Fluid Mechanics and Fluid Machinery Test 1

Number of Questions: 35 **Time:60 min.**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

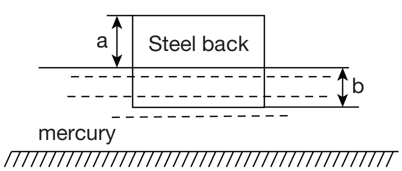
1. The magnitude of hydrostatic force on one side of a circular surface of unit area with the centroid 10 m and centre of pressure 15 m below a free surface of water (density ρ) is
(A) less than $10\rho g$ (B) equals to $10\rho g$
(C) less than $15\rho g$ (D) equals to $15\rho g$

2. Which one of the following is the bulk modulus 'K' of a fluid?
(A) $\rho\frac{d\rho}{dp}$ (B) $\frac{dp}{\rho d\rho}$
(C) $\frac{d\rho}{\rho dp}$ (D) $\rho\frac{dp}{d\rho}$

3. For a fully developed viscous flow through a pipe, the velocity distribution across any section is
(A) linear (B) hyperbolic
(C) parabolic (D) circular

4. What is the pressure (N/m^2) with in a 2 mm diameter spherical droplet of water relative to the atmospheric pressure outside?
(Assume σ for pure water to be 0.073 N/m)
(A) 146 (B) 292
(C) 73 (D) 584

5. A block of steel (specific gravity = 7.9) floats at a mercury water interface as shown in figure. If specific gravity of mercury is 13.6 then the ratio of a and b for this condition will be



(A) 1.826 (B) 0.826
(C) 0.124 (D) 0.528

6. Surface tension is due to
(A) viscous forces
(B) cohesion
(C) adhesion
(D) difference between adhesive and cohesive forces

7. A rectangular plate of size 30 cm by 60 cm and weighing 30 N slides down a 30° inclined surface at a uniform velocity of 2 m/sec.
If the uniform 3 mm gap between the plate and the inclined surface is filled with oil, then the viscocity (N – sec/m^2) will be
(A) 0.5 (B) 0.25
(C) 0.625 (D) 0.125

8. A pressure head of 100 m of water is equivalent to
(A) 12.5 m of mercury
(B) 62.5 m of oil (s = 1.2)
(C) 75.8 m of diesel (s = 0.8)
(D) 123.46 m of kerosene (s = 0.81)

9. A 0.5 m pipe carries water at a velocity of 24.3 m/s. At a point, measurement of pressure and elevation were respectively 392.4 kN/m^2 and 30 m. The total energy at that point will be
(A) 150 m (B) 112 m
(C) 100 m (D) 200 m

10. The momentum correction factor for turbulent flow through circular pipe is
(A) 4/3 (B) 1.2
(C) 2 (D) 1.33

11. If 'D' is a diameter of the circular pipe, then the maximum thickness of boundary layer in pipe is equal to
(A) $\frac{D}{2}$ (B) D
(C) $\frac{D}{3}$ (D) $\frac{D}{4}$

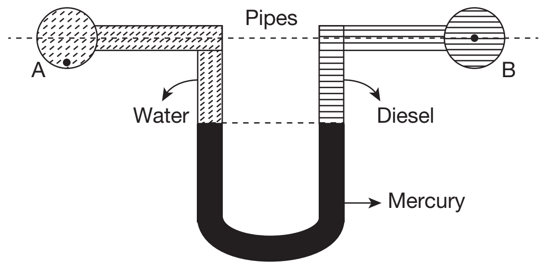
12. A rough pipe of 0.1 m diameter carries water at the rate of 60 litres/sec. The average height of roughness is 0.15 mm. The friction factor will be
(A) 0.0217 (B) 0.031
(C) 0.0114 (D) 0.001

13. A jet of diesel with relative density 0.8 strikes normally a plate with a velocity of 12 m/s. The jet has an area of 0.02 m^2. The force exerted on the plate by the jet is
(A) 2304 kN (B) 2.304 N
(C) 192 N (D) 2.304 kN

14. A hydroelectric reservoir can supply water continuously at a rate of 200 m^3/sec. The head is 100 m. The maximum power that can be developed in MW will be
(A) 142.4 (B) 196.2
(C) 98.1 (D) 74.8

