CLASS TEST

Sl. : 03DLSKCE_EFGHI_09102025

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HYDRAULIC MACHINE

CIVIL ENGINEERING

Date of Test : 09/10/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

2. (c)

3. (d)

NPSH (Net positive suction head) = Cavitation coefficient × Manometric head = 0.1 × 50 = 5 m

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

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

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

4. (b)

5. (b)

As per Stokes law

Drag coefficient for sphere is

$$C_D = \frac{24}{R_e} \qquad \text{(when Re < 0.2)}$$

$$\Rightarrow \quad 240 = \frac{24}{\left(\frac{VD}{v}\right)}$$

$$\Rightarrow \quad 240 = \frac{24v}{(40\times10^{-3})\times(5\times10^{-3})}$$

$$\Rightarrow \quad v = 2 \times 10^{-3} \text{ m}^2/\text{s} = 20 \text{ cm}^2/\text{s}$$

6. (a)

$$\text{NPSH} = \frac{P_a}{\rho g} - \frac{P_v}{\rho g} - h_s - h_f$$

NPSH = Net positive suction head

$\frac{P_a}{\rho g}$ = Atmospheric pressure head

$\frac{\rho_v}{\rho g}$ = Vapour pressure head

h_s = Suction head

h_f = head loss

$$\frac{P_a}{\rho g} = \frac{100\times10^3}{1000\times9.81} = 10.1936 \text{ m}$$

$$\frac{\rho_v}{\rho g} = 0.40 \text{ m}$$

$$h_f = 0.5 \text{ m}$$

$$\text{NPSH} = 3.3 \text{ m}$$
$$h_s = 10.1936 - 3.3 - 0.40 - 0.5$$
$$= 5.9936 = 5.99$$

7. (c)

Putting $\frac{u}{V} = \varepsilon$, $\eta = 2\varepsilon(1-\varepsilon)^2$ and in this expression the limits of ε are, $\varepsilon \geq 0$ and $\varepsilon < 1.0$. For maximum efficiency

$$\frac{d\eta}{d\varepsilon} = 0.$$

Hence $$\frac{d\left(\varepsilon(1-\varepsilon)^2\right)}{d\varepsilon} = 0$$

$$\frac{d\left(\varepsilon - 2\varepsilon^2 + \varepsilon^3\right)}{d\varepsilon} = 0$$

Leading to $\Rightarrow 3\varepsilon^2 - 4\varepsilon + 1 = 0$

The roots to this equation are $\varepsilon = 1$ and $\varepsilon = \frac{1}{3}$. Since $\varepsilon = 1$ is not feasible and hence for maximum efficiency $\varepsilon = \frac{1}{3}$.

Substituting this in the expression for η the maximum efficiency is obtained as

$$\eta_{max} = 2\times\frac{1}{3}\times\left(1-\frac{1}{3}\right)^2 = \frac{8}{27} = 29.6\%$$

8. (b)

$$\text{Speed } (v) = \sqrt{2gH}$$

$\therefore$ $$U \propto H^{1/2}$$

$$\text{Discharge } (Q) = AV$$

$\therefore$ $$Q \propto D^2\sqrt{H}$$

$\therefore$ $$Q \propto H^{1/2}$$

Now,

$$\text{Power } (P) = \rho QgH$$
$$P \propto \sqrt{H}\times H$$
$$P \propto H^{3/2}$$

9. **(d)**

When diameter constant

(i) $$U_1 = \frac{\pi DN}{60} \propto \sqrt{H}$$

∴ $$H \propto N^2$$

(ii) $$Q = \pi D_1 b_1 \times V_f$$

$$Q \propto V_f^2 \, \alpha N$$

∴ $$Q \propto N$$

(iii) $$\text{Power } P = \rho g Q H$$

$$P \propto N \times N^2$$

$$P \propto N^3$$

Now, $$\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$$

$$H_2 = 10 \times \left(\frac{2000}{1000}\right)^2 = 40 \text{ m}$$

$$\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3 ; P_2 = 1 \times \left(\frac{2000}{1000}\right)^3 = 8 \text{ kW}$$

