CLASS TEST

Sl. : 05DLSK_CE_IJKLM_12092026

MADE EASY

Leading Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

HYDRAULIC MACHINE

CIVIL ENGINEERING

Date of Test : 12/09/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

$$F = \rho(v - u)^2 A = 10^3(30 - 10)^2 \times 0.005 = 5 \times 400 = 2000 \text{ N} = 2 \text{ kN}$$

2. (d)

$$u \propto DN$$

$$u \propto \sqrt{H}$$

$$\frac{\sqrt{H}}{N} = \text{Const}$$

$$\frac{\sqrt{25}}{1000} = \frac{\sqrt{H_2}}{2000}$$

$$\sqrt{H_2} = 5 \times 2$$

$$H_2 = 100 \text{ m}$$

3. (c)

- NPSH is the difference between the absolute pressure at the pump suction and the vapour pressure of the liquid at operating temperature.
- Available NPSH is provided by the system and depends on factor like suction head, pipe friction and atmospheric pressure.
- Required NPSH is the minimum NPSH needed by the pump to avoid cavitation.
- For cavitation free operation, the available NPSH must be greater than the required NPSH. If the available NPSH is less, cavitation will occur, damaging the pump.

4. (b)

A draft-tube is a diverging passage fitted at the outlet of a reaction turbine to

1. Recover kinetic energy of the water exiting the turbine.
2. Reduce the velocity of discharged water, converting kinetic energy into pressure energy.
3. Establish a negative pressure head at the exit, improving the efficiency of the turbine.

5. (b)

$$u = k_u\sqrt{2gH} = 0.48\sqrt{2 \times 10 \times 1125}$$

$$= 0.48 \times 150 = 72 \text{ m/s}$$

6. (c)

7. (c)

Given : $D = 0.2$, $L = 0.4$ m, $N = 60$ rpm

Theoretical discharge is given by,

$$Q_{th} = \frac{ALN}{60} = \frac{\pi}{4}D^2 \times \frac{LN}{60}$$

$$= \frac{\pi}{4} \times 0.2^2 \times \frac{0.4 \times 60}{60}$$

$$= 0.0125 \text{ m}^3/\text{s}$$

8. (d)

Given : $Q_a = 0.011\ m^3/s$

$$\therefore \quad \text{The percentage slip, \%slip} = \frac{Q_t - Q_a}{Q_t} \times 100 = \frac{0.0125 - 0.011}{0.0125} \times 100 = 12\%$$

9. (c)

$$P_{th} = \rho g Q_{th} H$$

We have, $H = 30$ m (given)

$$\therefore \quad P_{th} = 10^3 \times 9.81 \times 0.0125 \times 30 = 3.67 \text{ kW}$$

10. (d)

In mixed flow, the water enters the runner in the radial direction and leaves in the axial direction.

Example : Francis turbine

11. (d)

$$\text{Velocity of wheel is given by, } U = \text{Speed ratio} \times \sqrt{2gH}$$

$$U = 0.45 \times \sqrt{2 \times 9.81 \times 450} = 42.28 \text{ m/s}$$

$$= 42.28 \text{ m/s}$$

or
$$\frac{\pi DN}{60} = 42.28$$

$$\therefore \quad D = \frac{60 \times 42.28}{\pi \times 600} = 1.34 \text{ m}$$

12. (b)

Given : $D_2 = 1.5$ m, $D_1 = 0.5$ m, $V_{f_1} = V_{f_2}$, $B_2 = 250$ mm $= 0.25$ m

Using the relation for discharge,

$$Q = \pi D_1 B_1 V_{f_1} = \pi D_2 B_2 V_{f_2}$$

or
$$B_1 = \frac{D_2 B_2}{D_1} = \frac{1.5 \times 0.25}{0.5} \qquad \left(\because\ V_{f_1} = V_{f_2}\right)$$

or
$$B_1 = 0.75 \text{ m}$$

13. (d)

Draft tube is an integral part of a pressure or reaction turbine. In case of pressure turbines, the energy that is not extracted by the runner appears as exit velocity energy, it helps to convert the exit velocity head into pressure or potential head. By providing draft tube, we can install the turbine above the tail race level without any loss in the static head.

14. (c)

15. (b)

Following are the characteristics of centrifugal pump :

- Discharge is continuous and smooth
- Starting torque is more
- Maintenance cost is less
- Can run at higher speeds
- Less wear and tear
- Less efficiency

- Cost of centrifugal pump is less
- Needs smaller floor area
- Suction and delivery valve is not necessary
- It can handle any type of liquid
- Priming is necessary

16. (d)

Air vessel on delivery side:

(i) Almost constant delivery discharge is obtained.