15. A Francis turbine running at 250 rpm develops 6 MW power under a head of 28 m. The power output of turbine under a head of 100 m in MW will be
(A) 40.5 (B) 30.5
(C) 50.5 (D) 45.5

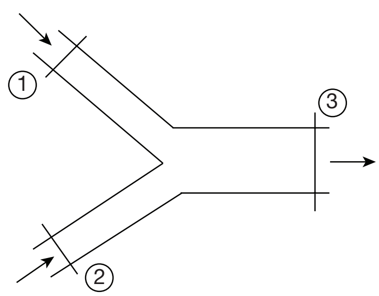
16. The manometer shown in the figure below connects two pipes, carrying diesel and water respectively.
From the figure, which one of the following is correct.
(P = pressure)



(A) $P_B > P_A$ (B) $P_A > P_B$
(C) $P_B = P_A$ (D) Insufficient data

17. A long tapered duct of length 3 m has having variable cross - section area which is varying as $A = (2 - 1.5x)$ m^2, where 'x' is the distance in meters. At a given instant, a discharge of 1 m^3/sec is flowing in the duct and is found to increase at a rate of 0.5 m^3/sec. The local acceleration (m/s^2) at $x = 1$ will be
(A) 1.5 (B) 1.0
(C) 0.25 (D) 4

18. Two separate pipe carrying water converges to one pipe as shown in figure.

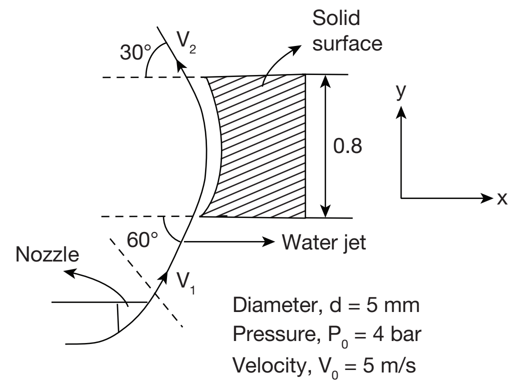


The following table gives the velocities, corresponding areas and total energy head.

Pipe No	Area (cm^2)	Velocity (cm/s)	Energy head (cm)
1	50	10	1000
2	50	12	500
3	80	13.75	H_3

The value of H_3 in cm is
(A) 1000 (B) 750
(C) 500 (D) 727.3

19. A curve solid surface is struck by a jet water as shown in the below figure. 10% of the initial kinetic energy is lost while passing through the surface. Assuming steady flow, neglecting energy loss in nozzle and difference in elevation of exit and inlet of nozzle.



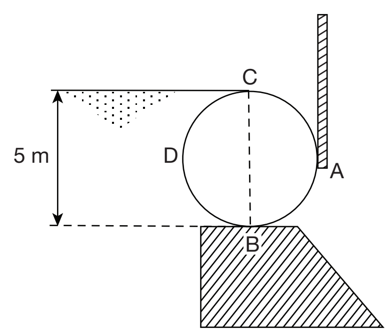
The force exerted on the solid body in x direction by the jet in (N) will be
(A) 16.78 (B) 23.22
(C) 21.27 (D) 6.5

20. Which one of the following velocity distribution of $\frac{u}{U_\infty}$ satisfies the boundary conditions for laminar flow on a flat plate? ($U_\infty \rightarrow$ Free stream velocity; $u \rightarrow$ Velocity at any normal distance y from the plate and δ is boundary layer thickness)

(A) $2\left(\frac{y}{\delta}\right)-\left(\frac{y}{\delta}\right)^2$ (B) $\frac{3}{2}\left(\frac{y}{\delta}\right)-\frac{1}{2}\left(\frac{y}{\delta}\right)^3$

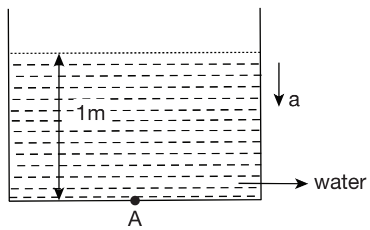
(C) $\text{Sin}\left(\frac{\pi}{2}\frac{y}{\delta}\right)$ (D) All of these

