PRACTICE QUESTIONS

for SSC-JE : CBT-2

Fluid Mechanics

Mechanical Engineering

02 Fluid Mechanics

Q.1 A battle ship weighs 240 MN. On filling the ship's boats on one side with water weighing 10 MN and its mean distance from the centre of the ship being 10 m. If the angle of displacement of the plumb line is 5.71°. Then the metacentric height is (take tan5.71° = 0.1)

(a) 2 m (b) 5 m
(c) 4 m (d) 3 m

Q.2 A vertical isoceles triangular gate with its vertex up has a base width of 2 m and a height of 1.5 m. If the vertex of the gate is 1 m below the free water surface, then the position of centre of pressure on one side of the plate is

(a) 2.0625 m (b) 2.502 m
(c) 2.125 m (d) 2.10 m

Q.3 Consider the following statements:

1. In Lagrangian approach, the position and velocity of a particle are functions of time even though the flow is steady.
2. In steady flow, the streamlines shapes do not vary from one instant to the next.

Which of the above statements are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of the above

Q.4 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I

A. Existence of stream function
B. Existence of velocity potential
C. Flow through a non-uniform dia pipe.
D. Absence of temporal variations

List-II

1. Non-uniform flow
2. Irrotational flow
3. Continuity of flow
4. Steady flow

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	2	1	4
(c)	2	1	3	4
(d)	4	1	2	3

Q.5 A right circular cylinder, opens at the top is filled with liquid of sp. gravity 1.2 and rotated about its vertical axis at such speed that half of the liquid spills out. The pressure at the centre of the bottom is

(a) zero
(b) one-fourth its value when cylinder was full
(c) one-half its value when cylinder was full
(d) same as before rotation

Q.6 In an experiment, the following shear stress and time rate of shear strain values are obtained for a fluid:

Time rate of shear strain$(1/s)$:	0	2	3	4
Shear stress(kPa)	1	3	4.4	6.3

How can the fluid be classified.

(a) Thixotropic (b) Dilatant
(c) Pseudo plastic (d) Rheopectic

Q.7 The continuity equation for an incompressible flow in the cylindrical coordinates is

(a) $\frac{\partial(rU_r)}{\partial r}+\frac{\partial(U_\theta)}{r\partial\theta}+\frac{\partial(U_z)}{\partial z}=0$

(b) $\frac{1}{r}\frac{\partial(U_r)}{\partial r}+\frac{\partial(U_\theta)}{r\partial\theta}+\frac{\partial(U_z)}{\partial z}=0$

(c) $\frac{r\partial(U_r)}{\partial r}+\frac{\partial(U_\theta)}{r\partial\theta}+\frac{\partial(U_z)}{\partial z}=0$

(d) $\frac{1}{r}\frac{\partial(rU_r)}{\partial r}+\frac{1}{r}\frac{\partial(U_\theta)}{\partial\theta}+\frac{\partial(U_z)}{\partial z}=0$

Q.8 Which of the following expression is not a dimensionless parameter?

(a) $\frac{\tau_w}{\rho V^2}$ (b) $\frac{V^2}{gL}$

(c) $\frac{\rho V^2}{P}$ (d) $\frac{\rho L^2}{gV}$

where, τ_w = shear stress, ρ = density, V = velocity, P = pressure, g = acceleration due to gravity.

Q.9 A fluid is flowing through a pressurized pipe with the help of pump. The pumping power is P. When the discharge is doubled with all other parameters being same then the new pumping power required is (Assuming laminar flow)

(a) 4 P (b) 9 P

(c) 0.125 P (d) 0.166 P

Q.10 Which one of the following is true to a 3-dimensional irrotational flow of ideal fluids?

(a) Potential function exists if stream function exists

(b) Stream function exists if potential function exists

(c) Both stream function and potential function exists

(d) Stream function may not exists but potential function exists

Q.11 Which one of the following statement is correct regarding net positive suction head (NPSH) and required net positive suction head ($NPSH_{required}$)?

(a) NPSH is independent on the type of fluid whereas $NPSH_{required}$ depends on the type of fluid.

(b) NPSH and $NPSH_{required}$, both are independent on the type of fluid.

(c) NPSH is dependent on the type of fluid whereas $NPSH_{required}$ does not depend on the type of fluid.

(d) NPSH and $NPSH_{required}$, both are dependent on the type of fluid.

