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UPPSC AE 2019
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 2

Part Syllabus Test

Fluid Mechanics, Open Channel Flow, Hydraulic Machines, & Hydropower Engg.

ANSWER KEY

1.	(c)	11.	(d)	21.	(b)	31.	(b)	41.	(a)
2.	(d)	12.	(b)	22.	(c)	32.	(b)	42.	(b)
3.	(d)	13.	(b)	23.	(a)	33.	(b)	43.	(a)
4.	(a)	14.	(a)	24.	(a)	34.	(d)	44.	(b)
5.	(b)	15.	(c)	25.	(a)	35.	(b)	45.	(c)
6.	(a)	16.	(c)	26.	(c)	36.	(b)	46.	(a)
7.	(d)	17.	(c)	27.	(a)	37.	(b)	47.	(c)
8.	(c)	18.	(d)	28.	(c)	38.	(b)	48.	(b)
9.	(c)	19.	(b)	29.	(c)	39.	(b)	49.	(c)
10.	(d)	20.	(b)	30.	(c)	40.	(b)	50.	(d)

DETAILED EXPLANATIONS

1. (c)

$$K = \frac{\Delta p}{\frac{\Delta V}{V}} = \frac{\Delta p}{\frac{\Delta \rho}{\rho}}$$

$$\therefore \quad K = \frac{200}{0.001} \times 10^4 \text{ N/m}^2 = 2 \text{ GN/m}^2$$

2. (d)

$$\begin{aligned} \text{NPSH (Net positive suction head)} &= \text{Cavitation coefficient} \times \text{Manometric head} \\ &= 0.1 \times 50 = 5 \text{ m} \end{aligned}$$

$$\text{Now, NPSH} = \frac{p_{\text{atm}} - p_v}{\rho \times g} - h_s - h_{f_s}$$

$$\text{Safe height of runner, } h_s = \frac{P_{\text{atm}} - P_v}{\rho \times g} - \text{NPSH} = \frac{P_{atm}}{\rho \times g} - \frac{P_v}{\rho \times g} - \text{NPSH} \qquad (\because \ h_{f_s} = 0)$$

$$= 10 - 2 - 5 = 3 \text{ m}$$

3. (d)

$$\begin{aligned} \text{Gauge pressure at } P &= 0.8 \times 1 + 1.0 \times 1.6 \\ &= 2.4 \text{ m of water} \\ &= 2.4 \times 10 \times 10^3 \text{ N/m}^2 \\ &= 24 \text{ kPa} \end{aligned}$$

4. (a)

$$\text{Critical Reynolds number, } R_{cr} = \frac{\rho \cdot V_{cr} \cdot d}{\mu}$$

$$\Rightarrow \quad V_{cr} = \frac{R_{cr} \cdot \mu}{\rho d} = \frac{2500 \times 0.143}{900 \times \frac{2.5}{100}} = 15.89 \text{ m/s} \simeq 15.9 \text{ m/s}$$

5. (b)

Chezy's formula:

$$V = c\sqrt{RS} \qquad \text{...(1)}$$

Manning's formula:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \qquad \text{...(2)}$$

From (1) and (2)

$$c\sqrt{RS} = \frac{1}{n} R^{2/3} \sqrt{S}$$

$$\Rightarrow \quad cR^{1/2} = \frac{1}{n} R^{2/3}$$

$$\Rightarrow \quad c = \frac{1}{n} R^{1/6}$$

6. **(a)**

$$\text{Maximum efficiency, } \eta_{max} = \left(\frac{1+\cos\theta}{2}\right)$$

For θ = 0°, the curved vanes will becomes semicircular and η_{max} = 1 or 100%.

7. **(d)**

Equating the head coefficients, we get

$$\frac{N_1 D_1}{\sqrt{H_1}} = \frac{N_2 D_2}{\sqrt{H_2}}$$

$$\therefore \quad D_1 = \left(\frac{N_2}{N_1}\right)\cdot\sqrt{\frac{H_1}{H_2}} \times D_2$$

$$= \left(\frac{1200}{1200}\right)\sqrt{\frac{25}{9}} \times 300 = 500 \text{ mm}$$

8. **(c)**

According to Newton's law of viscosity, shear stress is directly proportional to the rate of angular deformation (strains rate) or velocity gradient across the flow.

