Fluid Mechanics and Fluid Machinery Test 2

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

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

1. The speed ratio of a Pelton wheel operating under a head of 1600 m is 0.48. What is the peripheral velocity of the turbine wheel?
(A) 768 m/s (B) 369 m/s
(C) 68 m/s (D) 85 m/s

2. Head loss in turbulent flow in a pipe varies
(A) directly as velocity
(B) inversely as square of velocity
(C) approximately as square of velocity
(D) inversely as velocity

3. Consider the following statements regarding Bernoulli's theorem for fluid flow:
1. Conservation of energy
2. Steady flow
3. Viscous flow
4. Incompressible flow
(A) 1, 3 and 4 (B) 1, 2 and 4
(C) 2, 3 and 4 (D) 1, 2, 3 and 4

4. A hydraulic reaction turbine working under a head of 25 m with a discharge of 0.5 m^3/sec. What is the unit discharge of the turbine?
(A) 0.1 m^3/s (B) 0.004 m^3/s
(C) 0.05 m^3/s (D) 0.25 m^3/s

5. What acceleration would cause the free surface of a liquid contained in an open tank moving in a horizontal track to dip by 58°?
(A) g (B) 0.5 g
(C) 1.5 g (D) 1.6 g

6. The velocity of a water stream is being measured by a L-shaped Pitot tube and the reading is 0.46 m. What is the approximate value of velocity?
(A) 19.6 m/s (B) 3 m/s
(C) 9.8 m/s (D) 30 m/s

7. A body will be in stable equilibrium in a floating conditions if
(A) the metacentre is below the centre of gravity
(B) the metacentre is above the centre of gravity
(C) the metacentric height is zero
(D) the centre of buoyancy coincide with the centre of gravity

8. A gas weighs 19.62 N/m^3 at 25°C. The density of the gas in kg/m^3 will be
(A) 4 (B) 0.5
(C) 2 (D) Not Possible

9. A plate 0.04 mm distant from a fixed plate, moves at 65 cm/sec and required a force of 2.5 N/m^2 to maintain this speed. The dynamic viscosity (N-sec/m^2) of the fluid between the plates will be
(A) 2.69×10^{-4} (B) 8.31×10^{-6}
(C) 1.54×10^{-4} (D) 0.84×10^{-5}

10. The pressure drop in a 120 mm diameter horizontal pipe is 60 kPa over a length of 12 m. The shear stress (in kPa) at the pipe wall is
(A) 15 (B) 0.3
(C) 36 (D) 0.15

11. A body weighing 10 kg and occupying 0.02 m^3 volume will be completely submerged in a fluid having specific gravity of
(A) 1 (B) 5
(C) 0.75 (D) 0.5

12. The flow profile of a fluid depends upon
(A) the diameter of tube
(B) velocity of the fluid
(C) the Reynolds number
(D) the surface roughness

13. The continuity equation represents the conservation of
(A) Mass (B) Energy
(C) Force (D) Momentum

14. The value of momentum correction factor for turbulent flow through pipes is
(A) 4/3 (B) 1.2
(C) 2 (D) 3/4

15. If the stream function is given by $\psi = 5xy$ then the velocity (in units) at a pint (4, 6) will be
(A) 25 (B) 36
(C) 49 (D) 64

16. 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 twice the length has to carry a discharge of 2Q, then the head loss is
(A) $\frac{H}{2}$ (B) H
(C) $\frac{H}{4}$ (D) $\frac{H}{8}$

17. A cylindrical vessel 12 cm in diameter and 30 cm height is filled with water up to the top. The vessel is open at the top. If the vessel is rotated by 300 rpm about its vertical axis then the quantity of water left in the container (in m^3) will be
(A) 2.372×10^{-3} (B) 1.01×10^{-3}
(C) 3.39×10^{-3} (D) 4.4×10^{-3}

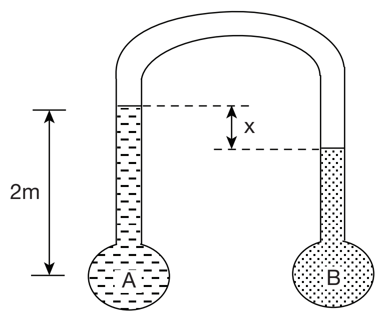
18. The velocity distribution in a boundary layer is given by $u = U\left[\frac{y}{\delta}\right]$ where, u = Velocity of fluid at vertical distance y from the surface of plate.

