CLASS TEST

Sl. : 03DLSKME_ABCDEFGH_10926

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HYDRAULIC MACHINE

MECHANICAL ENGINEERING

Date of Test : 10/09/2026

ANSWER KEY

1.	(a)	7.	(c)	13.	(b)	19.	(c)	25.	(b)
2.	(c)	8.	(b)	14.	(b)	20.	(d)	26.	(d)
3.	(a)	9.	(d)	15.	(c)	21.	(d)	27.	(a)
4.	(b)	10.	(b)	16.	(c)	22.	(c)	28.	(d)
5.	(b)	11.	(c)	17.	(d)	23.	(d)	29.	(b)
6.	(a)	12.	(b)	18.	(d)	24.	(d)	30.	(b)

DETAILED EXPLANATIONS

1. (a)

$$RP = \eta\left(\rho QgH\right) = 0.9(10^3 \times 10 \times 9.81 \times 81) \times 10^{-3} = 7151.49 \text{ kW}$$

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

2. (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.

3. (a)

Given: $Q = 150$ L/s $= 0.15$ m^3/s, $D_2 = 0.3$ m, $b_2 = 0.08$ m

As we know, $Q = \pi D_2 b_2 V_{f2}$

$$0.15 = \frac{22}{7} \times 0.3 \times 0.08 \times \left(V_{f_2}\right)$$

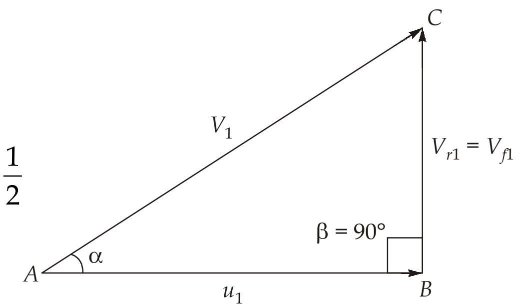
$$\left(V_{f_2}\right) = \frac{0.15 \times 7}{22 \times 0.3 \times 0.08} = 1.988 \approx 1.99 \text{ m/s}$$

4. (b)

As entrance is radial,

$\therefore$ $V_{r1} = V_{f1} = 4$ m/s

In ΔABC,



$$\sin\alpha = \frac{BC}{AC} = \frac{V_{r1}}{V_1} = \frac{4}{8} = \frac{1}{2}$$

$$\alpha = \sin^{-1}\left(\frac{1}{2}\right) = 30°$$

5. (b)

$$\text{Power} = \eta_0(\rho QgH)$$
$$= 0.9(10^3 \times 50 \times 9.81 \times 81) \times 10^{-3} = 35757.45 \text{ kW or } 36 \text{ MW}$$

6. (a)

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

7. (c)

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

or

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

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

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

8. **(b)**

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

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

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

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

9. **(d)**

At inlet, $$U_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 3 \times 300}{60} = 47.12 \text{ m/s}$$

$\therefore$ At the outlet, $$U_2 = \frac{D_2}{D_1} \times U_1$$

$$U_2 = \frac{1.5}{3} \times 47.12 = 23.56 \text{ m/s}$$

10. **(b)**

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}} = \frac{1500\sqrt{2.25}}{(16)^{3/4}} = 281.25$$

11. **(c)**

Given: $P = 15000$ kW $= 15 \times 10^6$ W, $H = 30$ m, $V_{f1} = 19$ m/s, $D_b = 0.4$ D.

