Fluid Mechanics Test 4

Number of Questions: 25 **Time:60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. A viscous fluid is flowing with some velocity through a pipe. Which of the following statement is CORRECT?
   (A) Shear stress and velocity are maximum at the pipe wall.
   (B) Shear stress is minimum at centre of pipe and velocity is maximum at pipe wall.
   (C) Shear stress and velocity are maximum at the centre of the pipe.
   (D) Shear stress is maximum at pipe wall and velocity is maximum at centre of pipe.

2. A laminar flow is taking place in a pipe of a diameter 100 mm. The radius at which mean velocity occurs will be
   (A) 50 mm (B) 70.71 mm
   (C) 35.35 mm (D) 42.32 mm

3. What is the maximum efficiency of power transmission through pipes?
   (A) 60% (B) 50%
   (C) 100% (D) 66.67%

4. A Francis turbine running at 200 rpm develops 5 MW power under a head of 25 m. Determine the power output under head of 100 m.
   (A) 30 MW (B) 45 MW
   (C) 35 MW (D) 40 MW

5. A fluid of specific density 0.8 is flowing through a 0.2 m diameter pipe with a velocity of 2 m/s. The mass flow rate (kg/hr) will be
   (A) 4π (B) 144π
   (C) 14400π (D) 400π

6. Which one of the following turbines is used in under water power station?
   (A) Pelton turbine
   (B) Tubular turbine
   (C) Deriaz turbine
   (D) Turbo-impulse turbine

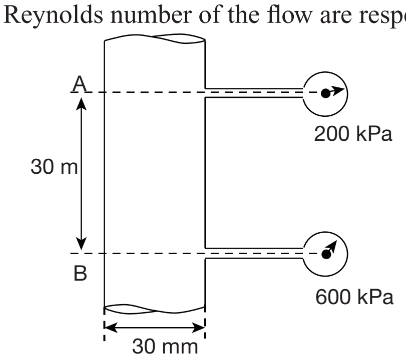
7. A 1 : 200 scale of model of a reservoir is drained in 5 minutes by opening the gate. The time required to empty the prototype will be (in minutes)
   (A) 28 (B) 64
   (C) 36 (D) 70.71

8. The hydrodynamic boundary layer thickness is defined as the distance from the surface where the
   (A) velocity equal the local external velocity
   (B) velocity equal the approach velocity
   (C) momentum equals 99% of the momentum of the free stream.
   (D) velocity equals 99% of the local external velocity.

9. In the entrance region of a pipe, the boundary layer grows and the inviscid core accelerates. This is accompanied by a
   (A) rise in pressure
   (B) constant pressure gradient
   (C) fall in pressure in the flow direction
   (D) Pressure pulse

10. Specific speed of Kaplan turbine and its practical range are respectively
   (A) $\dfrac{N\sqrt{P}}{(H)^{\frac{5}{4}}}$ and 200 to 480
   (B) $\dfrac{H\sqrt{P}}{(H)^{\frac{3}{4}}}$ $\dfrac{N\sqrt{P}}{(H)^{\frac{3}{4}}}$ and 200 to 480
   (C) $\dfrac{N\sqrt{P}}{(H)^{\frac{5}{4}}}$ and 600 to 1000
   (D) $\dfrac{N\sqrt{P}}{(H)^{\frac{3}{4}}}$ and 600 to 1000

11. Oil of dynamic viscosity 0.15 Ns/m^2 and relative density 0.9 flows through a 30 mm diameter vertical pipe. The pressure gauges fixed 30 m apart read 600 kPa and 200 kPa as shown in the figure. The direction of flow of oil and Reynolds number of the flow are respectively



   (A) *B* to *A* and 108.1 (B) *B* to *A* and 152.1
   (C) *A* to *B* and 108.1 (D) *A* to *B* and 152.1

