MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2025

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MECHANICAL ENGINEERING

Objective Practice Sets

Fluid Mechanics

Part-I : Fluid Mechanics

Part-II : Hydraulic Machines

3 CHAPTER

Hydraulic Pump

Q.1 Which of the following statements regarding reciprocating pump are correct
1. A reciprocating pump is positive displacement pump.
2. In double acting reciprocating pump, the suction and delivery strokes occur simultaneously.
3. Multi-cylinder pumping arrangement is employed to get more steady flow in the delivery pipe.
4. Darcy-Weisbach formula with friction factor f is used to estimate the friction losses h_{fs} and h_{fd} in suction pipe and delivery pipe respectively.

(a) 1, 2 and 4 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.2 A single acting reciprocating pump has a plunger of diameter 250 mm and stroke of 350 mm. If the speed of the pump is 60 rpm and it delivers 16.5 lps of water. The percentage slip of the pump is ___%.

Q.3 Cavitation in centrifugal pump is likely to occur
(a) at the outlet to the pump
(b) at the inlet to the pump
(c) anywhere inside the pump
(d) none of these

Q.4 If the pump head is 81 m, discharge is 0.25 m^3/s and the motor speed is 1500 rpm at rated condition, the specific speed of the pump is about __________.

Q.5 An oil is pumped through a pipe having dynamic viscosity as 0.15 N-s/m^2 and specific gravity of the oil is 0.9. A power input of 6 kW with an overall efficiency of 60% at the pump is noted. Assuming head loss due to friction as $1.458 \times 10^4\, Q$, where Q is discharge in m^3/s. The discharge through the pump is __________ *l*/s.

Q.6 A centrifugal pump has an impeller of outer diameter 30 cm. The vane tips are radial at the outlet. For a rotation speed of 1500 rpm and manometric efficiency of 0.80, the net head developed is __________ m.

Q.7 A centrifugal pump has an impeller of 40 cm diameter and runs at 1200 rpm giving best efficiency. It delivered 1.8 m^3/minute against a head of 36 m. What is its shape number is approximately (based on flow expressed in lps)?
[Take $\sqrt{9.81} = 3.132$, $\sqrt{\sqrt{9.81}} = 1.77$]

(a) 58 (b) 80
(c) 90 (d) 70

Q.8 Consider the following statements:
Air vessels are fitted on the suction side of a reciprocating pump to
1. Work in overcoming frictional resistance.
2. Achieve higher speed without separation.
3. Deliver constant discharge.

Which of the above statements are CORRECT?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.9 Consider the following statements:
1. By providing air vessels on the suction and delivery sides of a reciprocating pump, it is possible to increase the delivery head of the pump.
2. In reciprocating pump, the piston is considered to be moving with simple harmonic motion on assumption that the connecting rod is very large compared to be crank length.

Which of the above statements is(are) CORRECT?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of these

Q.10 Two identical centrifugal pumps are connected in parallel to a common delivery pipe of a system. The discharge performance curve of each of the pumps is represented by $H = 30 - 80Q^2$. The discharge head equation of the parallel duplex pump set is
(a) $H = 30 - 80Q^2$ (b) $H = 15 - 20Q^2$
(c) $H = 30 - 20Q^2$ (d) $H = 15 - 80Q^2$

Answers Hydraulic Pump

1. (d)	2. (4.07)	3. (b)	4. (27.78)	5. (5.29)	6. (45.27)	7. (b)	8. (a)	9. (c)	10. (c)
11. (15.696)	12. (3.7)	13. (0.17)	14. (c)	15. (b)	16. (a)	17. (3)	18. (8.1056)		
19. (c)	20. (b)	21. (c)	22. (d)	23. (c)	24. (a)	25. (d)	26. (c)	27. (c)	28. (b)
29. (b)	30. (c)	31. (b)	32. (c)	33. (a)	34. (c)	35. (c)	36. (b)	37. (b)	38. (d)
39. (a)	40. (d)	41. (d)	42. (b)	43. (b)					

Explanations Hydraulic Pump

2. 4.07 (3.5 to 4.5)