δ = Boundary layer thickness at distance x from the leading edge of plate.

The value of shape factor will be

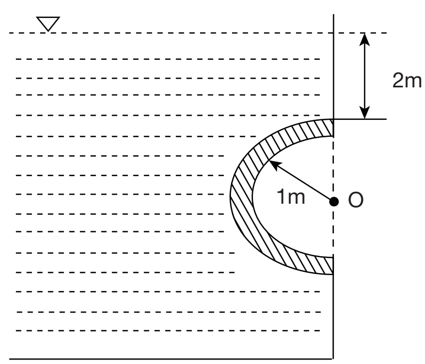
(A) 2.5 (B) 2
(C) 4 (D) 3

19. Two pipes A and B are in the same elevation as shown in the figure. Water is contained in A and rises to a level of 2.0 m above it. Carbon tetrachloride (Sp.$gr.$ = 1.59) is contained in B.
The inverted U-tube is filled with compressed air at 320 kN/m^2 and 30°C. Barometer reads 760 mm of mercury. If x = 0.5 m then the pressure difference in kN/m^2 between A and B is



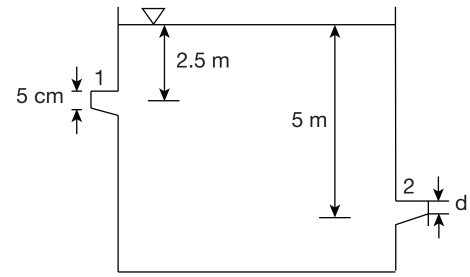
(A) 7.82 (B) 3.78
(C) 5.59 (D) 4.68

20. A spherical viewing port exist 2 m below the static water surface of a tank as shown in figure. What is the magnitude of the resultant thrust in kN on the viewing port?



(A) 20.5 (B) 92.4
(C) 94.7 (D) 112.9

21. A tank, shown in figure, has a nozzle of exit diameter 5 cm at a depth of 2.5 m below the surface. At the side opposite to this nozzle, another nozzle of diameter 'd' is attached to the tank at a depth 5 m from the free surface. If the net horizontal force on the tank is zero, then the value of 'd' in cm is



(A) 2.5 (B) 2.95
(C) 3.25 (D) 3.5

22. Match List-I (Phenomenon) with List-II (Condition) and select the correct answer using the codes given below the lists.

List-I	List-II
A. Singularities	1. Vorticity exist
B. Irrotational flow	2. Velocity zero or infinite
C. Streamline spacing	3. Proportional to velocity
D. Rotational flow	4. Vorticity is zero

Codes:

	A	B	C	D
(A)	2	4	3	1
(B)	3	1	2	4
(C)	3	4	2	1
(D)	2	1	3	4

23. Three pipes of length 1000 m, 800 m and 500 m and of diameter 600 mm, 500 mm and 200 mm respectively are connected in series. These pipes are to be replaced by a single pipe of length 2000 m. What is the diameter of the single pipe?

(A) 347 mm (B) 329 mm
(C) 263 mm (D) 279 mm

24. A shaft of 120 mm diameter rotates at 80 rpm in a 240 mm long bearing. Taking that the two surfaces are uniformly seperated by a distance of 0.5 mm and taking linear velocity distribution in the lubricating oil having dynamic viscosity of 4 centipoise, what is the power absorbed in the bearing in Watts?

(A) 0.183 (B) 0.052
(C) 0.249 (D) 0.169

25. A pipe line 80 cm diameter bifurcates at a Y-junction into two branches 60 cm and 45 cm in diameter. If the rate of flow in the main pipe is 2 m^3/s and mean velocity of flow in 45 cm diameter pipe is 6 m/s, then the velocity in 60 cm diameter pipe in m/s will be

(A) 3.37 (B) 7.07
(C) 4.56 (D) 3.7

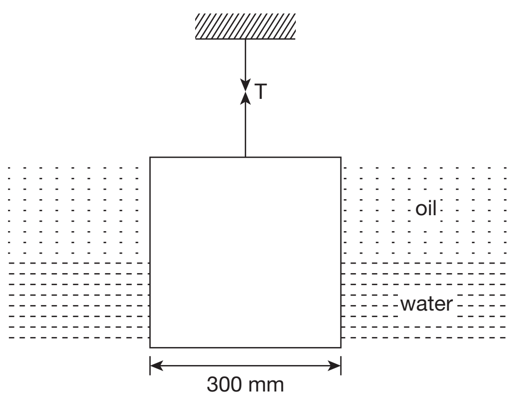
26. A jet of water of diameter 60 mm, having a velocity of 22 m/s strikes a curved vane which is moving with a

velocity of 10 m/s in the direction of jet. The jet leaves the vane at an angle of 60° to the direction of motion of vane at outlet. Neglect all losses. What will be the force exerted by the jet (in N) on the vane in the direction of motion?
(A) 349.2 (B) 520.7
(C) 447.9 (D) 569.1