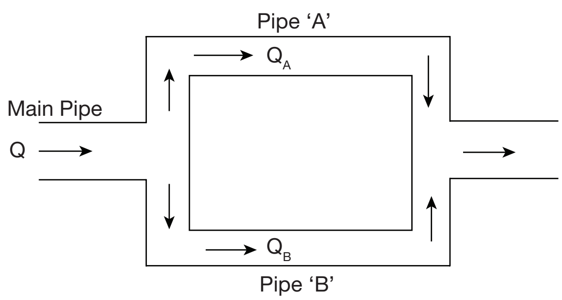
12. A pipe line of 2 km and 120 mm diameter is to carry glycerin of dynamic viscosity 0.8 Ns/m^2. The minimum power required to just make the glycerin flow in the pipe line at the rate of 10 litres/sec will be
   (A) 31.44 kW (B) 21.49 kW
   (C) 26.32 kW (D) 41.39 kW

13. At a sudden enlargement of a water pipeline from a diameter of 0.24 m to 0.48 m, the hydraulic gradient line rises by 10 mm, the discharge (in m^3/sec) will be
   (A) 32.7×10^{-3} (B) 20.64×10^{-3}
   (C) 24.34×10^{-3} (D) 36.79×10^{-3}

14. A main pipe carrying a fluid with a discharge of 'Q' is divided into two branches as shown in the figure. Pipe 'A' and 'B' are of equal length, made of same material and friction loss is also equal. If pipe 'A' is of diameter equal to the twice of pipe 'B' diameter then which of the following condition is CORRECT?

Q_A = Discharge in Pipe A

Q_B = Discharge in Pipe B



(A) $Q_A = 0.80\ Q$ (B) $Q_B = 0.25\ Q$
(C) $Q_A = 0.85\ Q$ (D) $Q_B = 0.10\ Q$

15. A pipe of 1.5 m diameter is required to transport an oil of density 900 kg/m^3 and kinematic viscosity 3×10^{-2} stokes at the rate of 3 m^3/sec. If a 15 cm diameter pipe with water having kinematic viscosity of 0.01 stokes is used to model the above flow then the discharge (in m^3/s) in the model will be

(A) 0.01 (B) 0.099
(C) 0.079 (D) 0.089

16. For air over a flat plate, the velocity (u) and boundary layer thickness (δ), can be expressed as $\dfrac{U}{U_\infty} = \dfrac{3y}{2\delta} - \dfrac{y^3}{2\delta^3}$

and $\delta = \dfrac{4.64x}{\sqrt{\mathrm{Re}_x}}$ where

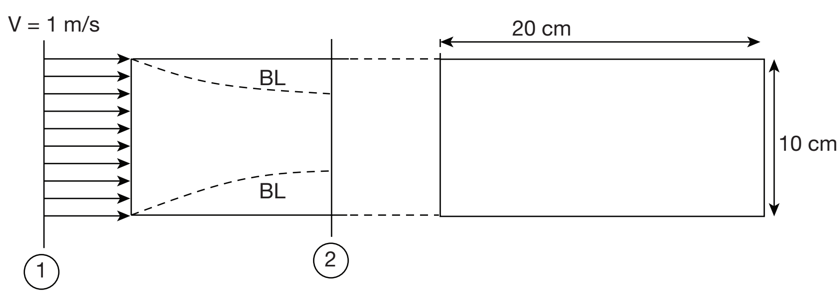
y = vertical distance of any section of fluid from the flat plate

x = Distance from the leading edge.

If the free stream velocity (U_∞) is 2 m/s, kinematic viscosity = 1.5×10^{-5} m^2/sec and density of the fluid is 1.23 kg/m^3 the shear stress (N/m^2) on the surface of the plate at x = 1 m will be

(A) 3.92×10^{-3} (B) 4.11×10^{-2}
(C) 4.356×10^{-2} (D) 4.356×10^{-3}

17. Air enters a horizontal vertical duct of cross-section 20 cm × 10 cm at a uniform velocity of 1 m/s as shown in the figure. Boundary layer starts to grow on all four walls and the boundary layer thickness (δ) at section (2) was measured to be 4 cm on each of four walls. If the displacement thickness (δ^*) = δ/8, assuming the flow to be steady incompressible, the pressure difference (in Pa) between section (1) and (2) will be (Take density of air = 1.15 kg/m^3 and neglect viscous losses outside the boundary layer)



