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PRACTICE QUESTIONS

for SSC-JE : CBT-2

Hydraulics

Civil Engineering

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03 Hydraulics

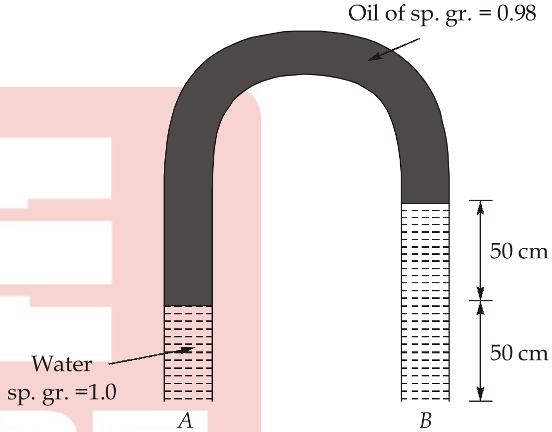
Q.1 Newton's law of viscosity for a fluid states that the shear stress is
(a) Proportional to angular deformation
(b) Proportional to rate of angular deformation
(c) Inversely proportional to angular deformation
(d) Inversely proportional to rate of angular deformation

Q.2 Dynamic viscosity of a fluid is 1.2 poise and its specific gravity is 0.8. Then kinematic viscosity in SI units is
(a) 9.6×10^{-4} m^2/s (b) 15×10^{-4} m^2/s
(c) 1.5×10^{-4} m^2/s (d) 0.667×10^{-4} m^2/s

Q.3 The vapour pressure is the characteristics fluid property involved in the phenomenon of
(a) Water hammer in a pipe flow
(b) Cavitation
(c) Rise of sap in a tree
(d) Spherical shape of rainwater drop

Q.4 Bourdon gauge measures
(a) Absolute pressure
(b) Gauge pressure
(c) Local atmospheric pressure
(d) Standard atmospheric pressure

Q.5 In the set-up shown in the figure assuming the specific weight of water as 10 kN/m^3, the pressure difference between the two points *A* and *B* will be



(a) 50 N/m^2 (b) 100 N/m^2
(c) 75 N/m^2 (d) 200 N/m^2

Q.6 A curved surface is submerged in a static liquid. The horizontal component of pressure force on it is equal to
(a) the pressure force on a horizontal projection of the surface
(b) product of the surface area and pressure at the centre of gravity
(c) pressure force on a vertical projection of the surface
(d) weight of the liquid contained between the curved surface and the liquid surface

Q.7 In a floating body, *I* = moment of inertia of waterline area about the longitudinal axis, *V* = volume of displaced liquid, *B* = centre of buoyancy, *G* = centre of gravity, *M* = metacentre, for stable equilibrium of this body

(a) $BG = \frac{I}{V} + MG$ (b) $MG = \frac{I}{V} + BG$

(c) $MG = \frac{\left(\frac{I}{V}\right)}{BG}$ (d) $BG + MG = \frac{I}{V}$

Q.8 A 3 m wide, 2.5 m deep, 10 m long tank open at the top has oil standing to a depth of 1 m. The maximum horizontal acceleration that can be given to the tank without spilling the oil will be nearly

(a) 0.10 g (b) 0.20 g
(c) 0.25 g (d) 0.31 g

Here g is acceleration due to gravity

Q.9 Which of the following is NOT an example of free vortex flow?

(a) A whirlpool in a river
(b) Flow of liquid through a hole provided at the bottom of a container
(c) Flow of liquid around a circular bend in a pipe
(d) Rotation of liquid in a vertical cylinder

Q.10 In defining a Froude number applicable to channels of any shape, the length parameter used is the

(a) Depth of flow
(b) Hydraulic radius
(c) Ratio of wetted area to top width
(d) Wetted perimeter

Q.11 In an M_2 type gradually varied flow profile

(a) $y_0 > y > y_c$ (b) $y_0 > y_c > y$
(c) $y > y_0 > y_c$ (d) $y_c > y_0 > y$

Here, y_0 and y_c refers to normal and critical depth respectively.