Q.12 A double overhung impulse turbine installation is to develop 3200×10^3 W at 400 rpm under a net head of 256 m. What will be the specific speed of the impulse turbine?

(a) 15.62 (b) 494.10

(c) 22.09 (d) 698.77

Q.13 The following are the design particular of a Kaplan turbine:

1. Head at the turbine inlet = 40 m.
2. Discharge = 120 m^3/s
3. Power developed = 30 MW

What will be the combined loss (guide blade losses + moving blade losses) in the Kaplan turbine, when mechanical efficiency is 90%?

(a) 12.55 MW (b) 13.75 MW

(c) 16.56 MW (d) 14.40 MW

Q.14 Consider the following statement(s) regarding the benefits of draft tube:

1. To enable the turbine to be set up at an elevation higher than the tail water level.
2. To utilize a major part of the kinetic energy of the water exiting the turbine.
3. Draft tube avoids flow separation at large angles also.

Select the correct statements using codes given below:

(a) 1 and 2 (b) 1 and 3

(c) 2 and 3 (d) 1, 2 and 3

Q.15 A liquid is compressed in a cylinder from a volume of 0.04 m^3 at 50 kg/cm^2 to a volume of 0.039 m^3 at 150 kg/cm^2. The bulk modulus of liquid is

(a) 400 kg/cm^2 (b) 4000 kg/cm^2

(c) 40×10^5 kg/cm^2 (d) 40×10^6 kg/cm^2

Q.16 For which of the following flow characteristics, both tangential and normal acceleration will be zero?

(a) Laminar flow with straight and intersecting stream lines.
(b) Laminar flow with straight and parallel stream lines.
(c) Steady flow with straight and intersecting stream lines.
(d) Steady flow with straight and parallel stream lines.

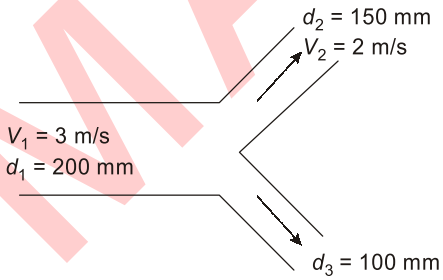
Q.17 A block weighing 3 kg in air was found to weigh 2.5 kg when submerged in water. Its specific gravity is

(a) 1 (b) 5
(c) 6 (d) 7

Q.18 The radial clearance between a 75 mm diameter shaft and its journal bearing is 0.80 mm, what is the shear stress induced in the lubricant if the shaft is rotating at 120 rpm? [Take, μ = 0.10 Ns/m]

(a) 28.7 Pa (b) 58.9 Pa
(c) 76.3 Pa (d) 103.2 Pa

Q.19 A 200 mm diameter pipe, conveying water, branches into two pipes of diameter 150 mm and 100 mm respectively. If the average velocities in the 200 mm diameter pipe and 150 mm diameter pipe are 3 m/s and 2 m/s respectively, what is the velocity in the 100 mm pipe?



(a) 3.15 m/s (b) 5 m/s
(c) 11.5 m/s (d) 7.5 m/s

Q.20 For the flow of a real liquid at constant rate with no addition of energy

(a) The energy line will be horizontal or sloping upward in the direction of flow.
(b) The energy line can never be horizontal or sloping upward in the direction of flow.
(c) The peizometric line can never be horizontal or sloping downward in the direction of flow.
(d) The centre line of the pipe can be above the energy line.

Q.21 Consider the following statement about various types of fluid acceleration in a flow:

1. The tangential acceleration is developed for a fluid particle when the magnitude of the velocity changes with respect to space and time.
2. Normal acceleration is developed when a fluid particles moves in a curved path along which the direction of the velocity is changing.

Which of the statements are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of these

Q.22 A velocity field is given by , $u = xy$ and $v = \frac{9}{2}\left(x^2 - y^2\right)$. What is the relevant equation of a streamline?

(a) $\frac{dy}{dx} = \frac{9}{2}\left(\frac{x}{y} - \frac{y}{x}\right)$ (b) $\frac{dx}{dy} = \frac{9}{2}\left(\frac{x}{y} - \frac{y}{x}\right)$

(c) $\frac{dy}{dx} = \frac{2}{9}\left(\frac{x}{y} - \frac{y}{x}\right)$ (d) $\frac{dx}{dy} = \frac{2}{9}\left(\frac{x}{y} - \frac{y}{x}\right)$

Q.23 A Francis turbine is coupled to an alternator to generate electricity with a frequency of 50 Hz. If the alternator has 12 poles, then the turbine should be regulated to run at which one of the following constant speeds?