(A) zero (B) 1.0
(C) 0.50 (D) 0.211

18. For a laminar flow of viscous fluid over a flat plate if the shear stress on surface of the plate at a section 2 m from the leading edge is 60 N/m^2 then the shear stress (in N/m^2) on surface of the plate at a section 2.5 m from the leading edge will be

(A) 53.66 (B) 60.00
(C) 62.23 (D) 57.64

19. A fluid flow phenomenon is to be studied in a model which is to be constructed by using Froude model law. The ratio of discharge in model to the discharge in prototype, if 'L_r' is given as scale ratio, will be

(A) $L_r^{\frac{1}{2}}$ (B) $L_r^{\frac{3}{2}}$

(C) $L_r^{\frac{5}{2}}$ (D) L_r^{2}

20. The shear stress distribution in laminar boundary layer is given by $\tau = \tau_0\left[1 - \dfrac{y}{\delta}\right]$

Where τ_o = shear stress on the plate wall

δ = Boundary layer thickness

y = Vertical distance from the plate wall

The displacement thickness will be

(A) δ/3 (B) 2δ/15
(C) δ/5 (D) δ/15

21. A jet of water 50 mm in diameter having a velocity of 20 m/s strikes normally a flat smooth plate. If the plate is moving in the same direction as the jet with velocity of 8 m/s then the work done per second on the plate (watts) will be

(A) 1236.4 (B) 2031.14
(C) 6281.6 (D) 2261.36

22. The following data refer to a water wheel comprising a series of flat plates mounted on the periphery of the wheel radially. Diameter of the wheel upto the centre of the plates is 1.26 m. Diameter of free jet is 168 mm. Head at the beginning of the nozzle is 18.3 m, coefficient of velocity of nozzle is 0.97 and speed of the wheel is 120 rpm. Calculate power delivered to water wheel.

(A) 21.23 kW (B) 33.73 kW
(C) 41.37 kW (D) 37.41 kW

23. An inward flow reaction turbine operating under 30 m head develops 4000 kW while running at 300 rpm. The overall efficiency of the water turbine is 0.85. The hydraulic efficiency is 0.9 and the radial velocity of flow at inlet is 7 m/sec. The inlet guide vane angle at full gate opening is 30°. If blade thickness coefficient is 5% and assuming that water leaves runner vane radially at exit then the width of the runner at inlet will be

(A) 0.36 (B) 0.26
(C) 0.98 (D) 0.55

24. A Pelton wheel is to be designed for the following specification:
Shaft power = 12000 kW, Head = 400 m, speed = 700 rpm, overall efficiency = 86%, jet diameter is not to exceed one-sixth of the wheel diameter, coefficient of velocity = 0.98, speed ratio = 0.45. The number of jet required will be

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

25. If vapor pressure of water is 2.6 m of water (absolute) and atmospheric pressure is 101.3 kPa, the maximum height of the runner exit of Francis turbine from the tail race level without causing cavitation will be
(Neglect kinetic energy head at exit of runner)

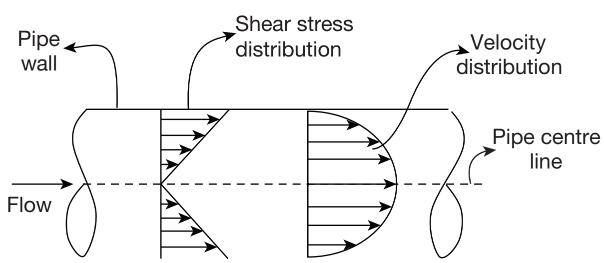
(A) 2.6 m (B) 4.31 m
(C) 7.72 m (D) 5.62 m

Answer Keys

1. D	**2.** C	**3.** D	**4.** D	**5.** C	**6.** B	**7.** D	**8.** D	**9.** C	**10.** C
11. B	**12.** A	**13.** A	**14.** C	**15.** B	**16.** D	**17.** D	**18.** A	**19.** C	**20.** A
21. D	**22.** B	**23.** D	**24.** A	**25.** C					

Hints and Explanations

1.