Theoretical discharge of the pump,

$$Q_{th} = \frac{ALN}{60}$$

$$= \frac{\pi}{4}\left(\frac{250}{1000}\right)^2 \times \frac{350}{1000} \times \frac{60}{60}$$

$$= 0.0172 \text{ m}^3/\text{s} = 17.2 \ l/\text{s}$$

$$\text{Percentage slip} = \frac{Q_{th} - Q_a}{Q_{th}} \times 100$$

$$= \frac{17.2 - 16.5}{17.2} \times 100 = 4.07\%$$

3. (b)

Cavitation is likely to occur at the inlet to the pump, since the pressure there is the minimum and is lower than the atmospheric pressure by an amount that equals the vertical height above when the pump is situated from the supply reservoir (known as sump) plus the velocity head and frictional losses in the suction pipe.

4. 27.78 (27 to 29)

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}} = \frac{1500\sqrt{0.25}}{(81)^{3/4}}$$

$$= \frac{1500 \times 0.5}{27} = \frac{250}{9} = 27.78$$

5. 5.29 (5.2 to 5.4)

Power output = 6 × 0.6 = 3.6 kW

Also power output = $\gamma Q H_L$

Head lost due to friction,

$$H_L = 1.458 \times 10^4 \, Q$$

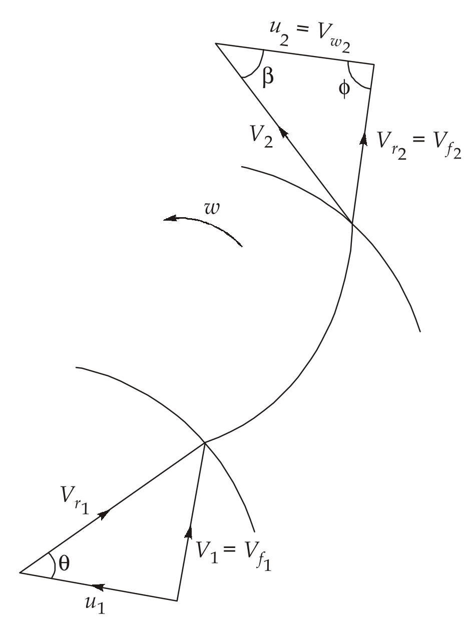
$$\therefore \quad P = \gamma Q(1.458 \times 10^4 \, Q) = 3.6 \times 10^3$$

$$\Rightarrow \quad 0.9 \times 9810 \times 1.458 \times 10^4 Q^2 = 3.6 \times 10^3$$

$$\Rightarrow \quad Q = 5.288 \times 10^{-3} \text{ m}^3/\text{s}$$

$$= 5.29 \ l/\text{s}$$

6. 45.27 (44.5 to 46)



$$\eta_{manomelric} = \frac{H_m}{\frac{V_{w_2} u_2}{g}}$$

$$0.8 = \frac{H_m}{\frac{u_2^2}{g}}$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.3 \times 1500}{60} = 23.56 \text{ m/s}$$

$$\therefore \quad 0.8 = \frac{H_m}{\frac{(23.56)^2}{9.81}}$$

$$H_m = 45.27 \text{ m}$$

7. (b)

$\because$ Shape number is also known as non-dimensional specific speed

$$\text{For pumps, } S_q = \frac{N\sqrt{Q}}{(gH)^{3/4}} = \frac{1200\times\sqrt{\frac{1.8\times10^3}{60}}}{\left(\sqrt{\sqrt{9.81}}\right)^3\times\left(6^2\right)^{3/4}}$$

$$= 80.67 \simeq 80$$

8. (a)

For delivering constant discharge, air vessels are provided on delivery side of the pump.