21. The cylindrical gate of a canal head works, having a diameter 5 m and a length of 8 m, is subjected to water pressure up to its top as shown in figure. The gate resisting on the concrete floor of the head works, is laterally supported at A where the coefficient of friction $\mu = 0.15$. Assuming watertight condition at B and no rotation of the cylinder, the minimum weight of the gate (kN) so that it may have no upward motion resulting from the water pressure will be



(A) 458.2 (B) 60.9
(C) 168.3 (D) 623.3

22. The maximum downward acceleration of the vessel if cavitation should be avoided will be ($P_{saturation}$ = Vapour pressure = 2.8 m of water (absolute) and atmospheric pressure = 100 kPa)



(A) 82.3 (B) 94.3
(C) 27.5 (D) 49.3

23. Assuming that the velocity distribution in the boundary layer is given by $\frac{u}{U_\infty} = \left(\frac{y}{\delta}\right)^{\frac{1}{7}}$.

Find the ratio of momentum thickness to the thickness of boundary layer (δ)

(A) 1/8 (B) 7/92
(C) 7/72 (D) 7/40

24. Match List-I (Type of model) with List-II (Transference ratio for velocity) and select the correct answer using the codes given below the lists.

	List – I		List – II
P	Mach model	1	$\frac{\mu}{\rho L}$
Q	Weber model	2	$\sqrt{gL}$
R	Froude model	3	$\sqrt{\frac{\sigma}{\rho L}}$
S	Reynolds model	4	$\sqrt{\frac{k}{\rho}}$

	P	Q	R	S
(A)	4	3	2	1
(B)	1	2	3	4
(C)	4	2	3	1
(D)	1	3	2	4

25. Oil of viscocity 0.2 P_a-sec and specific gravity 0.80 flows through a horizontal pipe of 30 mm diameter. If the pressure drop per meter length of the pipe is 15 kPa, then the power required (Watts) per 50 m length of pipe to maintain the flow will be

(A) 1696.3 (B) 1000
(C) 948.3 (D) 1118.6

26. A 1 : 10 scale model of a submarine moving far below the surface of water is tested in a water tunnel. If the speed of the prototype is 12 m/s, the ratio of the drag for the model and the prototype will be

Take $\vartheta_s = 1.121 \times 10^{-6}$ m²/sec; $\vartheta_w = 1 \times 10^{-6}$ m²/s; $\rho_s = 1027$ kg/m³; $\rho_w = 1000$ kg/m³

ϑ_s and ϑ_w = Kinematic viscocity of sea water and fresh water respectively.

ρ_s and ρ_w = Density of sea water and fresh water respectively.

(A) 77.5 (B) 7.75
(C) 0.0775 (D) 0.775

27. The head loss in a pipe of certain length carry a discharge 'Q' is found to be 'H'. If a pipe of twice the diameter of same length has to carry a discharge of '$3Q$' then the head loss is

(A) $\frac{9H}{8}$ (B) $\frac{H}{32}$
(C) $\frac{9H}{32}$ (D) $\frac{H}{8}$

28. An axial flow hydraulic turbine has a net head of 28 m across it, and when running at a speed of 200 rpm develops 25 MW. The blade tip and hub diameters are 4.8 and 2.0 m respectively. If the hydraulic efficiency is 94% and the overall efficiency 85%, then the inlet blade angle at the mean radius is
(Assume axial flow at output)

(A) 24° (B) 11.4°
(C) 18.1° (D) 14.2°

29. A radial flow hydraulic turbine is required to be designed to produce 30 MW under a head of 20 m at a speed of 100 rpm. A geometrically similar model with an output of 40 kW and a head of 5 m is to be tested under dynamically similar conditions. At what speed must the model be run?

(A) 112 rpm (B) 485 rpm
(C) 212 rpm (D) 38 rpm

30. A pipeline of 1 m in diameter is 2 km long. In order to augment the discharge, another parallel line of the same diameter is introduced in the second half of the length. Neglecting minor losses, if head at inlet is 40 m over that at the outlet and $f = 0.04$, then the increase in discharge (m³/s), will be

(A) 2 (B) 0.5
(C) 0.65 (D) 0.18

31. If the stream function is given by $\Psi = xy$, then the velocity at a point (2, 3) will be

(A) 3.6 units (B) 10.82 units
(C) 2 units (D) 3 units

Common data questions 32 and 33:

For air flow over a plate, the velocity distribution in boundary layer is given by

$$\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

Where U_∞ is free stream velocity, u is the velocity at any normal distance y from the plate and δ is boundary layer thickness. If the free stream velocity is 2 m/s and the air has kinematic viscocity 1.5×10^{-5} m^2/sec and mass density of air is 1.23 kg/m^3, then

32. The wall shear stress at 1 m length of plate in N/m^2 will be
(A) 9.8×10^{-3} (B) 4.9×10^{-3}
(C) 2.45×10^{-3} (D) 1.5×10^{-4}

33. The drag force (in N) on the plate if length of plate is 1.2 m and width is 0.8 m will be
(A) 17.2×10^{-3} (B) 8.6×10^{-3}
(C) 4.3×10^{-3} (D) 2.7×10^{-4}

Linked answer questions 34 and 35:
A closed cylinder 0.6 m in diameter and 1 m in height is filled with oil of specific gravity 0.8. If the cylinder is rotated about its vertical axis at a speed of 210 rpm then

34. The thrust of oil on top cover of cylinder is
(A) 2463.26 N (B) 3121.4 N
(C) 2868.4 N (D) 1676.2 N

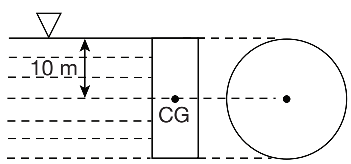
35. The thrust of oil on bottom cover of cylinder is
(A) 3895.17 N (B) 5340.37 N
(C) 5087.37 N (D) 4682.23 N

Answer Keys

1. B	**2.** D	**3.** C	**4.** A	**5.** B	**6.** B	**7.** D	**8.** D	**9.** C	**10.** B
11. A	**12.** A	**13.** D	**14.** B	**15.** A	**16.** A	**17.** B	**18.** D	**19.** C	**20.** D
21. B	**22.** A	**23.** C	**24.** A	**25.** D	**26.** D	**27.** C	**28.** D	**29.** B	**30.** C
31. A	**32.** B	**33.** B	**34.** A	**35.** D					

Hints and Explanations

1. $F = \rho g \times 10 \times 1$



$F = 10\,\rho g$ Choice (B)

2. $K = \dfrac{-dp}{dv/v}\left\{v = \dfrac{1}{\rho}\right\}$

$\therefore \quad K = \dfrac{-dp}{-\left(\dfrac{d\rho}{\rho^2}\right)\dfrac{1}{\rho}}$

$\Rightarrow \quad K = \rho\dfrac{dp}{d\rho}$ Choice (D)

3. $u = U_{max}\left[1 - \dfrac{r^2}{R^2}\right]$

$\Rightarrow$ Parabolic curve Choice (C)

4. $\Delta P = 2\sigma/R$

$\Delta P = \dfrac{2 \times 0.073}{1 \times 10^{-3}} = 146\text{N/m}^2$ Choice (A)

5. Weight of body = Total Buoyancy force acting on 1it
Let A = Cross-Sectional area of block
$A \times (a + b)\,(7900) \times g = [(b \times 13.6) + a] \times A \times g \times 10^3$
$7.9(a + b) = 13.6b + a$
$6.9a = 5.7b$
$\dfrac{a}{b} = 0.826$ Choice (B)

6. Choice (B)

7. Component of weight of plate along the slope
$= 30 \times \text{Sin}30° = 15$ N

$\tau = \mu\dfrac{du}{dy} = \dfrac{\mu V}{y}$

Force $= \tau \times A = \mu A\dfrac{V}{y} = \mu \times \dfrac{2}{0.003} \times (0.3 \times 0.6)$

$\therefore \quad 15 = 120 \times \mu$
$\therefore \quad \mu = 0.125$ N - sec/m^2 Choice (D)

8. $S_1h_1 = S_2h_2$
$100 \times 1 = h_2 \times s_2$
From options, (*d*) is correct Choice (D)

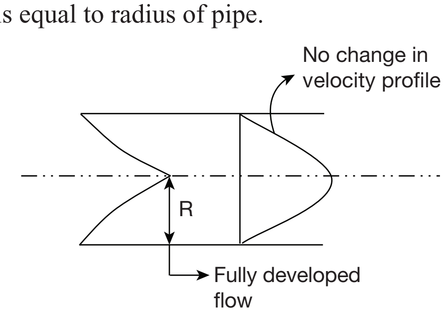
9. Total energy $= \dfrac{P}{\gamma} + \dfrac{V^2}{2g} + Z$

$= \dfrac{392.4}{9.81} + \dfrac{24.3^2}{2 \times 9.81} + 30$

$= 100.1$ m Choice (C)

10. Choice (B)

11. For a fully developed flow, the velocity profile cannot change. The maximum thickness of boundary layer in a pipe is equal to radius of pipe.