Choice (D)

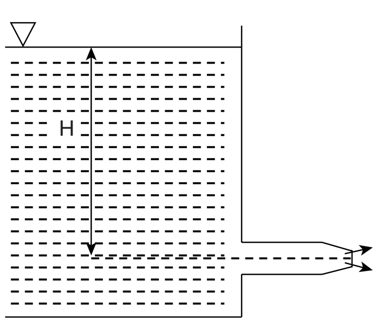
2. $\dfrac{u}{U_{\max}} = \left[1 - \dfrac{r^2}{R^2}\right]$ $\{\because$ Laminar flow$\}$

and $U_{\max} = 2u$ $\{u = \text{Mean velocity}\}$

$\therefore \quad 0.5 = 1 - \dfrac{r^2}{0.05^2} \left\{R = \dfrac{100}{2} = 50 \text{ mm}\right\}$

$\Rightarrow \quad r = 0.03535 \text{ m} = 35.35 \text{ mm}$ Choice (C)

3.



Theoretical power transmission, $P_{th} = \rho g Q H$
Actual power transmission, $P_{act} = \rho g\, Q(H - h_L)$
Where H = Net head available
h_L = Loss of head due to friction

$$\eta = \frac{P_{act}}{P_{th}} = \frac{H - h_L}{H} = 1 - \frac{h_L}{H} \qquad \text{——— (1)}$$

Now $P_{act} = \rho g\, Q(H - h_L) = \rho g\, Q\left[H - \dfrac{fLQ^2}{12D^5}\right]$

or $P_{act} = \rho g\left[HQ - \dfrac{fLQ^3}{12D^5}\right]$

For maximum power, $\dfrac{dP_{act}}{dQ} = 0$

$$\therefore \quad \frac{dP_{act}}{dQ} = \rho g\left[H - \frac{fL(3Q^2)}{12D^5}\right] = 0$$

$$\Rightarrow \quad H - \frac{3fLQ^2}{12D^5} = 0 \text{ or } H = 3h_L \qquad \text{——— (2)}$$

From equation (1) and (2) we get

$$\eta_{\max} = 1 - \frac{1}{3} = \frac{2}{3} = 0.6667 \text{ or } \eta_{\max} = 66.67\%$$

Choice (D)

4. $\left[\dfrac{P}{\rho D^2 \times (gH)^{3/2}}\right]_m = \left[\dfrac{P}{\rho D^2 (gH)^{3/2}}\right]_p$

$\because$ model and prototype are same

$$\therefore \quad \frac{P_m}{(100)^{3/2}} = \frac{5}{(25)^{3/2}} \Rightarrow P_m = 40 \text{ MW}$$

Choice (D)

5. $\dot{m} = \rho AV = 200 \times \frac{\pi}{4} \times 0.2^2 \times 2$

$\Rightarrow \quad \dot{m} = 4\pi$ kg/s or 14400π kg/hr Choice (C)

6. Choice (B)

7. $\because \quad t \propto \sqrt{h} \Rightarrow t_p = \sqrt{200}\, t_m$

$\Rightarrow \quad t_p = \sqrt{200} \times 5 = 70.71$ minutes Choice (D)

8. Choice (D)

9. The velocity is nearly rectangular at the entrance and it gradually changes to a parabolic profile at the fully developed region. Before the boundary layers from the periphery meet at the axis, there is corresponding fall in pressure. Choice (C)

10. Choice (C)

11. To find the direction, the total energy $\left[\frac{P}{\rho g} + \frac{V^2}{2g} + z\right]$ at the lower end B and upper end A is to be calculated.

But $A_A V_A = A_B V_B \Rightarrow V_A = V_B$ [$\because A_A = A_B$]

$$\therefore \quad E_A = \left[\frac{P}{\rho g} + z\right]_A = \left[\frac{200}{9.81 \times 0.9} + 30\right] = 52.652 \text{ m}$$

$$\text{and } E_B = \left[\frac{P}{\rho g} + z\right]_B = \left[\frac{600}{9.81 \times 0.9} + 0\right] = 67.96 \text{ m}$$

The direction of the flow is from the higher energy to the lower energy.