27. A water turbine delivering 20 MW power is to be tested with the help of a geometrically similar 1 : 10 model which runs at the same speed as the prototype. Assuming the efficiencies of the model and the prototype are equal, the ratio of heads of prototype to model is
(A) 0.03 (B) 0.046
(C) 32.768 (D) 21.54

28. The mean velocities at two ends of a stream tube 12 cm apart are 5 m/s and 2.5 m/s. The convectional tangential acceleration midway in m/s^2 will be
(A) 78.125 (B) 39.06
(C) 156.25 (D) 104.16

29. An aluminium cube of 300 mm on a side is suspended by a string in oil and water as shown below. The cube is submerged with half of it being in oil and the other half in water. If specific gravity of oil is 0.8 and the specific weight of aluminium is 25.93 kN/m^3, then the tension in the string in *N* is



(A) 521.3 (B) 461.7
(C) 239.1 (D) 700.11

30. Match List-I with List-II and select the correct answer using the codes given the lists.

List-I	List-II
A. Impulse turbine	1. Low heads
B. Turbular turbine	2. Micro-hydel projects
C. Kaplan turbine	3. Medium to high head
D. Francis turbine	4. Very high head hydel projects.

Codes:

	A	*B*	*C*	*D*
(A)	4	2	1	3
(B)	4	1	2	3
(C)	1	3	4	2
(D)	3	4	2	1

31. A fluid of viscosity 0.8 N-s/m^2 and specific gravity 1.6 is flowing through a circular pipe of diameter 150 mm. The maximum shear stress at the pipe wall is given as 200 N/m^2. What will be the average velocity of flow in m/s?
(A) 4.7 (B) 3.6
(C) 5.8 (D) 2.9

Common Data Questions 32 and 33

For the velocity profile in laminar boundary layer as

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

The plate is 3 m long and 2.4 m wide and it is placed in water which is moving with a velocity of 0.5 m/sec. Take μ for water as 0.03 × 10^{-1} N-s/m^2. Assume the follow data:

$$\delta=\frac{4.64\,x}{\sqrt{R_{ex}}}$$

$$C_{fx}=\frac{0.646}{\sqrt{R_{ex}}}$$

$$C_D=\frac{1.292}{\sqrt{R_{ex}}}$$

32. The shear stress (N/m^2) 2.0 m from the leading edge of plate is
(A) 0.023 (B) 0.14
(C) 0.236 (D) 0.014

33. The total drag force (in N) on the plate is
(A) 2.234 (B) 4.911
(C) 5.321 (D) 3.288

Linked Data Questions 34 and 35

A reaction turbine works at 600 rpm under a head of 150 m. Its diameter at inlet is 120 cm and the flow area is 0.5 m^2. The angles made by absolute and relative velocities at inlet are 20° and 60° respectively with the tangential velocity. Assume whirl at outlet to be zero.

34. The volume flow rate in m^3/sec is
(A) 8.7 (B) 9.9
(C) 7.6 (D) 8.1

35. The power developed in MW is
(A) 21.25 (B) 15.65
(C) 10.65 (D) 12.95

Answer Keys

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

Hints and Explanations

1. Speed ratio $= \dfrac{u}{\sqrt{2gH}}$

$$\Rightarrow u = 0.48 \times \sqrt{2 \times 9.81 \times 1600}$$

$\Rightarrow$ u = 85.045 m/s Choice (D)

2. $h_f = \dfrac{4fLV^2}{2gD}$ and $f = \dfrac{0.0791}{(R_e)^{\frac{1}{4}}}$

Now, $R_e = \dfrac{\rho VD}{\mu}$

$$\therefore h_f = \frac{4L}{2g\,D} \times \frac{0.0791}{\left(\dfrac{\rho\,D}{\mu}\right)^{\frac{1}{4}} \times (V)^{\frac{1}{4}}} \times V^2$$