Q.12 Consider the following statements with respect of the critical depth of flow in a prismatic rectangular channel.

1. For known specific energy, the discharge is minimum.
2. For known discharge, the specific energy is minimum.

Which of the above statement(s) is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.13 A reaction turbine discharges 30 m^3/s of water under a head of 10 m with an overall efficiency of 92%. The power developed is

(a) 2952 kW (b) 2870 kW
(c) 2760 kW (d) 2652 kW

Q.14 If two pumps identical in all respects and each capable of delivering a discharge 'Q' against a head H are connected in parallel, the resulting discharge is

(a) $2Q$ against a head $2H$
(b) $2Q$ against a head H
(c) Q against a head $2H$
(d) $2Q$ against a head $\sqrt{2}H$

Q.15 A turbine works under a head of 16 m, has a speed of 375 rpm and develops 400 kW power. Its specific speed in SI units is

(a) 375 (b) 83
(c) 234 (d) 167

Q.16 If u and v, the components of velocity in x and y directions respectively are given by

$u = ax + by$ and $v = cx + dy$

then the condition to be satisfied for possible flow is (Assume flow to be steady and incompressible.

(a) $a + c = 0$ (b) $b + d = 0$
(c) $a + b + c + d = 0$ (d) $a + d = 0$

Q.17 Vorticity in z-direction is given by

(a) $\left[\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right]$ (b) $\left[\frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}\right]$

(c) $\left[\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right]$ (d) $\left[\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right]$

Q.18 If flow conditions satisfy 'Laplace equation' then
(a) flow is irrotational
(b) flow does not satisfy continuity equation
(c) flow is irrotational but does not satisfy continuity equation
(d) flow is irrotational and satisfies continuity equation

Q.19 Bernoulli's equation $\frac{P}{\rho}+\frac{V^2}{2}+gZ=\text{constant}$, is valid for
1. Steady flow
2. Viscous flow
3. Incompressible flow
4. Flow along streamline

Which of the above statement(s) is/are correct?
(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4

Q.20 A venturimeter is a device based on Bernoulli's principle and is used for measuring
(a) Velocity (b) Pressure drop
(c) Total head (d) Flow rate

Q.21 Navier Stoke's equation represents the conservation of
(a) Energy (b) Mass
(c) Pressure (d) Momentum

Q.22 A Cipolletti weir has a side slope of
(a) 1 Vertical : 4 Horizontal
(b) 1 Vertical : 2 Horizontal
(c) 1 Horizontal : 4 Vertical
(d) 1 Horizontal : 2 Vertical

Q.23 Water hammer in pipeline takes place when
(a) fluid is flowing with high velocity
(b) fluid is flowing with high pressure
(c) flowing fluid is suddenly brought to rest by closing a valve
(d) flowing fluid is brought to rest by gradually closing a valve

Q.24 In case of transmission of hydraulic power by a pipeline to a turbine in a hydroelectric power station, the maximum power transmission efficiency through the pipeline is
(a) 76% (b) 67%
(c) 54% (d) 42%

Q.25 Hydraulic Gradient Line (HGL) represents the sum of
(a) pressure head and kinetic head
(b) kinetic head and datum head
(c) pressure head and datum head
(d) pressure head, kinetic head and datum head

Q.26 The Reynold's number for laminar flow of an oil in a certain pipe is 640. The Darcy-Weisbach friction factor 'f' for this flow is
(a) 0.02 (b) 0.01
(c) 0.1 (d) 0.064

Q.27 In laminar flow between two fixed parallel plates, the shear stress is
(a) constant across the passage
(b) maximum at centre and zero at the boundary
(c) zero all through the passage
(d) maximum at the boundary and zero at the centre

Q.28 In a fully rough-turbulent pipe flow, the friction factor 'f' is
(a) a function of R_e and $\frac{\varepsilon_s}{D}$
(b) a function of R_e only
(c) a function of $\frac{\varepsilon_s}{D}$ only
(d) independent of R_e and $\frac{\varepsilon_s}{D}$

where, R_e = Reynold's number, and
$\frac{\varepsilon_s}{D}$ = Relative roughness