$\because \quad E_B > E_A$

Oil will flow from B to A

Now h_f = Peizometric head loss $= \frac{32\mu VL}{\rho g D^2}$

$$\text{or } (E_B - E_A) = \frac{32\mu VL}{\rho g D^2}$$

$$\Rightarrow \quad 67.96 - 52.652 = \frac{32 \times 0.15 \times V \times 30}{200 \times 9.81 \times 0.03^2}$$

$\Rightarrow \quad$ V = 0.845 m/s

$$\therefore \quad R_e = \frac{\rho VD}{\mu} = \frac{900 \times 0.845 \times 0.3}{0.15} = 152.1$$

Choice (B)

12. Loss of pressure head, $h_f = \frac{32\mu VL}{\rho g D^2}$

$$\text{or } h_f = \frac{32 V \partial L}{g D^2} = \frac{32 \times Q \partial \times L}{A \times g \times D^2}$$

Now power required = ρg × Q × h_f

$$= \frac{\mu}{\partial} \times g \times Q \times \frac{32 \times Q \times \partial \times L}{A \times g \times D^2}$$

$$= \frac{32\mu \times Q^2 \times L}{A \times D^2}$$

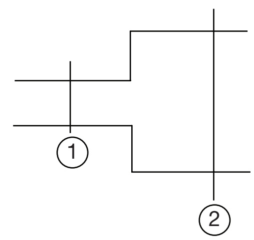
$$= \frac{32 \times 0.8 \times 0.01^2 \times 2000}{\frac{\pi}{4} \times 0.12^2 \times 0.12^2}$$

= 31438 W or 31.438 kW Choice (A)

13. $$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{P_2^2}{2g} + z_2 + \frac{(V_1 - V_2)^2}{2g}$$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \frac{(V_1 - V_2)^2}{2g}$$

$$\Rightarrow \quad \left[\frac{P_2}{\rho g} + z_2\right] - \left[\frac{P_1}{\rho g} + z_1\right] = \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - \frac{(V_1 - V_2)^2}{2g}$$



$$\Rightarrow \quad \frac{V_1^2 - V_2^2 - (V_1^2 + V_2^2 - 2V_1V_2)}{2g} = 10 \times 10^{-3}$$

$$= \frac{2V_1V_2 - 2V_2^2}{2g} = 10 \times 10^{-3}$$

Now $A_1 V_1 = A_2 V_2$

$\Rightarrow \quad 0.24^2 \times V_1 = 0.48^2 \times V_2$

$\Rightarrow \quad V_2 = 0.25\, V_1$

$$\therefore \quad \frac{2V_1 \times (0.25V_1) - 2(0.25V_1)^2}{2 \times 9.81} = 10 \times 10^{-3}$$

$\Rightarrow \quad V_1 = 0.7233$ m/s

$$Q = A_1 V_1 = \frac{\pi}{4} \times 0.24^2 \times 0.7233 = 0.0327 \text{ m}^3\text{/sec}$$

Choice (A)

14. This is a parallel connection type

$\therefore \quad h_{LA} = h_{LB}$

$$\Rightarrow \quad \left(\frac{fLQ^2}{12D^5}\right)_A = \left(\frac{fLQ^2}{12D^5}\right)_B$$

Now $f_A = f_B$; $L_A = L_B$

$$\therefore \quad \left(\frac{Q_A}{Q_B}\right)^2 = \left(\frac{D_A}{D_B}\right)^5 \Rightarrow \left(\frac{Q_A}{Q_B}\right)^2 = (2)^5$$

$$\text{or } \frac{Q_A}{Q_B} = \sqrt{(2)^5} \Rightarrow Q_A = 4\sqrt{2} Q_B$$

now $Q_A + Q_B = Q$

$\Rightarrow \quad 4\sqrt{2}\ Q_B + Q_B = Q$

$$\therefore \quad Q_B = \frac{Q}{(1 + 4\sqrt{2})} = 0.15Q$$

and $Q_A = 0.85Q$ Choice (C)

15. Given:

Prototype	Model
$D_P = 1.5$ m	$D_m = 15$ cm $= 0.15$ m
$\rho_p = 900$ kg/m^3	$\rho_m = 1000$ kg/m^3
$\vartheta_p = 3 \times 10^{-2}$ stoke	$\vartheta_m = 0.01$ stoke
$Q_P = 3$ m^3/sec	

