\therefore$ Shear velocity, $$u^* = V\sqrt{\frac{f}{8}} = 0.098 \times \sqrt{\frac{0.032}{8}} = 6.198 \times 10^{-3} \text{ m/s}$$

$$\tau_{\text{wall}} = \rho u^{*2} = 1000 \times (6.198 \times 10^{-3})^2 = 0.0384 \text{ Pa}$$

15. (b)

Sensitivity of inclined tube, $S \propto \dfrac{1}{\sin\theta}$

$$S_1 = \frac{k}{\sin 30^\circ} = \frac{k}{\left(\frac{1}{2}\right)} = 2k$$

$$S_2 = \frac{k}{\sin 60°} = \frac{k}{\left(\frac{\sqrt{3}}{2}\right)} = 1.1547$$

$$\% \text{ change} = \frac{|(S_2 - S_1)|}{S_1} \times 100 = \frac{|1.1547 - 2|}{2} \times 100\% = 42.26\%$$

16. (c)

Given: $u = 2xy^2$, $v = 3\,xyt$

$$a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + \frac{\partial u}{\partial t} = 2xy^2 \times 2y^2 + 3xyt \times 4xy + 0$$

At (1, 1) and t = 1s, $\quad a_x = 2 \times 2 + 12 = 16 \text{ m/s}^2$

$$a_y = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + \frac{\partial v}{\partial t} = 2xy^2 \times 3yt + 3xyt \times 3xt + 3xy$$

At (1, 1) and t = 1s, $\quad a_y = 6 + 9 + 3 = 18 \text{ m/s}^2$

$$a = \sqrt{a_x^2 + a_y^2} = \sqrt{16^2 + 18^2} = 24.08 \text{ m/s}^2 \simeq 24.1 \text{ m/s}^2$$

17. (a)

Radius: $\quad r = 10$ mm

∴ Diameter: $\quad d = 2r = 2 \times 10 = 20$ mm $= 0.02$ m

$$m = 72 \text{ kg/hr} = \frac{72}{3600} = 0.02 \text{ kg/s}$$

$$\mu = 0.002 \text{ kg/ms}$$

$$\text{Reynolds number: Re} = \frac{\rho V d}{\mu}$$

From continuity equation, $m = \rho A V$

or $$V = \frac{m}{\rho A} = \frac{m}{\frac{\rho \pi d^2}{4}} = \frac{4\text{m}}{\rho \pi d^2}$$

∴ $$\text{Re} = \frac{\rho d}{\mu} \times \frac{4\text{m}}{\rho \pi d^2} = \frac{4\text{m}}{\pi \mu d} = \frac{4 \times 0.02}{\pi \times 0.002 \times 0.02} = 636.62$$

18. (c)

$$u_{max} = 1.5 \text{ m/s}$$

$$\bar{u}_{avg} = \frac{2}{3} \times u_{max} = \frac{2}{3} \times 1.5 = 1 \text{ m/s}$$

$$\bar{u}_{avg} = -\frac{1}{12\mu}\left(\frac{\partial P}{\partial x}\right) B^2$$

$$\frac{\partial P}{\partial x} = \frac{1 \times 12 \times 0.001}{(0.002)^2} = -3000 \text{ N/m}^3$$

$$\text{Wall shear stress } (\tau_\omega) = \left(\frac{-\partial P}{\partial x}\right)\left(\frac{B}{2}\right)$$

$$= -(-3000)\left(\frac{0.002}{2}\right) = 3\ \text{N/m}^2$$

19. (c)

As the soap bubble have two interfaces, so total surface area = $4\pi R^2 \times 2$

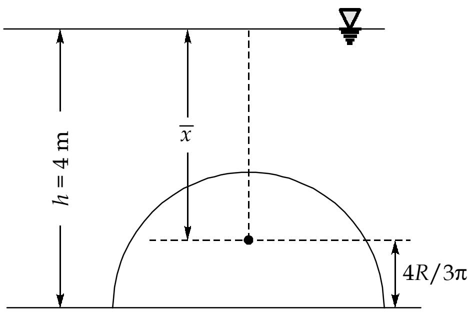
$$= 4\times\pi\times\left(\frac{0.14}{2}\right)^2 \times 2$$

and workdone = Surface tension × Total area increased

$$= 0.05\times\left[4\times\pi\times\left(\frac{0.14}{2}\right)^2\times 2 - 0\right] = 6.16\times 10^{-3}\ \text{Nm}$$

20. (c)

Refer figure,



Depth of centre of gravity,

$$\bar{x} = h - \frac{4R}{3\pi} = 4 - \frac{4\times 1}{3\times\frac{22}{7}} = 3.576\,\text{m}$$

21. (c)

As

In x-direction,
$$u = \frac{-x}{x^2+y^2}$$

$$\frac{\partial u}{\partial x} = \frac{-(x^2+y^2)+2x^2}{(x^2+y^2)^2} = \frac{x^2-y^2}{(x^2+y^2)^2}$$

and,

In y-direction,
$$v = \frac{-y}{x^2+y^2}$$

$$\frac{\partial v}{\partial y} = \frac{-(x^2+y^2)+2y^2}{(x^2+y^2)^2} = \frac{(y^2-x^2)}{(x^2+y^2)^2}$$

Continuity equation

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

22. (b)

A velocity potential is a scalar function used in potential flow theory.