10. **(b)**

$$\frac{ND}{\sqrt{H}} = \text{constant}$$

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

⇒ $$H_2 = \left(\frac{D_2}{D_1}\right)^2 H_1$$

or $$H_2 = \left(\frac{R_2}{R_1}\right)^2 H_1$$

$$R_1 = 100 \text{ mm}, R_2 = 100 - 10 = 90 \text{ mm}$$

∴ $$H_2 = (0.9)^2 \times 10 = 8.1 \text{ m}$$

11. **(b)**

$$V_1 = C_V \sqrt{2gH}$$

⇒ $$V_1 = 0.985\sqrt{2 \times 9.81 \times 45}$$

$$= 29.27 \text{ m/s}$$

$$\beta = 165°, \quad \beta' = 180 - 165 = 15°, \quad k = 1 \text{ (assumed)}$$

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

$$= 1000 \times 0.8 \times 14 \times (29.27 - 14) \times (1 + \cos 15) = 336.22 \text{ kW}$$

∴ Power delivered to shaft $= 336.22 \times 0.95$

$$= 319.411 \text{ kW}$$

12. (b)

$$V_r = \sqrt{L_r} = \sqrt{25} = 5$$

Force ratio, $F_r = \rho_r V_r^2 L_r^2 = L_r^3$ $(\because \rho_r = 1)$

or $F_r = (25)^3$

$$F_p = F_m \times F_r = 0.5 \times 15625 = 7812.5 \text{ kg}$$

13. (d)

14. (b)

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{145\sqrt{7000}}{(25)^{5/4}} = 217$$

Low head $\rightarrow$ Francis turbine

15. (d)

16. (a)

Given data :

$$P = 3 \text{ MW} = 3000 \text{ kW}$$
$$N = 140 \text{ rpm}$$
$$H = 10 \text{ m}$$

Specific speed : $N_s = \dfrac{N\sqrt{P}}{H^{5/4}}$

where N is in rpm

P is in kW

and H is in m

$$\therefore \quad N_s = \frac{140 \times \sqrt{3000}}{(10)^{5/4}} = 431.20$$

17. (d)

18. (c)

Pelton turbine — Specific speed from 10 to 50 + tangential flow.

Francis turbine — Specific speed from 60 to 300 + mixed flow.

Propeller turbine — Specific speed from 300 to 1000 + axial flow with fixed runner vanes.

Kaplan turbine — Specific speed from 300 to 1000 + axial flow with adjustable runner vanes.

19. (b)

$$\eta_{overall} = \frac{SP}{gQH}$$

or $$Q = \frac{500}{0.83} \times \frac{1}{9.81} \times \frac{1}{30} = 2.0469$$

20. (d)

21. (a)

Discharge is radial

$$\therefore \quad V_{w_2} = 0$$

$$u = 0.96\sqrt{2g8} = 12.03 \text{ m/s}$$

$$\eta_h = \frac{\rho Q V_{w_1} u}{\rho g Q H}$$

$$V_{w1} u = \eta_h g H$$

$$V_{w1} = \frac{0.85 \times 9.81 \times 8}{12.03} = 5.54 \text{ m/s}$$

22. (c)

Given data:

Condition-1

$$H_1 = 25 \text{ m}$$
$$N_1 = 200 \text{ rpm}$$
$$Q_1 = 9 \text{ m}^3/\text{s}$$
$$\eta_0 = 90\% = 0.90$$

also $$\eta_0 = \frac{P_1}{\rho Q_1 g H_1}$$

$$\therefore \quad 0.90 = \frac{P_1}{1000 \times 9 \times 9.81 \times 25}$$

or $$P_1 = 1986525 \text{ W}$$
$$= 1.98 \text{ MW}$$

Condition-2

$$H_2 = 20 \text{ m}$$
$$P_2 = ?$$

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

$$(P_u)_1 = (P_u)_2$$

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

or $$P_2 = P_1 \times \left(\frac{H_2}{H_1}\right)^{3/2} = 1.98 \times \left(\frac{20}{25}\right)^{3/2} = 1.41 \text{ MW}$$

23. (b)

$$v_1 = \sqrt{2gh}$$

where $$H = \frac{p}{\rho g} = \frac{10^3 \times 10^3}{10^3 \times 9.81} = 101.9 \text{ m}$$

$\therefore$ $$v_1 = \sqrt{2 \times 9.81 \times 101.9} = 44.72 \text{ m/s}$$

Also $$u = \frac{\pi DN}{60} = \frac{\pi \times 2 \times 320}{60} = 33.49 \text{ m/s}$$

$$\eta = 2\left(\frac{u}{v_1}\right)\left(1 - \frac{u}{v_1}\right)(1 - \cos\theta)$$

$$= 2 \times \frac{33.49}{44.72}\left(1 - \frac{33.49}{44.72}\right)(1 - \cos 162) = 0.733 \text{ or } 73.3\%$$

24. (c)

Specific speed is independent of dimensions, size of both actual and specific turbine.

25. (d)

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