Choice (A)

12. $$\frac{1}{\sqrt{f}} = 2\log\left(\frac{r}{k_s}\right) + 1.74$$

$$\therefore \quad \frac{1}{\sqrt{f}} = 2\log\left(\frac{0.05}{0.15\times10^{-3}}\right) + 1.74$$

$f = 0.0217$ Choice (A)

13. $F = \rho A V_1 (V_1 - V_2)$

$F = \rho A V_1^2 \{ V_2 = 0 \}$

$= 0.8 \times 1000 \times 0.02 \times 12^2$

$= 2304$ N

or 2.304 kN Choice (D)

14. Power, $P = \gamma Q H$

$= 9.81 \times 200 \times 100$

$= 196.2$ MW Choice (B)

15. $$\left[\frac{P}{\rho D (gH)^{\frac{3}{2}}}\right]_m = \left[\frac{P}{\rho D (gH)^{\frac{3}{2}}}\right]_p$$

$$\frac{P_m}{100^{\frac{3}{2}}} = \frac{6}{28^{\frac{3}{2}}}$$

$\Rightarrow \quad P_m = 40.5$ MW Choice (A)

16. $P_A + \rho_w gH = P_B + \rho_d gH$

$P_B - P_A = gH(\rho_w - \rho_d)$

Now, $\rho_w > \rho_d$

$\therefore \quad P_B > P_A$ Choice (A)

17. Local acceleration , $\dfrac{\partial v}{\partial t} = \dfrac{\partial}{\partial t}\left(\dfrac{Q}{A}\right)$

$\{\therefore Q = AV\}$

at $x = 1$, $A = 0.5$ m^2

$$\therefore \quad \frac{\partial v}{\partial t} = \frac{1}{A}\frac{\partial Q}{\partial t} = \frac{1}{0.5} \times 0.5$$

$$\frac{\partial v}{\partial t} = 1 \text{ m/s}^2$$ Choice (B)

18. $\gamma Q_1 H_1 + \gamma Q_2 H_2 = \gamma(Q_1 + Q_2)H_3$

$Q = AV$

$\therefore \quad A_1V_1H_1 + A_2V_2H_2 = [A_1V_1 + A_2V_2]H_3$

$[50 \times 10 \times 1000] + [50 \times 12 \times 500] = [(50 \times 10) + (50 \times 12)]H_3$

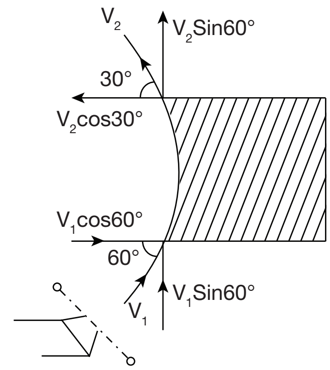
$\therefore \quad H_3 = 727.3$ cm Choice (D)

19. Bernoulli's equation between nozzle and inlet to body

$$\frac{P_0}{\rho g} + \frac{V_0^2}{2g} + Z_0 = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1$$

$$\frac{400}{9.81} + \frac{52}{(2\times9.81)} + 0 = 0 + \frac{v_1^2}{2g}$$

$\therefore \quad V_1 = 28.723$ m/s



$$\frac{V_1^2}{2g} + 0 = \frac{V_2^2}{2g} + 0.8 + \text{Loss}$$

$$\text{Loss} = 10\% \text{ of } \frac{V_1^2}{2g}$$

$$\therefore \quad 0.9\frac{V_1^2}{2g} - 0.8 = \frac{V_2^2}{2g}$$

$\therefore \quad V_2 = 26.96$ m/s

$$F_x = \rho A_1 V_1 \left[\overrightarrow{V_{x_1}} - \overrightarrow{V_{x_2}}\right]$$

$$= 1000 \times \frac{\pi}{4} \times 0.005^2 \times 28.723 \left[\overrightarrow{V_{x_1}} - \overrightarrow{V_{x_2}}\right]$$