As we know, $$P = \rho g Q H$$

$$15 \times 10^6 = 1000 \times 10 \times Q \times 30$$

$$150 = 3Q$$

$$Q = 50 \text{ m}^3/\text{sec}$$

Also, $$\text{Discharge, } Q = \frac{\pi}{4}\left(D^2 - D_b^2\right) \times V_{f1}$$

$$50 = \frac{22}{7 \times 4}\left(D^2 - (0.4D)^2\right) \times 19$$

$$50 = \frac{22}{7 \times 4}\left(D^2 - 0.16D^2\right) \times 19$$

$$50 = \frac{22}{7 \times 4} \times 0.84D^2 \times 19$$

$$D^2 = 3.98$$

$$D \approx 2 \text{ m}$$

12. **(b)**

Given: $H = 51.2$ m, $\beta = 180 - 150 = 30°$, $Q = 1$ m^3/s, $u = 16$ m/s

$$\text{Absolute velocity at inlet, } V_1 = \sqrt{2gH} = \sqrt{2 \times 10 \times 51.2} = \sqrt{1024}$$

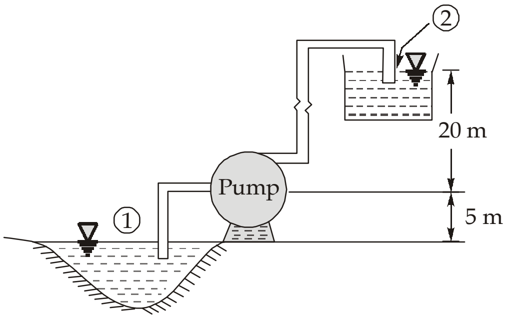
$$V_1 = 32 \text{ m/s}$$

Also, $$\text{Power } (P) = \rho Q u \,(V_1 - u)\,(1 + \cos\beta)$$

$$= 1000 \times 1 \times 16\,(32 - 16)\,(1 + \cos 30°) = 16000 \times 16\,(1 + 0.866)$$

$$P = 477.70 \text{ kW}$$

13. (b)



Applying energy conservation between (1) and (2)

$$H_p = 5 + 20 = 25 \text{ m}$$

$$\text{Power} = \frac{\rho Q g H_p}{\eta} = \frac{10^3 \times 3 \times 20 \times 10^{-4} \times g \times 25}{0.75} \times 10^{-3} \text{kW} = 2 \text{ kW}$$

14. (b)

$$P = \eta_0 \rho Q g H$$

$$P \propto QH \quad \text{...(i)}$$

$$Q \propto D^2 \sqrt{H} \quad \text{...(ii)}$$

$$u \propto \sqrt{H} \alpha DN \quad \text{...(iii)}$$

Putting (ii) and (iii) in equation (i),

$$P \propto \frac{H^{5/2}}{N^2}$$

$$\Rightarrow \quad \frac{PN^2}{H^{5/2}} = \text{Constant}$$

$$\left.\frac{PN^2}{H^{5/2}}\right|_P = \left.\frac{PN^2}{H^{5/2}}\right|_M$$

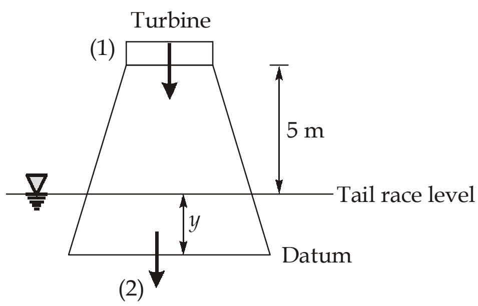
$$\frac{30 \times 100^2}{20^{2.5}} = \frac{40 \times N_m^2}{20^{2.5}}$$

$$N_m = \sqrt{\frac{30}{40}} \times 100 = 86.6 \text{ rpm} \simeq 87 \text{ rpm}$$

15. (c)

Refer figure,

By Bernoulli's equation applied to sections 1 and 2



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

or $$\frac{P_1}{\rho g} + 4 + (5 + y) = (10.3 + y) + 2 + 0.35 \times 2$$

$\therefore$ $$\frac{P_1}{\rho g} = 10.3 + 2 + 0.7 - 9$$

or $$\frac{P_1}{\rho g} = 4 \text{ m (abs)}$$

16. (c)