Now $Q_P = A_P V_P$

$$\Rightarrow \quad \frac{\pi}{4} \times 1.5^2 \times V_P = 3$$

$$\Rightarrow \quad V_P = 1.6976 \text{ m/s}$$

$$R_e = \frac{\rho VD}{\mu} = \frac{VD}{\partial} \text{ and } (R_e)_P = (R_e)_m$$

$$\therefore \quad \frac{V_m D_m}{\partial_m} = \frac{V_P D_P}{\partial_P} \Rightarrow \frac{V_m \times 0.15}{0.01} = \frac{1.6976 \times 1.5}{3 \times 10^{-2}}$$

$$\Rightarrow \quad V_m = 5.66 \text{ m/s}$$

$$\therefore \quad Q_m = A_m V_m = \frac{\pi}{4} \times 0.15^2 \times 5.66$$

$$\Rightarrow \quad Q_m = 0.0999 \text{ m}^3\text{/sec}$$

Choice (B)

16. $u = U_\infty \left[\dfrac{3y}{2\delta} - \dfrac{y^3}{2\delta^3} \right]$

Shear stress, $\tau = \mu \dfrac{du}{dy}$

on surface, $\tau_0 = \mu \left. \dfrac{du}{dy} \right|_{y=0}$

$$\therefore \quad \left. \frac{du}{dy} \right|_{y=0} = U_\infty \left[\frac{3}{2\delta} - \frac{3y^2}{2\delta^3} \right]_{y=0}$$

$$\Rightarrow \quad \left. \frac{du}{dy} \right|_{y=0} = \frac{3U_\infty}{2\delta}$$

$$\therefore \quad \tau_0 = \frac{3\mu U_\infty}{2\delta} \text{ and } \delta = \frac{4.64x}{\sqrt{\text{Re}_x}}$$

$$\tau_0 = \frac{3\mu U_\infty \times \sqrt{\text{Re}_x}}{2 \times 4.64x}$$

$$\Rightarrow \quad \tau_0 = \frac{3\mu U_\infty}{2 \times 4.64 \times x} \times \sqrt{\frac{\rho U_\infty x}{\mu}}$$

$$\text{or } \tau_0 = \frac{3 \times \partial \times \rho \times U_\infty}{2 \times 4.64 \times x} \times \sqrt{\frac{U_\infty \times x}{\partial}}$$

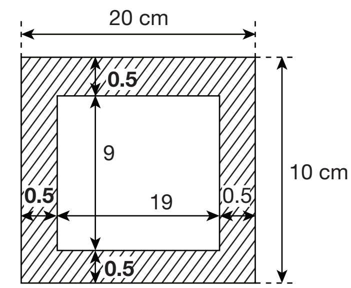
$$\Rightarrow \quad (\tau_0)_{x=1} = \frac{3 \times 1.5 \times 10^{-5} \times 1.23 \times 2}{2 \times 4.64 \times 1} \times \sqrt{\frac{2 \times 1}{1.5 \times 10^{-5}}}$$

$$\Rightarrow \quad (\tau_0)_{x=1} = 4.356 \times 10^{-3} \text{ N/m}^2$$

Choice (D)

17. $A_1 = 20 \times 10 = 200$ cm^2; $V_1 = 1$ m/s

Now, $\delta = 4$ cm and $\delta^* = \delta/8 = \dfrac{4}{8} = 0.5$ cm



$A_2 = 19 \times 9 = 171$ cm^2

$\therefore \quad A_1 V_1 = A_2 V_2$

$\Rightarrow \quad 200 \times 1 = 171 \times V_2 \quad \Rightarrow \quad V_2 = 1.1696$ m/s

Now Bernoulli's equation between section (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{\rho g} \Rightarrow \frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\Rightarrow \quad (P_1 - P_2) = \frac{\rho}{2}(V_2^2 - V_1^2) = \frac{1.15}{2} [1.1696^2 - 1^2]$$

$$\Rightarrow \quad (P_1 - P_2) = 0.211 \text{ Pa}$$

Choice (D)