Now $V_{x1} = V_1\text{Cos}60° = 28.723 \times \text{Cos}60°$

$V_{x1} = 14.3615$ m/s

and $V_{x2} = -V_2\text{Cos}30° = -26.96 \times \text{Cos}30°$

$V_{x2} = 23.348$ m/s

$\therefore \quad F_x = 0.564\ [14.3615 + 23.348]$

$F_x = 21.27$ N Choice (C)

20. For laminar flow, $\left.\dfrac{\partial u}{\partial y}\right|_{y=\delta} = 0$

(A) $$\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

$$\frac{\partial u}{\partial y} = U_\infty\left[\frac{2}{\delta} - \frac{2y}{\delta^2}\right] \Rightarrow \left.\frac{\partial u}{\partial y}\right|_{y=\delta} = 0$$

(B) $$\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

$$\frac{\partial u}{\partial y} = U_\infty\left[\frac{3}{2\delta} - \frac{3y^2}{2\delta^3}\right] \Rightarrow \left.\frac{\partial u}{\partial y}\right|_{y=\delta} = 0$$

(C) $$\frac{u}{U_\infty} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$$

$$\frac{\partial u}{\partial y} = U_\infty\left[\frac{\pi}{2\delta}\cos\left(\frac{\pi}{2}\frac{y}{\delta}\right)\right] \Rightarrow \left.\frac{\partial u}{\partial y}\right|_{y=\delta} = 0$$

Choice (D)

21. The reaction R and A is due to the horizontal component P_H of the water acting on the cylinder.

$R = P_H = 9.81 \times 5 \times 8 \times \frac{5}{2} = 981$ kN

As the gate tends to have upward motion, the frictional resistance F acting down wards will be developed at A which may be obtained as

$F = \mu R = 0.15 \times 981$

$F = 147.15$ kN

The upward motion of the gate will be caused by the vertical component P_V of the water pressure acting on the cylinder in the upward direction which is given as

P_V = weight of water in the position BDC

$= 9.81 \times 8 \times \frac{1}{2}\left[\frac{\pi}{4} \times 5^2\right]$

= 770.4756 kN

∴ Equillibrium condition

$W + 147.15 = 770.4756$

∴ $W = 623.3$ kN Choice (B)

22. $P_A = \rho h\,(g - a)$

$(P_A)_{abs} = 1000 \times 1 \times (9.81 - a) + \frac{100 \times 10^3}{1}$

Now, $(P_A)_{abs} \geq$ vapour pressure

$2.8 \times 9.81 \times 10^3 \geq 9810 - 1000a + (100 \times 10^3)$

∴ $a = 82.342$ m/s^2 Choice (A)

23. Momentum thickness, $\theta = \int_0^{\delta} \frac{u}{U_\infty}\left[1 - \frac{u}{U_\infty}\right] dy$

$$\theta = \int_0^{\delta} \left(\frac{y}{\delta}\right)^{\frac{1}{7}} \left[1 - \left(\frac{y}{\delta}\right)^{\frac{1}{7}}\right] dy$$

$$\theta = \frac{7}{72}\delta$$

or $\frac{\theta}{\delta} = \frac{7}{72}$ Choice (C)

24. Choice (A)

25. Velocity, $v = \frac{(P_1 - P_2)D^2}{32\mu L} = \frac{15 \times 10^3 \times 0.03^2}{32 \times 0.2 \times 1}$

V = 2.11 m/s

$Q = \frac{\pi}{4} \times 0.03^2 \times 2.11 = 1.4915 \times 10^{-3}$ m^3/sec

Power, $P = Q(P_1 - P_2)$

$= 1.4915 \times 10^{-3} \times 15 \times 10^3 \times 50$

$P = 1118.6$ W Choice (D)

26. Reynolds model law

$$\left(\frac{VL}{\partial}\right)_m = \left(\frac{VL}{\partial}\right)_p$$

$$\Rightarrow V_m = V_P \times \frac{L_P}{L_m} \times \frac{\partial_m}{\partial_p}$$

$$\Rightarrow V_m = 12 \times 10 \times \frac{1 \times 10^{-6}}{1.121 \times 10^{-6}}$$