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

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

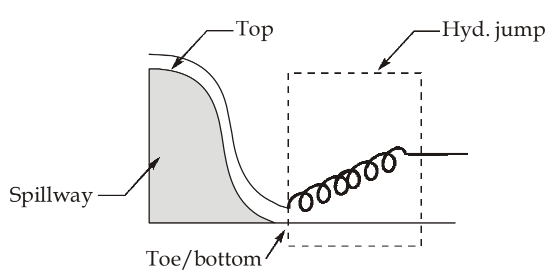
where μ = absolute or dynamic viscosity

9. **(c)**

For hydraulically most efficient symmetric trapezoidal channel section. The wetted perimeter is minimum for trapezoidal half hexagon, hydraulic radius is half the flow depth and discharge is maximum for given area of flow, bed slope and roughness.

The assumption of width at top to be twice the hydraulic depth is wrong and is valid for rectangular channel.

10. **(d)**



The energy dissipation in a hydraulic jump is given by

$$E_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2} = \frac{(2.4-0.4)^3}{4 \times 2.4 \times 0.4} = 2.08 \text{ m}$$

11. (d)

For V - notch

$$Q = \frac{8}{15} C_d \sqrt{2g} \tan\left(\frac{\theta}{2}\right) H^{5/2}$$

$$\therefore \quad \frac{dQ}{Q} = \frac{5}{2}\frac{dH}{H} = 2.5\%$$

12. (b)

We know that, $Q = AV$

$\Rightarrow$ $25 = 5 \times 2 \times V$

$\Rightarrow$ $V = 2.5 \text{ m/s}$

The specific energy is given by

$$E = y + \frac{V^2}{2g} = 2 + \frac{(2.5)^2}{2 \times 10} = 2 + 0.3125 = 2.3125 \text{ m} = 2.3 \text{ m}$$

13. (b)

Option (a) gives critical depth for rectangular channels which is derived from option (b) only.

14. (a)

For laminar flow through circular pipe

$$u = u_{\max}\left(1 - \frac{r^2}{R^2}\right)$$

$$\Rightarrow \quad u = 2u_{avg}\left(1 - \frac{r^2}{R^2}\right) = 2 \times 5\left(1 - \frac{5^2}{10^2}\right) = 7.5 \text{ m/s}$$

15. (c)

For smooth pipes

$$f = \frac{0.316}{(\text{Re})^{1/4}} \qquad \left(4 \times 10^3 < \text{Re} < 10^5\right)$$

$$= \frac{0.316}{\left(10^4\right)^{1/4}} = \frac{0.316}{10} = 3.16 \times 10^{-2}$$

16. (c)

$$L_r = \left(\frac{1}{25}\right) \qquad \text{(given)}$$

Water will be moving under the influence of gravitational force, hence Froude's model law will be applicable.

$$\therefore \quad V_r = \sqrt{L_r}$$

$$F_r = \frac{(\text{Force})_m}{(\text{Force})_p} = \rho_r v_r^2 L_r^{\,2} = \rho_r L_r^{\,3}$$

$$\Rightarrow \quad (\text{Force})_p = \frac{(\text{Force})_m}{L_r^{\,3}} \qquad (\because \ \rho_r = 1)$$
$$= 5 \times 25^3 = 78125 \text{ N} = 78.125 \text{ kN}$$

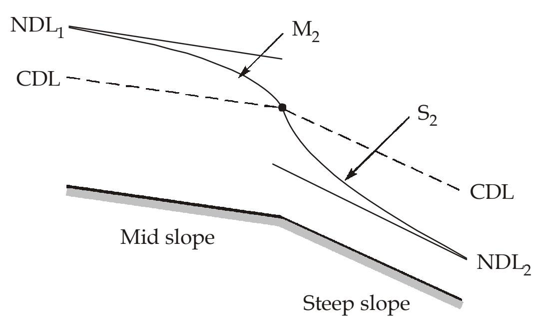
17. (c)

The SI unit of **kinematic viscosity** is m^2/s

$\therefore$ Dimension of **kinematic viscosity** $[\nu] = L^2/T$.