(a) 250 rpm (b) 500 rpm
(c) 600 rpm (d) 1000 rpm

Q.24 Priming is necessary in

(a) centrifugal pumps to lift water from a greater depth.

(b) centrifugal pumps to remove air in the suction pipe and casing.
(c) hydraulic turbine to remove air in the suction turbine casing.
(d) hydraulic turbine to increase the speed to turbine and to generate more power.

Q.25 In Couette flow with, zero pressure gradient the shear stress τ_0 at the boundary is given by

(a) $\tau_0 = \frac{UB}{\mu}$ (b) $\tau_0 = \frac{\mu U}{B}$

(c) $\tau_0 = \frac{B}{\mu}$ (d) $\tau_0 = \frac{\mu B}{U}$

Where B = gap between the plates
U = velocity of moving upper plate

Q.26 Both Reynold's and Froude's number assume significate in one of the following examples
(a) Motion of submarine at large depths.
(b) Motion of ship in deep sea.
(c) Cruising of a missile in air.
(d) Flow over spillways.

Q.27 In using, Darcy-Weisbach equation for flow in a pipe, the friction factor is misjudged by +25%, the resulting error in estimated discharge Q is
(a) +25% (b) –10.56%
(c) –5% (d) –12.5%

Q.28 Consider the following statements:
1. Real fluids have lower viscosity than ideal fluids.
2. Cavitation occurs when pressure falls below vapour pressure.
3. Surface energy is responsible for surface tension.

Which of the statements is correct?
(a) 2 and 3 (b) 1 and 3
(c) 2 only (d) All of these

Q.29 If in an impulse turbine designed for free vortex flow, tangential velocity of steam at the root radius of 250 mm is 430 m/s and the blade height is 100 mm, then tangential velocity of steam at the tip will be
(a) 602 m/s (b) 504 m/s
(c) 409 m/s (d) 307 m/s

Q.30 Uniform flow in a channel is characterized by the following statement:
(a) Total energy remains constant along the channel.
(b) Gradient of total energy is parallel to the channel bed.
(c) Specific energy decreases along the channel.
(d) Total energy line either rises or fall depending upon the Froude number.

■■■■

Answer Keys

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

Detailed Solutions

1. (c)

$$GM = \frac{w\,x}{W\tan\theta}$$

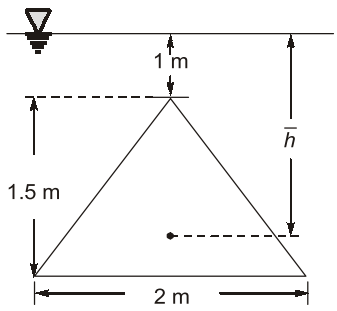
w = 10 MN

W = 240 + 10 = 250 MN

x = 10 m, θ = 5.71°

$$GM = \frac{10\times10}{250\times0.1} = 4\,\text{m}$$

2. (a)



We know that, $y_p = \bar{h} + \frac{I_{CG}}{A\bar{h}}$

Where, y_p = Position of centre of pressure

$\bar{h}$ = Depth of CG of traingular gate

A = Area of gate

I_{CG} = Moment of inertia about CG = $\frac{bh^3}{36}$

$$\bar{h} = 1+2\times\frac{1.5}{3} = 2\ \text{m}$$

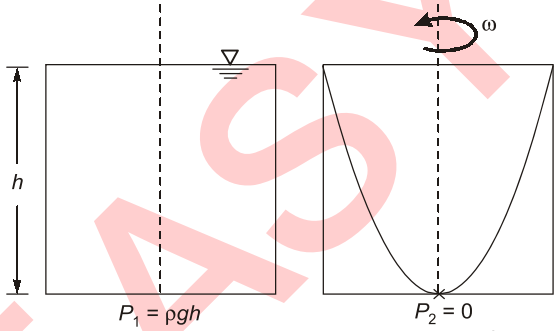
$$y_p = 2+\left(\frac{\frac{1}{36}\times2\times(1.5)^3}{\frac{1}{2}\times2\times(1.5)\times2}\right) = 2+\frac{(1.5)^2}{36}$$

= 2.0625 m

3. (c)

In Lagrangian method the fluid motion is described by tracing the kinematic behaviour of each and every individual particle consistituting the flow. Identities of the particles are made by specifying their initial postion at a given time. The position of particle at any instant of time then becomes a function of its identity and time. Thus time is inherent in this approach.