18. We know that $\tau_o \propto \dfrac{1}{\sqrt{x}}$

$$\text{or } \frac{\tau_{01}}{\tau_{02}} = \sqrt{\frac{x_2}{x_1}} \Rightarrow \frac{60}{t_{02}} = \sqrt{\frac{2.5}{2}}$$

$$\Rightarrow \quad \tau_{02} = 53.66 \text{ N/m}^2$$

Choice (A)

19. $L_r = \dfrac{L_m}{L_P}$ {scale ratio}

Now $\dfrac{A_m}{A_p} = \dfrac{L_m b_m}{L_p b_p} = L_r . L_r = L_r^2$

Froude Model law: $(F_r)_m = (F_r)_p$

$$\Rightarrow \quad \left(\frac{V^2}{gL} \right)_m = \left(\frac{V^2}{gL} \right)_p \Rightarrow \left(\frac{V_m^2}{L_m} \right) = \left(\frac{V_p^2}{L_p} \right)$$

$$\Rightarrow \quad \frac{V_m^2}{V_p^2} = \frac{L_m}{L_p} \Rightarrow \frac{V_m}{V_p} = \sqrt{\frac{L_m}{L_p}} = \sqrt{L_r}$$

$$\text{Now } \frac{Q_m}{Q_p} = \frac{A_m V_m}{A_p V_p} = L_r^2 \sqrt{L_r} \Rightarrow \frac{Q_m}{Q_p} = L_r^{\frac{5}{2}}$$

Choice (C)

20. $\tau = \mu \dfrac{du}{dy} = \tau_0 \left[\left(1 - \dfrac{y}{\delta} \right) \right]$

$$\Rightarrow \quad \frac{du}{dy} = \frac{\tau_0}{\mu} \left[1 - \frac{y}{\delta} \right] \Rightarrow du = \frac{\tau_0}{\mu} \left[1 - \frac{y}{\delta} \right] dy$$

$$\Rightarrow \quad u = \frac{\tau_0}{\mu} \left[y - \frac{y^2}{2\delta} \right] + C$$

Boundary Conditions:

At $y = 0$, $u = 0$

$\therefore \quad C = 0$

$\therefore \quad u = \frac{\tau_0}{\mu}\left[y - \frac{y^2}{2\delta}\right]$

At $y = \delta$, $u = U_\infty$

$\therefore \quad U_\infty = \frac{\tau_0}{\mu}\left[\delta - \frac{\delta}{2}\right] = \frac{\tau_0}{\mu} \times \frac{\delta}{2}$

$\therefore \quad \frac{u}{U_\infty} = \frac{2}{\delta}\left[y - \frac{y^2}{2\delta}\right]$

Displacement thickness, $\delta^* = \int_0^\delta \left[1 - \frac{u}{U_\infty}\right] dy$

$\Rightarrow \quad \delta^* = \int_0^\delta 1 - \left\{\frac{2y}{\delta} - \frac{y^2}{\delta}\right\} dy$

$\Rightarrow \quad \delta^* = \frac{\delta}{3}$ Choice (A)

21. $A = \frac{\pi}{4} \times 0.05^2 = 1.963 \times 10^{-3}$ m^2

$V = 20$ m/s

$F_x = \rho(V - u)^2 = 1000 \times 1.963 \times 10^{-3} \times (20 - 8)^2$

$\Rightarrow \quad F_x = 282.67$ N

$\frac{W.D}{\text{sec}} = F_x \times u = 282.67 \times 8$

$= 2261.36$ Watts Choice (D)

22. $V_{jet} = C_v \times \sqrt{2gH} = 0.97 \times \sqrt{2 \times 9.81 \times 18.3}$

$\Rightarrow \quad V_{jet} = 18.38$ m/s

$u = \frac{\pi DN}{60} = r_\omega = \frac{\pi \times 1.26 \times 120}{60} \Rightarrow u = 7.917$ m/s

$W.D/\text{sec} = \rho AV(V - u)u = 1000 \times \frac{\pi}{4} \times 0.168^2 \times$