Q.29 The lift force on a body
(a) is due to buoyant force
(b) is always in the direction of the gravity
(c) is the component of the resultant force in horizontal direction
(d) is the component of the resultant force in a direction normal to relative velocity

Q.30 When compared to a streamlined body, a bluff body will have
(a) more pressure drag but less friction drag
(b) more pressure drag and more friction drag
(c) less pressure drag and less friction drag
(d) less pressure drag but more friction drag

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Answer Keys

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

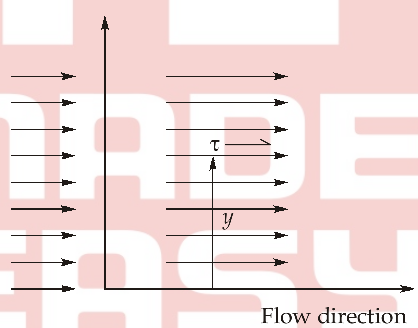
Detailed Solutions

1. (b)

Newton's law of viscosity:

According to this the shear stress (τ) acting on layer of fluid at a distance y from the surface is directly proportional to the rate of angular deformation.

$$\tau \propto \frac{d\theta}{dt}$$



2. (c)

Given, dynamic viscosity,

$$\mu = 1.2 \text{ Poise} = \frac{1.2}{10} \text{ Ns/m}^2 = 0.12 \text{ Ns/m}^2$$

Specific gravity = 0.8

Density, $\rho = 0.8 \times 1000 = 800 \text{ kg/m}^3$

Now, kinematic viscosity,

$$\nu = \frac{\mu}{\rho} = \frac{0.12}{800} = 1.5 \times 10^{-4} \text{ m}^2/\text{s}$$

3. (b)

Phenomenon		Fluid characteristics
Water hammer	–	Sudden closure of valve
Cavitation	–	Vapour pressure
Rise of sap in a tree	–	Capillarity
Spherical shape of rain water drop	–	Surface tension

4. (b)

A bourdon gauge records the gauge pressure relative to the pressure of the medium surrounding the tube.

5. (b)

From figure

$$P_A - 0.5 - 0.5 \times 0.98 + 1.0 = P_B$$

$$\Rightarrow \quad P_A - P_B = -0.01 \text{ m of water}$$

$$= -10 \times 10^3 \times 0.01$$

$$= -100 \text{ N/m}^2$$

6. (c)

Net horizontal force on curved surface

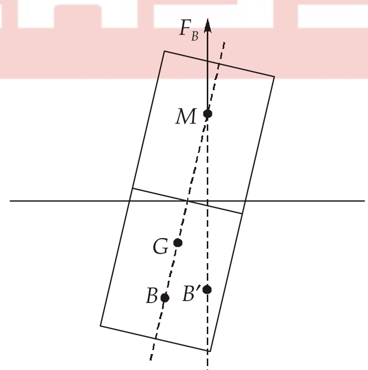
= Force on the vertical projection of the curved surface

Net vertical force on curved surface

= Weight of the liquid contained in the zone bound by two verticals drawn from two ends of the curved surface and the free surface.

7. (d)

In a floating body, for stable equilibrium

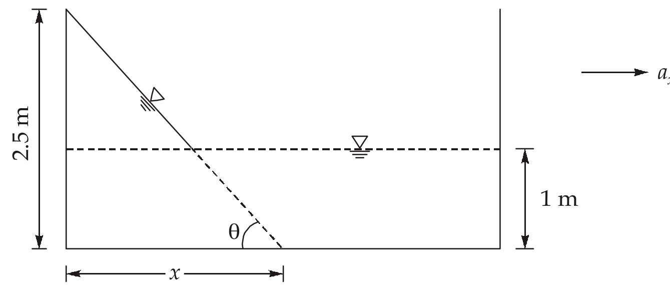


$$BM = \frac{I}{V}$$

$$\Rightarrow \quad BG + MG = \frac{I}{V}$$

8. (d)

For maximum given acceleration, oil will reach just upto the maximum height of the tank without being spill out and volume of oil will remain same.