$\Rightarrow V_m = 107.047$ m/s

$$\frac{F_m}{F_p} = \frac{\rho_m}{\rho_p} \times \left(\frac{L_m}{L_p}\right)^2 \times \left(\frac{V_m}{V_p}\right)^2$$

$$\frac{F_m}{F_p} = \frac{1000}{1027} \times \left(\frac{1}{10}\right)^2 \times \left(\frac{107.047}{12}\right)^2$$

$\frac{F_m}{F_p} = 0.775$ Choice (D)

27. $H = H = \frac{fLQ^2}{12d^5}, H' = \frac{fL(3Q)^2}{12(2d)^5}$

$$H' = \frac{9}{2} \times \frac{fLQ^2}{12d^5}$$

$\Rightarrow H' = \frac{9}{32}$H Choice (C)

28. Mean diameter, $d_m = \frac{4.8 + 2}{2} = 3.4$ m

Overall efficiency, $\eta_{ov} = \frac{S.P}{\rho g Q H}$

$$\therefore Q = \frac{25 \times 10^6}{(1000 \times 9.81 \times 0.85 \times 28)}$$

$\Rightarrow Q = 107.076$ m^3/sec

Hydraulic efficiency, $\eta_h = \frac{\text{Rotor Power}}{\rho g Q H}$

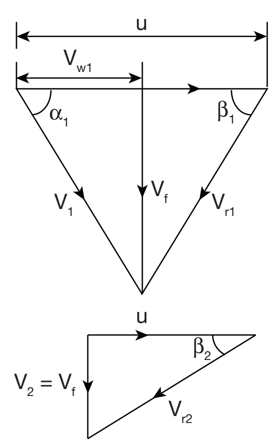
∴ Rotor power $= 0.94 \times \frac{25 \times 10^6}{0.85} = 27.647$ MW

Rotor speed, $u = \frac{\pi d_m N}{60} = \frac{\pi \times 3.4 \times 200}{60}$

$\Rightarrow u = 35.6$ m/s

∴ $10^3 \times 107.076 \times V_{W1} \times 35.6 = 27.647 \times 10^6$

$\Rightarrow V_{W1} = 7.253$ m/s



$$V_f = \frac{107.076}{\pi[4.8^2 - 2^2]/4} = 7.16 \text{ m/s}$$

$$\tan\beta_1 = \frac{V_f}{u - V_{W1}} = \frac{7.16}{35.6 - 7.253}$$

$\Rightarrow$ β_1 = 14.1755° or 14.2°

Choice (D)

29. $$\frac{P_m}{\rho_m N_m^3 D_m^5} = \frac{P_P}{\rho_P N_P^3 D_P^5}$$

$$\frac{P_m}{P_P} \times \frac{\rho_P}{\rho_m} \times \frac{N_P^3}{N_m^3} \times \frac{D_P^5}{D_m^4} = 1 \qquad \{\rho_p = \rho_m\}$$

$$\left[\frac{40\times10^3}{30\times10^6}\right]\times\left(\frac{D_P}{D_m}\right)^5 = \left(\frac{N_m}{N_p}\right)^3$$

$$\frac{D_p}{D_m} = 3.76\left(\frac{N_m}{N_p}\right)^{\frac{3}{5}} \qquad (1)$$

$$\frac{gH_m}{(N_m D_m)^2} = \frac{gH_p}{(N_P D_P)^2}$$

$$\left(\frac{D_P}{D_m}\right)^2 = \frac{H_p}{H_m}\times\left(\frac{N_m}{N_p}\right)^2$$

$$\therefore \quad \frac{D_p}{D_m} = \left(\frac{20}{5}\right)^{\frac{1}{2}}\times\left(\frac{N_m}{N_p}\right) \qquad (2)$$

From eq (1) and (2)

$$\left(\frac{N_m}{N_p}\right)\times\left(\frac{20}{5}\right)^{\frac{1}{2}} = 3.76\times\left(\frac{N_m}{N_p}\right)^{\frac{3}{5}}$$

$$\therefore \quad \left(\frac{N_m}{N_p}\right)^{0.4} = 1.88$$

$$\Rightarrow \quad \frac{N_m}{N_p} = 4.846125$$

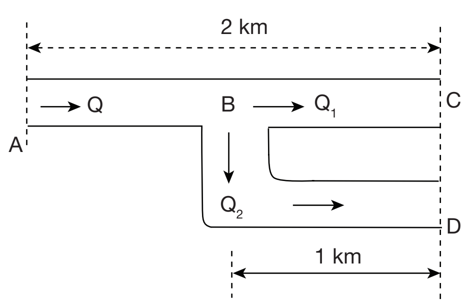
N_m = 100 × 4.846125

N_m = 484.6 rpm

~ 485 rpm

Choice (B)