(ii) Reduction in friction loss and hence saving in power.

17. (c)

$$\text{Unit power, } P_u = \frac{P}{H^{3/2}}$$

or
$$\frac{P_1}{H_1^{3/2}} = \frac{P_2}{H_2^{3/2}}$$

$\therefore$
$$P_2 = P_1 \times \left(\frac{H_2}{H_1}\right)^{3/2} = 9000 \times \left(\frac{16}{25}\right)^{3/2}$$

$$P_2 = 4608 \text{ kW}$$

18. (b)

$$\text{Power per wheel} = \frac{5000}{2} = 2500 \text{ kW}$$

$\therefore$
$$\text{Power, } P = \eta_0 \cdot \rho g Q H$$

$\therefore$
$$Q = \frac{P}{\eta_0 \cdot \rho g H} = \frac{2500 \times 10^3}{0.8 \times 10^3 \times 9.81 \times 300}$$

$$Q = 1.06 \text{ m}^3/\text{s}$$

19. (c)

$$\text{Power, } P = \eta_0 \cdot \rho g Q H$$

$\therefore$
$$Q = \frac{P}{\eta_0 \cdot \rho g H} = \frac{10000 \times 10^3}{0.9 \times 10^3 \times 9.81 \times 40}$$

$$Q = 28.3 \text{ m}^3/\text{s}$$

Also,
$$Q = \frac{\pi}{4}\left(D_0^2 - D_b^2\right) \times V_{f_1}$$

$\Rightarrow$
$$28.3 = \frac{\pi}{4}\left(2^2 - 1^2\right) \times V_{f_1}$$

$$V_{f_1} = \frac{4 \times 28.3}{\pi \times 3} = 12.01 \text{ m/s}$$

20. (d)

For homologous pumps, the specific speed of the pump is the same,

Hence,
$$N_{sA} = N_{sB}$$

$$\frac{N_A \sqrt{Q_A}}{H_A^{3/4}} = \frac{N_B \sqrt{Q_B}}{H_B^{3/4}}$$

or $$\frac{\sqrt{4}}{(81)^{3/4}} = \frac{\sqrt{2}}{(H_B)^{3/4}} \qquad (\because \; N_A = N_B)$$

$\therefore$ $$(H_B)^{3/4} = \frac{\sqrt{2}}{\sqrt{4}} \times (81)^{3/4}$$

$$H_B = 19.09^{4/3} = 51 \text{ m}$$

21. (a)

$$RP = \eta\left(\rho QgH\right)$$

$$= 0.9(10^3 \times 10 \times 9.81 \times 81) \times 10^{-3}$$

$$= 7151.49 \text{ kW}$$

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{300\sqrt{7151.49}}{\left(3^4\right)^{\frac{5}{4}}} = 104.4$$

22. (d)

As flow rate increases frictional losses in the suction pipe increase, leading to higher NPSH requirement.

23. (a)

- Kaplan turbines are high head turbines meaning they rely on pressure difference rather than direct impulse force to generate power.
- The axial flow design works best under low-pressure conditions, which occur at low head sites with large flow rate.
- At high heads, the water velocity would be too high, leading to excessive mechanical stress.

24. (a)

25. (c)

Even if the fluid were non-viscous (ideal fluid), slip would still occur due to the following reasons:

1. **Non-Ideal Flow Patterns:** The flow in an impeller does not follow the exact theoretical streamline pattern assumed in ideal cases. Due to the finite number of blades, fluid particles do not move exactly along the blade curvature, leading to deviation from the ideal flow path.
2. **Finite Number of Blades (Blade Loading Effect):** In an ideal case (infinite blades), the fluid would perfectly follow the blade curvature, achieving the theoretical head. In real pumps with a finite number of blades, the flow deviates from the blade angle, causing a reduction in energy transfer.
3. **Secondary Flow and Circulation:** Even in inviscid flow, secondary circulations can develop within the impeller passages due to blade curvature and pressure variations. This alters the velocity triangle at the impeller exit, leading to slip and a reduction in head.

Final Conclusion: Slip is not solely dependent on viscosity; rather, it results from the complex flow field within the impeller, blade loading effects, and secondary flow patterns. Even in a non-viscous fluid, slip would still occur due to these fundamental hydrodynamic effects.

■■■■