Given : $\eta_0 = 0.8$; $V = 4$ m/s; $H = 20$ m; $L = 100$ m; $f' = 0.01$; $D = 0.1$ m

$$\text{Loss of head in the pipeline, } h_f = \frac{4f'LV^2}{2gD} = \frac{4 \times 0.01 \times 100 \times 4^2}{2 \times 9.81 \times 0.1}$$

$$= 32.62 \text{ m}$$

∴ Head against which the pump has to work,

$$H_m = H + h_f = 20 + 32.62$$

$$= 52.62 \text{ m}$$

∴ Power required to drive the pump,

$$P = \frac{\rho g Q H_m}{\eta_0} = \frac{10^3 \times 9.81 \times \frac{\pi}{4} \times 0.1^2 \times 4 \times 52.62}{0.8}$$

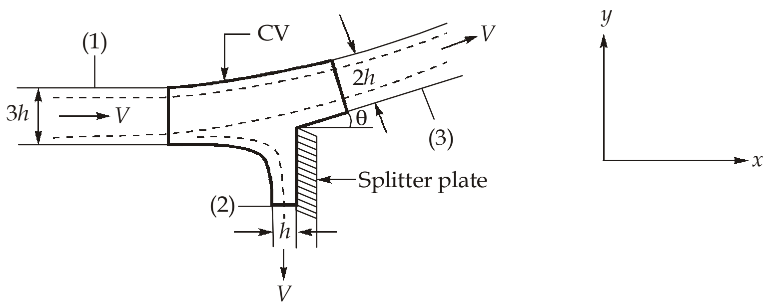
$$= 20.27 \text{ kW}$$

17. (d)

Reasons when pump fails to start pumping :

(i) Pump may not be properly primed.
(ii) Suction lift and delivery head too high.
(iii) Too low speed
(iv) Wrong direction of pump rotation.
(v) Clogging of impeller or strainer or suction line.

18. (d)



As the weight of water and friction along plate is neglected, so the force by jet on the plate in y-direction must be zero.

$$\Sigma F_y = \left[(\dot{m}v)_{out} - (\dot{m}v)_{in}\right]_{y-dir}$$

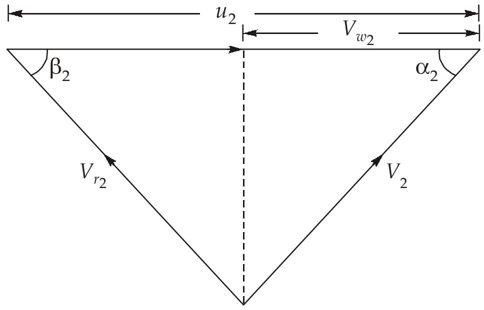
$$0 = \rho(2h \times 1)V \cdot V \sin\theta + \rho(h \times 1)V \cdot (-V) \qquad \left[\because\ (\dot{m}v)_{in} = 0\right]$$

$$\therefore \qquad \theta = \sin^{-1}(0.5)$$

19. (c)

20. (d)

Refer outlet velocity triangle,



Velocity triangle (outlet)

Now, $$U_2 = \frac{\pi DN}{60} = \frac{\pi \times 0.3 \times 1200}{60} = 18.85 \text{ m/s}$$

Manometric efficiency is

$$\eta_{mano} = \frac{gH}{V_{w_2} U_2}$$

or $$V_{w_2} = \frac{9.81 \times 30}{0.9 \times 18.85} = 17.35 \text{ m/s}$$

21. (d)

Given : $P = 400$ kW, $H = 100$ m, $\eta_{hyd} = 0.9$, $\eta_{mech} = 0.85$

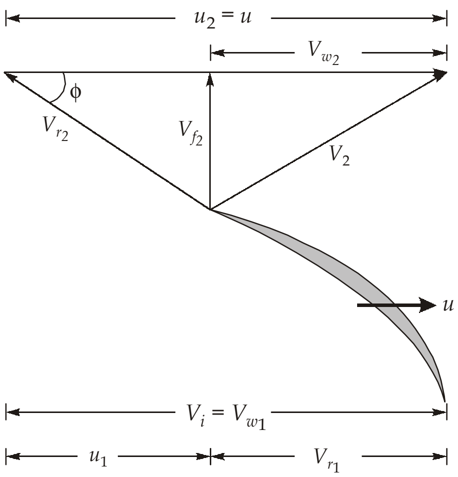
$$\text{Overall efficiency, } \eta_0 = \eta_{hyd} \times \eta_{mech}$$