$$\frac{1}{2}\times x\times 2.5\times 3 = 10\times 1\times 3$$

$$x = 8 \text{ m}$$

$$\tan\theta = \frac{a_x}{g} = \frac{2.5}{8}$$

$$\therefore \quad a_x = \frac{2.5}{8}\times g = 0.3125g \simeq 0.31\text{ g}$$

9. (d)

Free vortex flow:

Example:
(i) Flow around a circular bend
(ii) A whirlpool in a river
(iii) Flow of liquid in a centrifugal pump casing after it has left the impeller.
(iv) Flow of water in a turbine casing before it enters the guide vanes
(v) Flow of liquid through a hole/outlet provided at the bottom of a shallow vessel (e.g., wash basin, bath tub etc.)

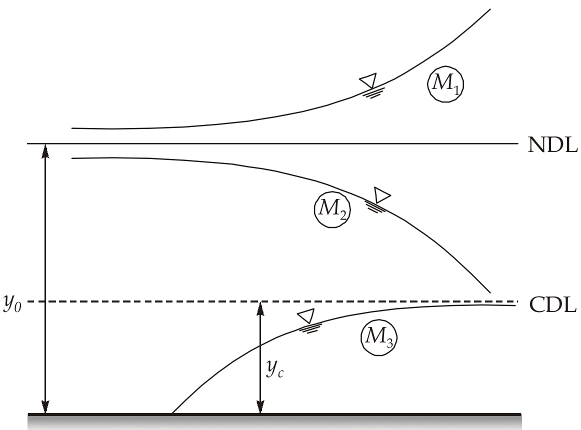
10. (c)

In an open channel flow.

Froude number, $$F_r = \frac{V}{\sqrt{gD}}$$

$$D = \text{Hydraulic depth} = \frac{\text{Area}}{\text{Top width}}$$

11. (a)



Mild slope

For M$_1$ profile: $y > y_0 > y_c$

M$_2$ profile: $y_0 > y > y_c$

M$_3$ profile: $y_0 > y_c > y$

12. (b)

$$\frac{Q^2T}{gA^3} = 1, \text{ Corresponds to critical flow condition such that:}$$

(a) for a given discharge, specific energy is minimum

(b) for a given specific energy, discharge is maximum

13. (c)

Given, discharge, $Q = 30 \text{ m}^3/\text{s}$

Overall efficiency, $\eta_0 = 92\%$

Head on turbine, $H = 10 \text{ m}$

$\therefore$Power, $P = (\gamma_w QH)\,\eta_0$

$= 10 \times 30 \times 10 \times 0.92$

$= 2760 \text{ kW}$

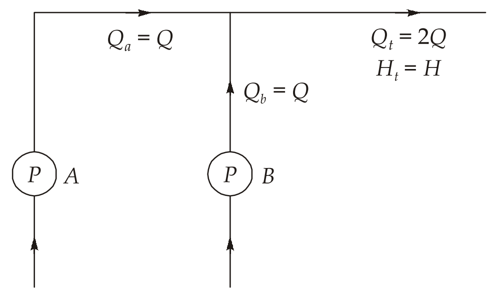
14. (b)

If two similar pumps A and B are connected in parallel, the combined discharge Q_t will be the sum of the individual discharge Q_a and Q_b

$$Q_t = Q_a + Q_b$$
$$= Q + Q$$
$$= 2Q$$

The head H will however be the same in both the pumps and will also be the net head of the combined discharge.

$$H_{net} = H = H_a = H_b$$



15. (c)

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{375 \times 20}{(24)^{5/4}} = 234.37 \simeq 234$$

16. (d)

For flow to be possible continuity equation must be satisfied

For 2-D flow,

Continuity equation

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

$$\Rightarrow \quad \frac{\partial}{\partial x}(ax + by) + \frac{\partial}{\partial y}(cx + dy) = 0$$

$$\Rightarrow \quad a + d = 0$$

17. (d)

Vorticity,

$$\xi_z = 2\omega_z$$

$$= 2\left[\frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\right]$$

$$= \left[\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right]$$

18. (d)

If flow condition satisfies Laplace equation e.g., $\left(\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0\right)$ and $\left(\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0\right)$ then it has to satisfy continuity equation and the flow is irrotational.