23. (b)

$$F_v = \gamma \times \frac{1}{2} \times \frac{\pi D^2}{4} \times 1$$

$$F_v = 10 \times \frac{1}{2} \times \frac{\pi (2)^2}{4} \times 1 = 15.7 \text{ kN/m}$$

24. (b)

Froude model law is applicable here

$$\text{Force ratio, } F_r = \frac{F_m}{F_p} = \rho_r V_r^2 L_r^2$$

Since, $V_r = \sqrt{L_r}$

∴ $F_r = \rho_r L_r^3$

$$L_r = \frac{L_m}{L_p} = \frac{1}{25} \qquad (\because \rho_r = 1)$$

Thus, $F_p = \dfrac{F_m}{L_r^3} = 0.5 \times (25)^3 = 7812.5$ kg

25. (b)

Velocity of air in pitot tube is

$$V = c\sqrt{2gh}$$

$$h = x\left(\frac{S_m}{S} - 1\right) = 12 \times 10^{-3}\left(\frac{1}{1.2 \times 10^{-3}} - 1\right)$$

$$h = 9.988 \text{ m}$$

$$V = \sqrt{2 \times 9.81 \times 9.988} \simeq 14 \text{ m/s}$$

26. (b)

Conservation of mass,

$$\dot{m}_{in} - m_{out} = \left.\frac{d\dot{m}}{dt}\right|_{\text{tank}}$$

$$\Rightarrow \quad \rho A V_1 - \rho A V_2 = \rho \times \frac{\pi}{4} D^2 \times \frac{dh}{dt}$$

$$\Rightarrow \quad (0.12)^2 \times [2.5 - 1.9] = (0.75)^2 \times \frac{dh}{dt}$$

$$\Rightarrow \quad \frac{dh}{dt} = 0.01536 \text{ m/s}$$

So, time required to fill remaining tank,

$$t = \frac{1-0.3}{0.01536} s$$

$$\Rightarrow \quad t = 45.57 s$$

27. (c)

Minor due to sudden expansion from 6 cm diameter pipe to 12 cm is given by

$$(h_f)_{\text{expansion}} = \frac{V_1^2}{2g}\left[1 - \frac{A_1}{A_2}\right]^2$$

$$= \frac{V_1^2}{2g} \times \left[1 - \frac{d_1^2}{d_2^2}\right]^2 = \frac{V_1^2}{2g} \times \left(1 - \left(\frac{1}{2}\right)^2\right)^2 = \frac{9}{16}\left(\frac{V_1^2}{2g}\right)$$

28. (d)

$$\text{Projected area } (A_p) = l \times d$$
$$= 1 \times 0.05 = 0.05 \text{ m}^2$$

$$\text{Total drag, } F_D = C_d \times \frac{1}{2}\rho u_0^2 \times A_p$$

$$= 1.25 \times \left[\frac{1}{2} \times 1.2 \times 0.2^2\right] \times 0.05$$

$$= 1.5 \times 10^{-3} \text{ N}$$

$$\text{Shear drag} = 0.18 \times \left[\frac{1}{2} \times 1.2 \times 0.2^2\right] \times 0.05$$

$$= 0.216 \times 10^{-3} \text{ N}$$

$$\text{Total drag} = \text{Shear drag} + \text{Pressure drag}$$

$$1.5 \times 10^{-3} = 0.216 \times 10^{-3} + \text{Pressure drag}$$

$$\text{Pressure drag} = 1.284 \times 10^{-3} \text{ N}$$

29. (c)

For air,

$$500 = mg - \rho_{\text{air}} \times V \times g$$
$$= \rho_m \times v \times g - \rho_{air} \times V \times g$$
$$500 = (\rho_m - \rho_{air}) \times Vg \qquad \text{...(i)}$$
$$200 = (\rho_m - \rho_{water}) \times Vg \qquad \text{...(ii)}$$

From equation (i) and (ii), we get

$$\frac{500}{200} = \frac{(\rho_m - 1)}{(\rho_m - 1000)}$$

$$5\rho_m - 5000 = 2\rho_m - 2$$

$$\rho_m = \frac{4998}{3} = 1666 \text{ kg/m}^3$$

30. (d)

$$P = \rho_{\text{Hg}} \times g \times H$$
$$6.8 \times 10^4 = 13.6 \times 10^3 \times 9.81 \times H$$
$$H_{\text{Hg}} = 0.5096 \text{ m}$$

$$H_{\text{water}} = \frac{13.6}{1} \times 0.5096$$

$$H_{\text{water}} = 6.93 \text{ m}$$