$$\text{Kinematic viscosity } (\nu) = \frac{\text{Dynamic viscosity } (\mu)}{\text{Mass density } (\rho)}$$
$$= \frac{\text{kg/ms}}{\text{kg/m}^3} = \frac{\text{kg}}{\text{ms}} \times \frac{\text{m}^3}{\text{kg}} = \frac{\text{m}^2}{\text{s}}$$
$$[\nu] = [L^2 \, T^{-1}]$$

18. (d)



19. (b)

For a rectangular weir, $$Q = \frac{2}{3} C_d L \left(\sqrt{2g}\right) H^{3/2} = kH^{3/2}$$

$$\therefore \quad dQ = \frac{3}{2} kH^{1/2} . dH$$

$$\therefore \quad \frac{dQ}{Q} = \frac{3}{2} \frac{dH}{H}$$

$$\Rightarrow \quad \frac{dQ}{Q} = 1.5 \times 2.5 = 3.75\%$$

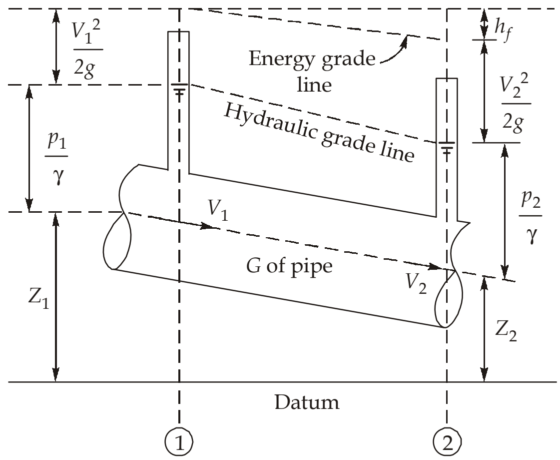
20. (b)

$\because$ Speed of sound, C = 330 m/s = 1188 km/hr

$\simeq$ 1200 km/hr (in air or vacuum)

$$\therefore \quad \text{Mach number} = \frac{V}{C} = \frac{800}{1200} = 0.67$$

21. (b)



⇒ Total energy lines lies over the hydraulic gradient line by an amount equal to the velocity head.

22. (c)

$$P_1 - P_2 = \rho g (h_2 - h_1)$$

$$\Rightarrow \quad 80 \times 10^3 - 60 \times 10^3 = \rho \times 9.81 \times (8 - 5)$$

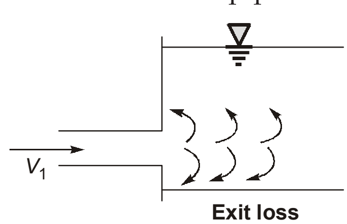
$$\Rightarrow \quad 20 \times 10^3 = \rho \times 9.81 \times 3$$

$$\Rightarrow \quad \rho = 679.58$$

$$\Rightarrow \quad \rho \simeq 680 \text{ kg/m}^3$$

23. (a)

When a pipe discharges into a large reservoir as shown in figure, the velocity head in the pipe $\left(\frac{V_1^2}{2g}\right)$ which corresponds to the kinetic energy per unit weight is lost in turbulence of eddies in the reservoir. This loss is termed as the exit loss for the pipe.



24. (a)

For flow to be irrotational,

$$\omega_z = 0$$

i.e.,
$$\frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) = 0$$

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

25. (a)

26. (c)

27. (a)

$$\text{Head available at the nozzle} = 0.9 \times 400 = 360 \text{ m}$$

$$\therefore \quad \text{Velocity of jet, } v = C_v\sqrt{2gH}$$

$$\Rightarrow \quad v = 0.98\sqrt{2 \times 10 \times 360} = 83.16 \text{ m/s} \simeq 83 \text{ m/s}$$

28. (c)

In case of pump,

$$P = \left[\frac{P}{N^3D^5}\right]_m = \left[\frac{P}{N^3D^5}\right]_p \qquad \text{(Given } N = \text{constant)}$$

$$\Rightarrow \quad \frac{P_m}{P_p} = \left(\frac{D_m}{D_p}\right)^5 = \left(\frac{1}{2}\right)^5 = \frac{1}{32}$$

29. (c)

30. (c)