$$\eta_0 = 0.9 \times 0.85 = 0.765$$

$$\text{Hence, discharge, } Q = \frac{P}{\eta_0 \times \rho g h} = \frac{400 \times 10^3}{0.765 \times 10^3 \times 9.81 \times 100}$$

$$= 0.53 \text{ m}^3/\text{s}$$

22. (c)



$$u = \frac{\pi DN}{60} = \frac{\pi \times 1 \times 764}{60} = 40 \text{ m/s}$$

$$V_{r_1} = V_{r_2} = V_1 - u$$
$$= 100 - 40 = 60 \text{ m/s}$$
$$\phi = 180 - \delta = 180° - 120° = 60°$$
$$V_{w_2} = V_{r_2}\cos\phi - u$$
$$= 40\cos 60° - 40 = -20 \text{ m/s}$$
$$\eta = \frac{\dot{m}\left(V_{w_1} - V_{w_2}\right)u}{\frac{1}{2}\dot{m}V_1^2} = \frac{2\left(V_{w_1} - V_{w_2}\right)u}{V_1^2}$$
$$= \frac{2\times(100-20)\times 40}{100^2} = 0.64 \text{ or } 64\%$$

23. (d)

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

Hence,
$$N_{s_A} = N_{s_B}$$
$$\frac{N_A\sqrt{Q_A}}{H_A^{3/4}} = \frac{N_B\sqrt{Q_B}}{H_B^{3/4}}$$
or
$$\frac{\sqrt{4}}{(81)^{3/4}} = \frac{\sqrt{2}}{(H_B)^{3/4}} \qquad (\because\ N_A = N_B)$$
$\therefore$
$$(H_B)^{3/4} = \frac{\sqrt{2}}{\sqrt{4}}\times(81)^{3/4}$$
$$H_B = 19.09^{4/3} = 51 \text{ m}$$

24. (d)

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

25. (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
$$B_1 = 0.75 \text{ m}$$

26. (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.

27. (a)

$$\text{Net head, } H = \text{Static lift + Friction loss}$$
$$= 40 + 1.5 + 7.5$$
$$= 49 \text{ m}$$

$$\text{Peripheral velocity at outlet, } U_2 = \frac{\pi \times 0.5 \times 1200}{60} = 31.42 \text{ m/s}$$

$$\text{Manometric efficiency, } \eta_{\text{mano}} = \frac{gH_{net}}{V_{w_2} \cdot U_2}$$

$$\therefore \quad V_{w_2} = \frac{9.81 \times 49}{31.42 \times 0.8} = 19.12 \text{ m/s}$$

28. (d)

Using the relation for overall efficiency,

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

$$\text{or} \quad H = \frac{S.P.}{\rho g Q \eta_0} = \frac{12000}{9.81 \times 4 \times 0.9}$$

$$\therefore \quad H = 339.78 \text{ m} \simeq 340 \text{ m}$$

29. (b)

In this case, $D_1 = D_2$

$$\frac{Q_1}{N_1 D_1^3} = \frac{Q_2}{N_2 D_2^3}$$

$$\text{Hence,} \quad N_2 = \left(\frac{Q_2}{Q_1}\right)\left(\frac{D_1}{D_2}\right)^3 \times N_1$$

$$= \frac{0.6}{0.5} \times 1^3 \times 1200 = 1440 \text{ rpm}$$

30. (b)

$$\text{Power developed, } P = \rho g Q H_n, \text{ where } H_n \text{ is the net head utilized}$$

$$\therefore \quad H_n = \frac{P}{\rho g Q}$$

$$\therefore \quad H_n = \frac{800 \times 10^3}{10^3 \times 9.81 \times 0.72} = 113.26 \text{ m}$$

$$\therefore \quad \text{Total head loss} = 130 - 113.26$$
$$= 16.74 \text{ m}$$

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