$\therefore h_f \propto (V)^{\frac{7}{4}}$ Choice (C)

3. Assumption made in derivation of Bernoulli's equation
(1) The fluid is ideal i.e., zero viscosity
(2) Steady flow
(3) Incompressible flow Choice (B)

4. Unit discharge, $Q_u = \dfrac{Q}{\sqrt{H}}$

$$\Rightarrow Q_u = \frac{0.5}{\sqrt{25}}$$

$\Rightarrow$ Q_u = 0.1 m^3/sec Choice (A)

5. $\tan\theta = \dfrac{a}{g}$

$\Rightarrow$ $a = \tan(58^\circ) \times g = 1.6g$ Choice (D)

6. $\dfrac{V^2}{2g} = 0.46$ m

$$\Rightarrow V = \sqrt{2 \times 9.81 \times 0.46}$$

$\Rightarrow$ V = 3 m/s Choice (B)

8. We know that, $w = \rho g$
$\Rightarrow$ $19.62 = \rho \times 9.81$
$\Rightarrow$ $\rho = 2$ kg/m^3 Choice (C)

9. $\tau = \mu \dfrac{du}{dy}$

$$\Rightarrow 2.5 = \frac{\mu \times 0.65}{0.04 \times 10^{-3}}$$

$\Rightarrow \mu = 1.54 \times 10^{-4}\ \dfrac{N\text{-sec}}{\text{m}^2}$ Choice (C)

10. $\tau = \left(\dfrac{dP}{dx}\right)\dfrac{R}{2}$

$$= \frac{60 \times 10^3}{12} \times \frac{0.12}{2 \times 2}$$

= 0.15 kPa Choice (D)

11. Weight of body = γ × volume of fluid displaced
$\Rightarrow$ $10 \times 9.81 = \rho \times 9.81 \times 0.02$
$\Rightarrow$ $\rho = 500$ kg/m^3
$\therefore$ Specific gravity $= \dfrac{\rho}{\rho_w} = \dfrac{500}{1000}$

= 0.5 Choice (D)

12. By Reynolds number only, the flow can be predicted as laminar or turbulent. Choice (C)

13. Continuity equation represents the conservation of mass

$$\dot{m} = \rho\,AV$$

$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$ Choice (A)

14. Choice (A)

15. $u = -\dfrac{d\Psi}{dy}$ and $v = -\dfrac{d\Psi}{dx}$

$u = -5x$ and $v = -5y$
At (4, 6)
$u = -20$ and $v = -30$
$\therefore$ Resultant $= \sqrt{u^2 + v^2}$

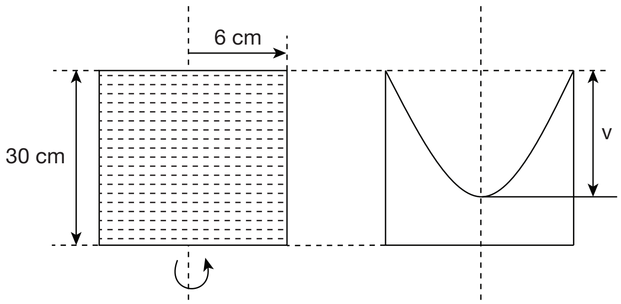
$= \sqrt{20^2 + 30^2}$ = 36 units Choice (B)

16. $H = \dfrac{f\,LQ^2}{12\,d^5}$

Now, $H_1 = \dfrac{f\,(2L)(2Q)^2}{12(2d)^5}$

$\Rightarrow H_1 = \dfrac{2^3}{2^5}\,\dfrac{f\,LQ^2}{12\,d^5} \Rightarrow H_1 = \dfrac{H}{4}$ Choice (C)

17.



$$y=\frac{\omega^2 r^2}{2g} \Rightarrow y=\frac{\left[\frac{2\pi\times 300}{60}\right]^2\times 0.06^2}{2\times 9.81}$$

$\Rightarrow$ $y = 0.18$ m

Initial volume of water in vessel $= \pi r^2 h$

$=\pi\times 0.06^2\times 0.3$

$= 3.39 \times 10^{-3}$ m^3

Volume of paraboloid $=\frac{1}{2}\pi r^2 h$

$=\frac{1}{2}\times\pi\times 0.06^2\times 0.18$

$= 1.0178 \times 10^{-3}$ m^3

$\therefore$ Volume left $= (3.39 – 1.0178) \times 10^{-3}$

$= 2.372 \times 10^{-3}$ m^3 Choice (A)