10. (c)

For total quality of discharge (Q) the discharge from each pump will be (Q/2)

$$H = 30 - 80\left(\frac{Q}{2}\right)^2 = 30 - 20Q^2$$

11. **15.696 (15 to 16)**

Total head for pumping, $H = 4 + 20 = 24$ m

$$\text{Power, } P = \frac{\rho gHQ}{\eta}$$

$$= \frac{9.81\times24\times0.05}{0.75}\text{ kW} = 15.696\text{ kW}$$

12. **3.7 (3.6 to 3.8)**

NPSH (Net positive suction head) = Cavitation coefficient × Manometric head

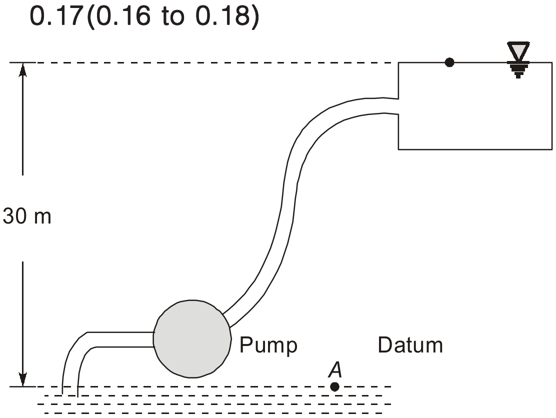
$= 0.15 \times 30 = 4.5$ m

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

$$\therefore \text{Safe height of runner} = \frac{p_{atm} - p_v}{\rho g} - NPSH$$

$$(h_s + h_{fs}) = 9.2 - 1 - 4.5 = 3.7\text{ m}$$

13. **0.17(0.16 to 0.18)**



$P = 80$ kW, $L = 3$ km, $H = 30$ m, $f = 0.2$

$$\theta = \left(\frac{800}{8\times3600}\right) = \frac{1}{36}\text{m}^3/\text{sec}$$

$$P = \rho_\theta H_P$$

$$\Rightarrow 80\times10^3 = 9810\times\frac{1}{36}\times H_P$$

$$\Rightarrow H_P = 293.58\text{ m}$$

Applying Bernoulli's equation between point A to B

$$\Rightarrow \frac{P_A}{\gamma} + z_A + \frac{V_A^2}{2g} + H_P = \frac{P_B}{\gamma} + z_B + \frac{V_B^2}{2g} + h_{f_{AB}}$$

$$\Rightarrow 0 + 0 + 0 + 293.58 = 0 + 30 + 0 + h_{f_{AB}}$$

$$\Rightarrow h_{f_{AB}} = 263.58\text{ m}$$

From Darcy Weisbach equation,

$$h_{f_{AB}} = \frac{\rho L\theta^2}{12.1d^5} = 263.58$$

$$\Rightarrow \frac{0.2\times3\times10^3\times\left(\frac{1}{36}\right)^2}{12.1\times263.58} = d^5$$

$$\Rightarrow d = 0.1708\text{ m}$$

14. (c)

The maximum suction lift,

$$h_s = \left(\frac{p_a - p_v}{\rho g}\right) - NPSH - h_{fs}$$

$p_a = 100$ kPa;

$\rho g = 1000 \times 9.81 = 9810$ N/m^3

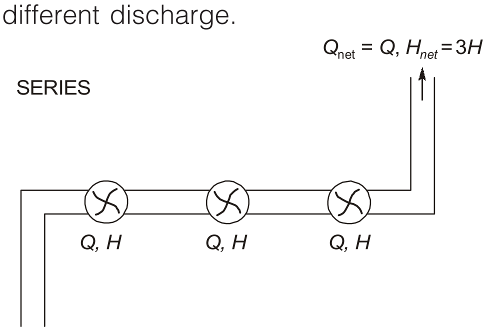
$$\frac{p_v}{\rho g} = 0.44\text{ m}$$

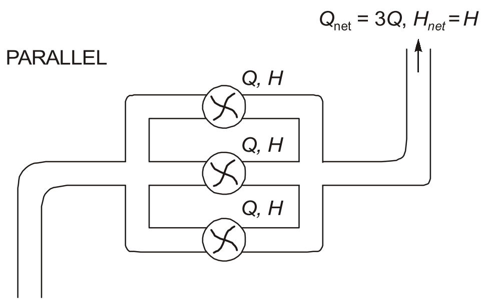
$$\frac{p_a}{\rho g} = \frac{100\times10^3}{9810} = 10.19\text{ m}$$

$$\therefore \quad h_s = 10.19 - 0.44 - 3.3 - 0.3 = 6.15\text{ m}$$

15. (b)

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





16. (a)

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}$$

17. (3)

Total head, $H = 150$ m, Specific speed, $N_s = 30$, $N = 1450$ rpm, $Q = 0.2$ m^3/s

Number of pumps, n = ?