Chezy's equation,

$$V = C\sqrt{RS}$$

$$= C\sqrt{\frac{d}{4}\cdot\frac{h_f}{L}} \qquad \left(\because R = \frac{d}{4} \text{ for pipe}\right)$$

$$\therefore \quad V^2 = C^2\frac{d}{4}\cdot\frac{1}{L}\cdot\frac{fLV^2}{2dg} \qquad \left(\because h_f = \frac{fLV^2}{2dg} \text{ Darcy-Weisbach equation}\right)$$

$$\Rightarrow \quad 8g = C^2f$$

$$\Rightarrow \quad C = \sqrt{\frac{8g}{f}}$$

31. (b)

$$\frac{\partial p}{\partial x} = \frac{\partial \tau}{\partial y}$$

32. (b)

33. (b)

$$\because \quad F_2^2 = \frac{V^2}{gy_2} = \frac{q^2}{gy_2^3}$$

$$= \frac{q^2}{gy_1^3\left(\frac{y_2}{y_1}\right)^3} = \frac{F_1^2}{\left(\frac{y_2}{y_1}\right)^3}$$

$$= \frac{8F_1^2}{\left(-1+\sqrt{1+8F_1^2}\right)^3}$$

34. (d)

$$\frac{U_{max}}{\bar{U}} = 1.43\sqrt{f} + 1$$

For both smooth and rough pipes, the friction factor (f) increases with ageing.

So, ratio $\frac{U_{max}}{\bar{U}}$ also increases.

35. (b)

36. (b)

For flow to be incompressible,

$$\nabla \cdot \vec{V} = 0$$

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

$$\Rightarrow \quad \frac{\partial}{\partial x}(5 + a_1 x + b_1 y) + \frac{\partial}{\partial y}(4 + a_2 x + b_2 y) = 0$$

$$\Rightarrow \quad a_1 + b_2 = 0$$

37. (b)

In laminar viscous flow, the ratio of maximum velocity to average velocity of flow between two fixed parallel plates is

$$\frac{U_{max}}{\bar{U}} = \frac{3}{2}$$

$$\therefore \quad \bar{U} = \frac{2 \times U_{max}}{3} = \frac{2 \times 12}{3} = 8 \text{ m/s}$$

38. (b)

$$\text{Theoretical discharge, } Q_t = \frac{ALN}{60} = \frac{\pi \times (20 \times 10^{-2})^2 \times 40 \times 10^{-2} \times 60}{4 \times 60}$$

$$= 0.01257 \text{ m}^3/\text{s} = 12.57 \ l/\text{s}$$

39. (b)

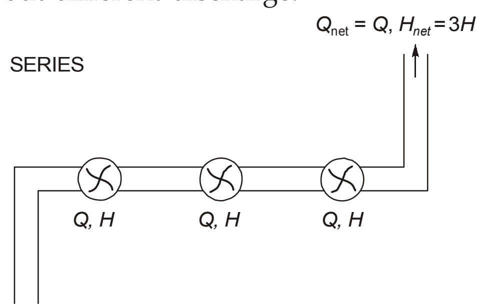
$$V = C_v\sqrt{2g\left(p_{\text{stag}} - p_{\text{static}}\right)}$$

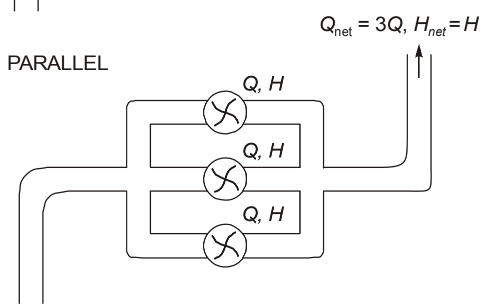
$$= 0.98 \times \sqrt{2 \times 9.81 \times (3 - 0.5)}$$

$$= 6.86 \text{ m/s} \simeq 6.9 \text{ m/s}$$

40. (b)

Pumps operating in series carries same discharge but different heads. Whereas pumps operating in parallel carries same head but different discharge.