18. Shape factor $=\frac{\delta^*}{\theta}$

$$\delta^*=\int_0^{\delta}\left(1-\frac{u}{U}\right)dy \Rightarrow \delta^*=\int_0^{\delta}\left\{1-\frac{y}{\delta}\right\}dy$$

$\Rightarrow$ $\delta^*=\frac{\delta}{2}$

$$\theta=\int_0^{\delta}\frac{u}{U}\left\{1-\frac{u}{U}\right\}dy \Rightarrow \theta=\int_0^{\delta}\frac{y}{\delta}\left\{1-\frac{y}{\delta}\right\}dy$$

$\Rightarrow \theta=\frac{\delta}{6}$

$\therefore$ Shape factor $=\frac{\delta/2}{\delta/6}=3$ Choice (D)

19. $\frac{P_A}{\gamma}-2=\frac{P_3}{\gamma}-\left[(2-0.5)\times 1.59\right]$

$\Rightarrow \frac{P_B-P_A}{\gamma}=0.385$

$\Rightarrow$ $P_B – P_A = 3.78$ kN/m^2 Choice (B)

20. Horizontal force, $F_H = \rho g \bar{x} A$

$\Rightarrow$ $F_H = 1000 \times 9.81 \times (2 + 1) \times \pi \times 1^2$

$\Rightarrow$ $F_H = 92.457$ kN

Vertical force, $F_v = \rho g \times$ Volume of liquid displaced

$= 1000 \times 9.81 \times \frac{4}{6} \times \pi \times 1^3$

$= 20.546$ kN

Resultant Force $=\sqrt{F_H^2+F_v^2}$

$=\sqrt{92.457^2+20.546^2}$

$= 94.712$ kN Choice (C)

21. Applying Bernoulli's theorem between free surface and exit of nozzle 1.

$$\frac{P_{atm}}{\rho g}+0+2.5=\frac{P_{atm}}{\rho g}+\frac{V_1^2}{2g}+0$$

$\Rightarrow V_1=\sqrt{2\times 9.81\times 2.5}$

$\Rightarrow$ $V_1 = 7$ m/s

Similarly, $V_2=\sqrt{2\times 9.81\times 5}$

$\Rightarrow$ $V_2 = 9.9$ m/s

Mass flow rate, $\dot{m}_1=\rho\times\frac{\pi}{4}\times 0.05^2\times V_1$

$=1000\times\frac{\pi}{4}\times 0.05^2\times 7$

$= 13.745$ kg/sec

and $\dot{m}_2=\rho\times\frac{\pi}{4}\times d^2\times 9.9$

$= 7775.442\, d^2$

Now applying momentum equation and equate it to zero because the net horizontal force acting on tank is zero.

$\Rightarrow$ $F_x=\dot{m}_1(-V_1)+\dot{m}_2 V_2=0$

$\Rightarrow$ $– [13.745 \times 7] + [7775.442 \times d^2 \times 9.9] = 0$

$\Rightarrow$ $d = 0.03535$ m $= 3.53$ cm Choice (D)

22. Choice (A)

23. $\because$ Pipes are connected in series

$h_L = h_{L1} + h_{L2} + h_{L3}$

$$\Rightarrow h_L=\frac{f L_1 Q^2}{12 d_1^5}+\frac{f L_2 Q^2}{12 d_2^5}+\frac{f L_3 Q^2}{12 d_3^5}$$

Now a compound pipe is said to be equivalent to a pipe of constant diameter if discharge and head loss in both the pipes are same

$\therefore h_{Le}=\frac{f L_e Q^2}{12 d_e^5}$

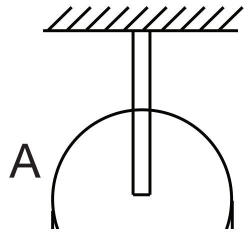
and $h_{Le} = h_L$

$$\Rightarrow \frac{L_e}{d_e^5}=\frac{L_1}{d_1^5}+\frac{L_2}{d_2^5}+\frac{L_3}{d_3^5}$$

$$\Rightarrow \frac{2000}{d_e^5}=\frac{1000}{0.6^5}+\frac{800}{0.5^5}+\frac{500}{0.2^5}$$

$\Rightarrow$ $d_e = 0.2626$ m $\cong 263$ mm Choice (C)