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}$$

$$\therefore \quad 30 = \frac{1450\sqrt{0.2}}{H^{3/4}}$$

$$\therefore \quad H = 60.21 \text{ m}$$

Head lift capacity of each pump,

$$H = 60.21 \text{ m}$$

Number of pumps required,

$$n = \frac{150}{60.21} = 2.49 \approx 3 \text{ pumps}$$

18. (8.1056)

$$\text{Power} = 2 \text{ kW}$$
$$N = 3000 \text{ rpm}$$
$$R = 0.05 \text{ m} \times 2 = 0.1 \text{ m}$$

$$u = \frac{\pi DN}{60} = \frac{\pi \times 0.1 \times 3000}{60}$$
$$= 15.708 \text{ m/s}$$

For centrifugal pump,

$$\text{Power} = \rho Q(u^2)$$
$$2 \times 10^3 = \dot{m}(15.708)^2$$
$$\dot{m} = 8.1056 \text{ kg/s}$$

19. (c)

- Jet pumps, also known as ejector pump are devices capable of handling and transporting al forms of motive fluid including gas, steam or liquids.
- Jet pumps are less efficient than typical centrifugal pumps.

20. (b)

$l = 4$ km $= 4000$ m

$d = 0.2$ m, $f = 0.01$, $V = 2$ m/s, $h = 5$ m

$$h_f = \frac{flV^2}{2gd} = \frac{0.01 \times 4000 \times (2)^2}{2 \times 9.81 \times 0.2}$$
$$= 40.77 \text{ m/s}$$

Head produced by the pump,

$$H = h + h_f$$
$$= 5 + 40.77 = 45.77 \text{ m of water}$$

Absolute discharge pressure at the pump exit

$$p_{abs} = \rho gH + p_{atm}$$
$$= 1000 \times 9.81 \times 45.77 + 101325$$
$$= 5.503 \times 105 \text{ Pa} = \mathbf{5.503 \text{ bar}}$$

21. (c)

$$\text{Piston area } (A) = 0.1 \text{ m}^2$$
$$\text{Stroke } (L) = 0.3 \text{ m}$$
$$Q_{actual} = \frac{2.4}{60} \text{m}^3/\text{s}$$
$$N = 45 \text{ rpm}$$
$$H = h_s + h_d = 10 \text{ m}$$
$$Q_{theo} = \frac{2\,A.L.N}{60} \text{ m}^3/\text{s}$$
$$= \frac{2(0.1)(0.3)(45)}{60} \text{ m}^3/\text{s}$$
$$= \frac{2.7}{60} \text{ m}^3/\text{s}$$
$$\text{Slip} = Q_{Theo} - Q_{Act}$$
$$= \frac{2.7}{60} - \frac{2.4}{60} = 0.005 \text{ m}^3/\text{s}$$
$$\text{Power required} = \dot{m}.g.H = \rho.Q_{theo}.g.H$$
$$= \left(10^3\right)\left(\frac{2.7}{60}\right)(9.81)(10)$$
$$= 4.41 \text{ kW}$$

22. (d)

$$\left.\frac{H_m}{D^2N^2}\right|_1 = \left.\frac{H_m}{D^2N^2}\right|_2$$
$$\left.\frac{20}{1200^2}\right|_1 = \left.\frac{H_m}{1500^2}\right|_2$$
$$H_{m2} = 31.3 \text{ m}$$
$$\left.\frac{Q}{D^3N}\right|_1 = \left.\frac{Q}{D^3N}\right|_2$$
$$\frac{30}{1200} = \left.\frac{Q}{1500}\right|_2$$
$$Q_2 = 37.5 \text{ lps}$$