5. (a)



Value of parabolid = $1/2(\pi r^2 h)$

When halft of the liquid spilled out then at the cenre of vessel there will be no liquid. So no pressure at centre.

6. (d)

Given, $\tau_0 = 1$ at $\frac{du}{dy} = 0$

Slope, 1 = $\frac{3-1}{2-0} = 1$

Slope, 2 = $\frac{4.4-3}{3-2} = 1.4$

Slope, 3 = $\frac{6.3-4.4}{4-3} = 1.9$

So we can see that slope is increasing this fluid

is $\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)^n$ $\quad n > 1$

So, Rheopectic.

8. (d)

$$\frac{\rho L^2}{gV} = \frac{\frac{\text{kg}}{\text{m}^3}\times\text{m}^2}{\frac{\text{m}}{\text{s}^2}\times\frac{\text{m}}{\text{s}}} = \frac{\text{kgs}^3}{\text{m}^3}$$

9. (a)

Pumping power, (P) ∝ Pressure drop (ΔP) × Discharge (Q)

$$\propto \frac{128\mu QL}{\pi D^4} \times Q$$

$$P \propto Q^2$$

So, $P_2 = 4P_1$

11. (c)

- $\text{NPSH} = \left(\frac{P}{\rho g} + \frac{V^2}{2g}\right)_{\text{pump inlet}} - \left(\frac{P_V}{\rho g}\right)$

  From above equation ρ and P_v both depends on the type of fluid.
- Required net positive suction head ($\text{NPSH}_{\text{required}}$) is defined as the minimum NPSH necessary to avoid cavitation in the pump corresponding to the given volume flow rate. It varies with the volume flow rate but it does not depend on the type of fluid.

12. (a)

$$\text{Specific speed, } N_s = \frac{N\sqrt{P}}{(H)^{5/4}} \quad \ldots(1)$$

$$\text{Power per wheel} = \frac{P}{2} = \frac{3200}{2}(\text{kW}) = 1600 \text{ kW}$$

$$\text{From equation (1), } N_s = \frac{400 \times \sqrt{1600}}{(256)^{5/4}} = 15.62$$

13. (b)

$\eta_{\text{mech}} = 0.9$

$$\eta_{\text{mech}} = \frac{SP}{RP}$$

$$0.9 = \frac{30}{RP}$$

$$RP = \frac{30}{0.9}\text{MW} = 33.333 \text{ MW}$$

Now, Power supplied to the turbine inlet,

$P = \rho QgH = 10^3 \times 120 \times 9.81 \times 40$

$P = 47.088$ MW

Combined losses = $P - RP$ = 47.088 – 33.333 = 13.755 MW

14. (a)

Draft tube avoids flow separation only at small angle. So generally draft angle is 8° in draft tube.

15. (b)

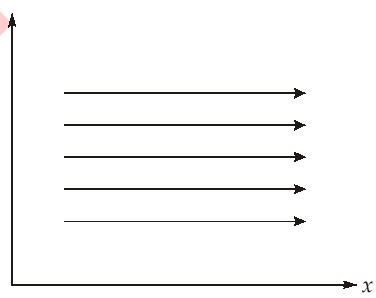
$$K = \frac{dP}{-\frac{dV}{V}}$$

$$K = \frac{50 - 150}{\frac{0.04 - 0.039}{0.04}} = 4000 \text{ kg/cm}^2$$

16. (d)

For a flow characteristics, both tangential and normal acceleration will be zero when there is no change in magnitude as well as direction of velocity w.r.t. time, space or both.

e.g. steady flow with straight and parallel stream lines.