24.



$$u = \frac{\pi DN}{60} = \frac{\pi \times 0.12 \times 80}{60}$$

$\Rightarrow$ $u = 0.502655$ m/s

Now $\tau = \mu \frac{du}{dy} \Rightarrow \tau = \frac{\mu u}{y}$

$\Rightarrow$ $\tau = \frac{0.04 \times 10^{-1} \times 0.502655}{0.5 \times 10^{-3}}$

$\Rightarrow$ $\tau = 4.02$ N/m^2

Viscous resistance, $F = \tau \times A$

$\Rightarrow$ $F = 4.02 \times \pi DL$

$\Rightarrow$ $F = 4.02 \times \pi \times 0.12 \times 0.24$

$\Rightarrow$ $F = 0.364$ N

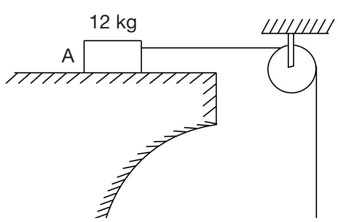
Power, $P = F \times u$

$= 0.364 \times 0.502655$

$= 0.183$ Watt

Choice (A)

25.



$d_1 = 0.8$ m

$d_2 = 0.6$ m

$d_3 = 0.45$ m

Now $Q_1 = Q_2 + Q_3$

$Q_1 = 2$ m^3/s (Given)

$Q_3 = A_3\, V_3$

$\Rightarrow$ $Q_3 = \frac{\pi}{4} \times 0.45^2 \times 6$

$\Rightarrow$ $Q_3 = 0.95426$ m^3/s

$\therefore$ $Q_2 = Q_1 - Q_3$

$\Rightarrow$ $Q_2 = 2 - 1.2723$

$\Rightarrow$ $Q_2 = 1.0457$ m^2/sec

Now $Q_2 = A_2\, V_2$

$\Rightarrow$ $\Rightarrow \frac{\pi}{4} \times 0.6^2 \times V_2 = 1.0457$

$\Rightarrow$ $V_2 = 3.698$ m/s

~ 3.7 m/s

Choice (D)

26.

We know that, $F_x = \rho A V_{r_1} \left[V_{w_1} - V_{w_2} \right]$

<u>Given:-</u> $V_1 = V_{w_1} = 22$ m/s

$u_1 = u_2 = u = 10$ m/s

$V_{r_1} = V_{r_2}$

Now $V_{r_1} = V_1 - u = 22 - 10$

$\Rightarrow V_{r_1} = V_{r_2} = 12$ m/s

In Δ EGF, $\frac{V_{r_2}}{\text{Sin}\,60^o} = \frac{u_2}{\text{Sin}(120 - \varphi)}$

$\Rightarrow \frac{12}{\text{Sin}\,60^o} = \frac{10}{\text{Sin}(120 - \varphi)}$

$\Rightarrow$ $\phi = 73.8^o$

From ΔEGH, $\text{Cos}\phi = \frac{(u_2 - V_{w_2})}{V_{r_2}}$

$\Rightarrow$ $\text{Cos}\ 73.8^o = \frac{10 - V_{w_2}}{12}$

$\Rightarrow V_{w_2} = 6.653$ m/s

$\therefore$ $F_x = 1000 \times \frac{\pi}{4} \times 0.06^2 \times 12 \times [12 - 6.653]$

$\Rightarrow$ $F_x = 520.711$ N

Choice (B)

27. Given: $\frac{D_p}{D_m} = 10, P_p = 20$ MW

and $\left[\frac{P}{\rho g\, QH}\right]_p = \left[\frac{P}{\rho g\, QH}\right]_m$ ----------- (1)

Now $\left[\frac{Q}{ND^3}\right]_p = \left[\frac{Q}{ND^3}\right]_m$

$\because$ $N_p = N_m$

$\therefore \frac{Q_p}{Q_m} = \left(\frac{D_p}{D_m}\right)^3 \Rightarrow \frac{Q_p}{Q_m} = 10^3$

and $\left[\frac{P}{N^3\, D^5}\right]_p = \left[\frac{P}{N^3\, D^5}\right]_m$

$\Rightarrow \frac{P_p}{P_m} = \left(\frac{D_p}{D_m}\right)^5 \Rightarrow \frac{P_p}{P_m} = (8)^5$