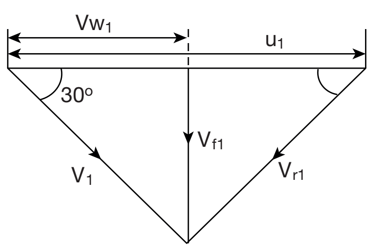
$18.38 \times (18.38 - 7.91) \times 7.91$

$= 33.73$ kW Choice (B)

23. $H_{net} = 30\ m;\ \eta_0 = \frac{P}{\rho g Q H} \Rightarrow \frac{4000}{9.81 \times Q \times 30} = 0.85$

$\Rightarrow \quad Q = 16$ m^3/sec and $Q = \pi D_1 B_1 V_{f_1} k$

Now $V_{f_1} = 7$ m/s, $k = 0.95$



$\eta_{hyd} = 0.9 = \frac{V_{w_1} u_1}{g H_{net}}$ and $\tan 30° = \frac{V_{f_1}}{V_{w_1}}$

$\therefore \quad V_{w_1} = \frac{7}{\tan 30°} \Rightarrow V_{w_1} = 12.12$ m/s and

$0.9 = \frac{12.12 \times u_1}{9.81 \times 30} \Rightarrow u_1 = 21.85$ m/s

$u_1 = \frac{\pi D_1 N}{60} \Rightarrow D_1 = \frac{60 \times 21.85}{\pi \times 300} = 1.39$ m

Now, $16 = \pi \times 1.39 \times B_1 \times 7 \times 0.95$

$\Rightarrow \quad B_1 = 0.55$ m Choice (D)

24. Given:- $S.P = 12000$ kW, $H = 400$ m, $N = 700$ rpm, $\eta_o = 0.86$, $\frac{d}{D} = \frac{1}{6}$, $C_v = 0.98$, $k_u = 0.45$

$V_1 = C_v\sqrt{2gH}$

$\Rightarrow \quad V_1 = 0.98 \times \sqrt{2 \times 9.81 \times 400} = 86.81716$ m/s

$u = k_u \sqrt{2gH}$

$\Rightarrow \quad 0.45 \times \sqrt{2 \times 9.81 \times 400} = 39.865$ m/s

$u = \frac{\pi DN}{60} \Rightarrow D = \frac{39.865 \times 60}{\pi \times 700} = 1.08766$ m

$\because \quad \frac{d}{D} = \frac{1}{6} \Rightarrow d = 0.1813$ m

$\therefore$ Discharge of one jet, $Q = \frac{\pi}{4} \times d^2 \times V_1 = \frac{\pi}{4} \times$

$0.1813^2 \times 86.81716 \Rightarrow Q = 2.24125$ m^3/s

Now $\eta_0 = \frac{S.P}{\rho g Q_t H}$

$\therefore$ Total discharge, Q_t

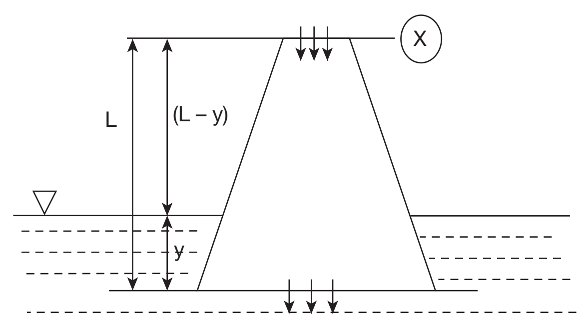
$= \frac{S.P}{\rho g \eta_0 H} = \frac{12000 \times 10^3}{1000 \times 9.81 \times 0.86 \times 400}$

$\Rightarrow \quad Q_t = 3.556$ m^3/s

$\therefore$ Number of jets $= \frac{Q_t}{Q} = \frac{3.556}{2.24125} = 1.59 \sim 2$ jets

Choice (A)

25.



$\frac{P_3}{\rho g} \geq -[L - y] \Rightarrow 2.6 - \frac{101.3}{9.81} \geq -[L - y]$

$\Rightarrow \quad -7.72 \geq -[L - y] \Rightarrow [L - y] = 7.72$ m

Choice (C)