17. (c)

$$(\rho_b - \rho_w) V_g = 2.5g$$

$$\rho_b \times \text{Volume} = 3$$

$$\Rightarrow \quad V = \frac{3}{\rho_b}$$

$$\Rightarrow \quad (\rho_b - \rho_w) \times \frac{3}{\rho_b} g = 2.5g$$

$$\Rightarrow \quad 3\rho_b - 3\rho_w = 2.5g$$

$$\frac{\rho_b}{\rho_w} = 6$$

18. (b)

$$u = \frac{\pi DN}{60} = \frac{\pi \times 75 \times 10^{-3} \times 120}{60} = 0.47 \text{ m/s}$$

$$\tau = \mu \frac{du}{dy} = 0.10 \times \frac{0.47}{0.8 \times 10^{-3}} = 58.9 \text{ Pa}$$

19. (d)

$$Q_1 = Q_2 + Q_3$$

$$\frac{\pi}{4}d_1^2V_1 = \frac{\pi}{4}d_2^2V_2 + \frac{\pi}{4}d_3^2V_3$$

$$d_1^2\,V_1 = d_2^2\,V_2 + d_2^2\,V_3$$

$$(0.2)^2 \times 3 = (0.15)^2 \times 2 + (0.1)^2 \times V_3$$

$$\Rightarrow \quad V_3 = 7.5 \text{ m/s}$$

21. (c)

- Tangential component arises if there is change in the magnitude of velocity with respect to time, space or both. It is tangential to stream line.
- Normal component arises when the direction of velocity changes w.r.t time, space or both. This happens when fluid is moving along a curved path. It is normal to stream line.

22. (a)

Equation of streamline, $\frac{dx}{dy} = \frac{u}{v} = \frac{xy}{\frac{9}{2}\left(x^2 - y^2\right)}$

$$\Rightarrow \frac{dx}{dy} = \frac{2}{9} \times \left(\frac{xy}{x^2 - y^2}\right)$$

$$\Rightarrow \frac{dy}{dx} = \frac{9}{2} \times \left(\frac{x^2 - y^2}{xy}\right) = \frac{9}{2} \times \left(\frac{x^2}{xy} - \frac{y^2}{xy}\right)$$

$$\Rightarrow \frac{dy}{dx} = \frac{9}{2}\left(\frac{x}{y} - \frac{y}{x}\right)$$

23. (b)

$$\text{Speed } N = \frac{120f}{P}$$

[$\because f$ = frequency, p = no. of poles/generator]

$$N = \frac{120 \times 50}{12} = 500 \text{ rpm}$$

24. (b)

Priming of a centrifugal pump is the operation of filling the suction pipe, casing of the pump and a portion of the delivery pipe completely from outside source with the liquid to be raised, before starting the pump, to remove any air, gas or vapour from those parts of the pump.

25. (b)

$$\therefore u = \frac{Uy}{B} - \frac{1}{2\mu}\left(\frac{\partial P}{\partial x}\right)\left(By - y^2\right)$$

$$\because \frac{\partial P}{\partial x} = 0$$

$$\therefore \quad u = \frac{Uy}{B}$$

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

At $y = b,\ u = U$

$$\tau_0 = \frac{\mu U}{B}$$

27. (d)

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

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

$$Q = \sqrt{\frac{12.1h_L\,D^5}{L}}\,f^{\frac{-1}{2}}$$

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

$$\frac{dQ}{Q} = \sqrt{\frac{12.1h_L\,D^5}{L}}\,\frac{-1}{2}f^{\frac{-3}{2}}df \times \sqrt{\frac{L}{12.1h_LD^5}} \times f^{\frac{+1}{2}}$$

$$\frac{dQ}{Q} = \frac{-1}{2}f^{\frac{-3}{2}}\,f^{\frac{-1}{2}}\,df$$

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

Percentage error in discharge,

$$= \frac{-1}{2} \times 25\% = -12.5\%$$

28. (a)

1. Dynamic viscosity is the property of a fluid in motion.
2. Cavitation occurs when pressure falls below vapour pressure.
3. Real fluids have viscosity of ideal fluid is zero.
4. Surface energy is the fluid property and is responsible for phenomena such as surface tension, capillarity.

29. (d)

In a free vortex flow, $V_r = C$ therefore velocity at the tip will be given by

$$V_\theta \times (250 + 100) = 250 \times 430$$

$$V_\theta = 307.14 \text{ m/s}$$

30. (b)

Uniform flow in an open channel must satisfy the following conditions:

(i) The water depth, flow area, discharge and the velocity distribution at all sections throughout the entire channel reach must remains unchanged.

(ii) The energy gradient line, the water surface line and the channel bottom line must be parallel to each other.

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