From equation (1) we get

$\frac{H_p}{H_m} = \frac{Q_m}{Q_p} \times \frac{P_p}{P_m}$

$\Rightarrow \frac{H_p}{H_m} = \frac{1}{10^3} \times 8^5 = 32.768$

Choice (C)

28. Convectional tangential acceleration

$$u\frac{du}{dx}=u\frac{-du}{dx}=\left(\frac{5+2.5}{2}\right)\times\left[\frac{5-2.5}{0.12}\right]=78.125\,\text{m/s}^2$$

Choice (A)

29. $T = W - F_B$

$$\Rightarrow T=\left[25.93\times10^3\times0.3^3\right]-9.81\times10^3\left[\left(\frac{0.3^3}{2}\times0.8\right)+\left(\frac{0.3^3}{2}\times1\right)\right]$$

$\Rightarrow$ T = 461.727 N Choice (B)

30. Choice (A)

31. $\tau_o = -\left(\frac{\partial P}{\partial x}\right)\frac{R}{2}$

$$\Rightarrow\left(\frac{\partial P}{\partial x}\right)=-\frac{\tau_o\times2}{R}$$

$$\Rightarrow\left(\frac{\partial P}{\partial x}\right)=-\frac{200\times2}{0.075}$$

$$\Rightarrow\left(\frac{\partial P}{\partial x}\right)=-5333.34\ \text{N/m}^2\ \text{per m}$$

Now Average velocity(u) = $\frac{U_{max}}{2}$

$$\Rightarrow u=\frac{1}{2}\left[-\frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)R^2\right]$$

$$\Rightarrow u=\frac{1}{2}\left[+\frac{1}{4\times0.8}\times5333.34\times0.075^2\right]$$

$\Rightarrow$ u = 4.687 m/s

or u ~ 4.7 m/s Choice (A)

32. $R_{e_x}=\frac{\rho Ux}{\mu}=\frac{1000\times0.5\times2.0}{0.03\times10^{-1}}\Rightarrow R_{e_x}=3.34\times10^5$

Now shear stress, $\tau_o = 0.323\frac{\mu U}{x}\sqrt{R_{e_x}}$

$$\Rightarrow\tau_o=0.323\times\frac{0.03\times10^{-1}\times0.5}{2}\sqrt{3.34\times10^5}$$

$\Rightarrow$ τ_o = 0.14 N/m^2 Choice (B)

33. Now Drag force = $0.646\,\mu U\sqrt{\frac{\rho U L}{\mu}}\times b$

$$=0.646\times0.03\times10^{-1}\times0.5\times\sqrt{\frac{1000\times0.5\times3}{0.03\times10^{-1}}}\times2.4$$

= 1.644 N

Total drag force = 2 × 1.644 = 3.288 N Choice (D)

34. **Given:**

H = 150 m

N = 600 rpm

D_1 = 1.2 m

$\pi\ D_1\times B_1=0.5\ \text{m}^2$

α = 20°, θ = 60° and $V_{w_2}=0$

Tangential velocity at inlet

$$u_1=\frac{\pi\ D_1\ N}{60}=\frac{\pi\times1.2\times600}{60}$$

$\Rightarrow$ u_1 = 37.7 m/s

From inlet velocity triangle

$$\tan\alpha=\frac{V_{f_1}}{V_{w_1}}\Rightarrow\tan20^o=\frac{V_{f_1}}{V_{w_1}}$$

$$\Rightarrow\frac{V_{f_1}}{V_{w_1}}=0.364\Rightarrow V_{f_1}=0.364V_{w_1}$$

Also $\tan\theta=\frac{V_{f_1}}{V_{w_1}-u_1}\Rightarrow\frac{0.364V_{w_1}}{V_{w_1}-37.7}=\tan60^o$

$$\Rightarrow V_{w_1}=47.734\,\text{m/s}$$

and $V_{f_1}=0.364\times V_{w_1}=0.364\times47.734$

$$\Rightarrow V_{f_1}=17.375\,\text{m/s}$$

Now $Q=\pi\,D_1\,B_1\times V_{f_1}$

$\Rightarrow$ Q = 0.5 × 17.375

$\Rightarrow$ Q = 8.687 m^3/s

~ 8.7 m^3/s Choice (A)

35. Work done per second = $\rho Q\left[V_{w_1}\ u_1\right]$

= 1000 × 8.7 × [47.734 × 37.7]

= 15.656 MW

∴ Power developed = 15.65 MW Choice (B)