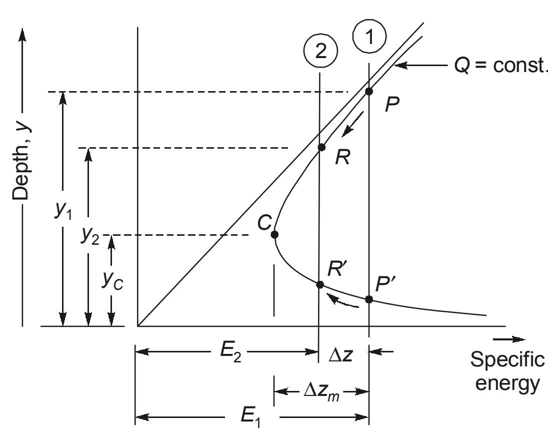


41. (a)

A Pitot tube is a device used for velocity measurement. It in fact measures the stagnation pressure at any point in the flow.

42. (b)

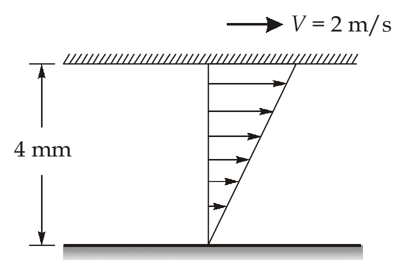
$y_p < y_s < y_a$



43. (a)

$$F_D = C_D \frac{\rho A V^2}{2}$$
$$= \frac{1.2 \times 1000 \times (1 \times 2) \times 3^2}{2}$$
$$= 1.2 \times 1000 \times 9$$
$$= 10.8 \times 1000 \text{ N}$$
$$= 10.8 \text{ kN}$$

44. (b)



Fixed Plate

Velocity gradient, $\frac{du}{dy} = \frac{V}{h} = \frac{2.0}{4 \times 10^{-3}} = 500\, s^{-1}$

$\therefore$ Shear stress, $\tau = \mu \frac{du}{dy} = 0.2 \times 500 = 100 \frac{\text{N}}{\text{m}^2} = 100 \text{ Pa}$

45. (c)

We know that for triangular channel

$$y_c = \frac{4}{5} E_{\min} = \frac{4}{5} \times 1.5 = 1.2 \text{ m}$$

$\because$ $$E_{\min} = y_c + \frac{v_c^2}{2g}$$

$$1.5 = 1.2 + \frac{v_c^2}{2 \times 9.81}$$

$\Rightarrow$ $$v_c = \sqrt{0.3 \times 2 \times 9.81} \text{ m/s}$$

$\Rightarrow$ $$v_c = 2.43 \text{ m/s}$$

46. (a)

$\because$ Wave is travelling downstream

$\therefore$ Celerity, $C = V_w - V_1 = 4 - 0.4 = 3.6$ m/s

47. (c)

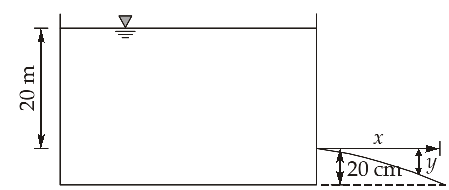
The non-dimensional form of specific speed for pumps is known as shape factor.
The specific speed of the pumps has dimensions of $[L^{3/4}\ T^{-3/2}]$.
The range of specific speeds far axial flow pumps is between 200 and 300.

48. (b)

$$\text{Mach number, } M = \left(\frac{\text{Inertia Force}}{\text{Compressibility/ Elastic Force}}\right)^{1/2} = \frac{V}{\sqrt{E/\rho}} = \frac{V}{C}$$

where, C is velocity of sound in the medium.

49. (c)



$$C_v = \frac{x}{2\sqrt{yH}}$$

$$\Rightarrow \quad 0.98 = \frac{x}{2\sqrt{0.2\times 20}}$$

$$\Rightarrow \quad x = 4 \times 0.98$$

$$\Rightarrow \quad x = 3.92 \text{ m}$$

50. (d)

Since, pipes are parallel

$$\therefore \quad h_{L,P} = h_{L,Q}$$

$$\left(\frac{fLQ^2}{12.1D^5}\right)_P = \left(\frac{fLQ^2}{12.1D^5}\right)_Q$$

$$\Rightarrow \quad 16fQ_P^2 = fQ_Q^2$$

$$\Rightarrow \quad Q_P = \frac{Q_Q}{4} = 0.25Q_Q$$

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