30.



$$h_f = \frac{fLQ^2}{12d^5}$$

$$\Rightarrow \quad 40 = \frac{0.04\times2000\times Q^2}{12\times1^5}$$

$\therefore$ Q' = 2.45 m³/s {for single pipe}

Now, $Q = Q_1 + Q_2$ {for parallel pipe}

$$(h_f)_{BC} = \frac{fLQ_1^2}{12d^5}$$

$$\Rightarrow \quad (h_f)_{BC} = \frac{0.04\times1000}{12\times1^5}\times Q_1^2$$

$(h_f)_{BC} = 3.34Q_1^2$

Similarly, $(h_f)_{BD} = 3.34Q_2^2$

At outlet, $H_C = H_D$

$\therefore$ $Q_1 = Q_2 = Q/2$

Applying Bernoulli's eqⁿ between A and C

$$40 = \left[\frac{0.04\times1000}{12\times1^5}\right]\times Q^2 + \left[\frac{0.04\times1000}{12\times1^5}\right]\times\frac{Q^2}{4}$$

Q = 3.1 m³/s

Increase in the rate of discharge

$Q - Q'$ = 3.1 – 2.45 = 0.65 m³/s

Choice (C)

31. $$v = \frac{\partial\Psi}{\partial x} = y$$

$$-u = \frac{\partial\Psi}{\partial y} = x$$

$$\therefore \quad \vec{V} = -x\hat{i} + y\hat{j}$$

At (2, 3) ; $\vec{V} = -2\hat{i} + 3\hat{j}$

$|\vec{V}|$ = 3.6 units

Choice (A)

32. $$\tau_0 = \frac{1}{2}\rho U_\infty^2\left[\frac{1.46}{\sqrt{R_{ex}}}\right]_{x=1m}$$

$$= \frac{1}{2}\times1.23\times2^2\left[\frac{1.46}{\sqrt{\frac{2\times1}{1.5\times10^{-5}}}}\right]$$

= 4.918 × 10⁻³ N/m²

Choice (B)

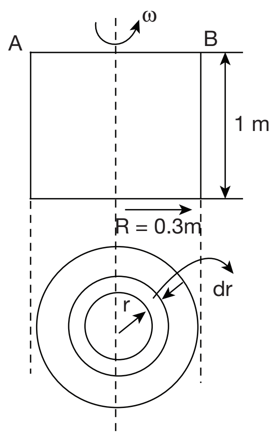
33. $$F = \frac{1}{2}\rho U_\infty^2\left[\frac{0.73}{R_{ex}}\right]\times(b\times L)$$

$$F = \frac{1}{2}\times1.23\times2^2\frac{1.46}{\sqrt{\frac{2\times1.2}{1.5\times10^{-5}}}}\times0.8\times1.2$$

$F = 8.62\times10^{-3}$ N

Choice (B)

34. In top plane *AB* of the cylinder, pressure head at any radial distance r is given by



$$\frac{P}{\rho g} = \frac{\omega^2 r^2}{2g}$$

Thrust on top plane $F_T = \int_0^R P(2\pi r)dr$

$$F_T = \pi\rho\omega^2 \int_0^R r^3 dr$$

$$\Rightarrow \quad F_T = \frac{\pi\rho\omega^2 R^4}{4}$$

$$\omega = \frac{2\times\pi\times 210}{60} = 22 \text{ rad/sec}$$

$R = 0.3$ m

$$\therefore \quad F_T = \frac{\pi\times 0.8\times 1000\times 22^2\times 0.3^4}{4}$$

$\Rightarrow \quad F_T = 2463.26$ N   Choice (A)

35. Thrust at the bottom cover

$F = F_T + (\rho gH + \pi R^2)$

$F = 2463.26 + [0.8 \times 1000 \times 9.81 \times 1 \times \pi \times 0.3^2]$

$F = 4682.23$ N   Choice (D)