19. (c)

Bernoulli's equation

$$\frac{P}{\rho}+\frac{V^2}{2}+gZ = \text{Constant}$$

The condition to be satisfied for the applicability of Bernoulli's equation

- flow along a streamline
- flow is steady and incompressible
- effect of friction (viscous forces) is negligible

20. (d)

A venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe.

21. (d)

Bernoulli's equation: Law of conservation of energy.

Continuity equation: Law of conservation of mass.

Navier-Stokes equation: Law of conservation of momentum.

22. (c)

Cipolletti weir is a trapezoidal weir, which has side slope of 1 horizontal to 4 vertical.

23. (c)

When the water flowing in a pipe is suddenly brought to rest by closing the valve or by any similar cause, there will be sudden rise in pressure due to the momentum of the moving water being destroyed. This cause a wave of high pressure to be transmitted along the pipe which creates noise known as knocking. This phenomenon of sudden rise in pressure in the pipe is known as water hammer.

24. (b)

Efficiency of power transmission through pipe is

$$\eta = \frac{H-h_f}{H}$$

for maximum power transmission through the pipe the condition is

$$h_f = \frac{H}{3}$$

$$\therefore \qquad \eta_{max} = \frac{H-\frac{H}{3}}{H} = \frac{2}{3} \text{ or } 66.6\% \simeq 67\%$$

25. **(c)**

Hydraulic gradient line: It is defined as the line which gives the sum of pressure head $\left(\frac{P}{\gamma}\right)$ and datum head (Z) of a flowing fluid in a pipe with respect to some reference line.

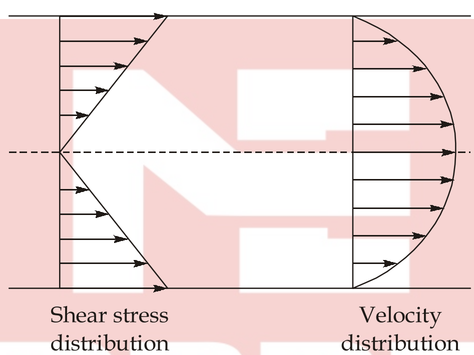
26. **(c)**

Since, flow is laminar

$$f = \frac{64}{Re} = \frac{64}{640} = \frac{1}{10} = 0.1$$

27. **(d)**

For laminar flow between two parallel plate.



28. **(c)**

For turbulent flow in rough pipes, friction factor is a function of relative roughness $\left(\frac{\varepsilon_s}{D}\right)$ and it is independent of Reynold's number (Re).

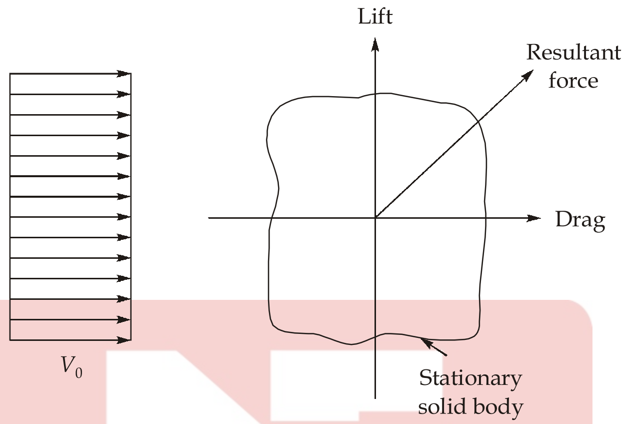
Note: For turbulent flow, in smooth pipes, friction factor is a function of Reynold's number only.

29. (d)

The lift force (F_L), which occurs normal to the direction of relative motion (V_0) is expressed as

$$F_L = \frac{1}{2} C_L A \rho V_0^2$$

C_L = Lift coefficient



A = Area of the body which is the projected area of the body perpendicular to the direction of flow.

30. (a)

Bluff body: A bluff body is defined as that body whose surface does not coincide with the streamlines, when placed in a flow.

Bodies of such a shape in which the pressure drag is very large as compared to friction drag are called bluff bodies.

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