

- (b) Two geometrically similar pumps are to run at the same speed of 1200 r.p.m. If one of the pumps which has an impeller diameter of 0.3m lifts water at the rate of 0.02m³/s through a head of 16m, determine the head developed and impeller diameter of the other pump to deliver half the quantity of water.

5 + 7 = 12

Group – E

8. (a) Draw and explain the diagram of rate of delivery vs crank angle for (i) single acting and (ii) double acting reciprocating pump.
- (b) A single acting reciprocating pump has a cylinder diameter 150 mm and of stroke length 300 mm. The centre of pump is 4 m above the water surface in the sump. The atmospheric pressure head is 10.3 m of water and pump is running at 40 r.p.m. If the length and diameter of the suction pipe are 5 m and 10 cm respectively, determine the pressure head due to acceleration in the cylinder (i) at the beginning of the suction stroke, (ii) in the middle of suction stroke.

6 + 6 = 12

9. (a) Derive the expression of pressure head in the suction pipe of a reciprocating pump

$$h_{as} = \frac{l_s}{g} \times \frac{A}{a_s} r \omega^2 \cos \theta, \text{ where the symbols have their usual meanings.}$$

- (b) A single acting reciprocating pump operating at 45 r.p.m has a piston diameter of 25 cm and stroke length of 50 cm. The delivery pipe is 10 cm in diameter and 20 m long. Find the frictional head at the beginning of the delivery stroke. Assume Darcy's friction factor $f = 0.015$.

(1 + 6) + 5 = 12

**FLUID MACHINERY
(MECH 2201)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

**Group – A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: 10 × 1 = 10
- (i) In a Rotodynamic Pump, tangential momentum of the working fluid
 (a) increases (b) decreases
 (c) remains constant (d) may increase or decrease.
- (ii) Discharge of a centrifugal pump with rotational speed N is
 (a) directly proportional to N (b) inversely proportional to N
 (c) directly proportional to N² (d) inversely proportional to N².
- (iii) Inlet Guide Vane (IGV) is used in
 (a) Centrifugal pump (b) Francis turbine
 (c) Pelton turbine (d) Axial flow pump.
- (iv) Two hydraulic turbines are similar and homologous when they are geometrically similar and have the same
 (a) unit speed (b) Froude number
 (c) specific speed (d) rotational speed.
- (v) Francis turbine is a
 (a) impulse turbine (b) reaction turbine
 (c) may either impulse or reaction turbine (d) none of the above.
- (vi) For a radial flow pump
 (a) head is more and discharge is less
 (b) discharge is more and head is more
 (c) discharge is more and head is less
 (d) both head and discharge are very less.

- (vii) $\frac{Q}{ND^3}$ is known as
 (a) Head coefficient (b) Power coefficient
 (c) Flow coefficient (d) None of these.
- (viii) Cavitation in a Francis turbine is likely to occur at the
 (a) outlet to the runner (b) inlet to the runner
 (c) both inlet and outlet to the runner (d) none of the above.
- (ix) In a reciprocating pump without air vessels, the friction head in the suction or delivery pipe is maximum when the crank angle is
 (a) 0° (b) 90° (c) 120° (d) 180°.
- (x) For a negative slip, the coefficient of discharge in a reciprocating pump will be
 (a) less than unity (b) more than unity
 (c) equal to unity (d) infinite.

Group - B

2. (a) Classify different types of fluid machines, based on (i) direction of energy transfer (ii) principle of operation and (iii) direction of fluid path within rotor.
- (b) With the help of necessary velocity diagrams at impeller blade entry and exit, show that the Euler head H_E developed by a centrifugal pump is linearly related with discharge Q , when rotational speed N (in r.p.m) of the impeller and β_2 the blade angle at outlet, remain constant. Also draw both the ideal and actual H vs Q curves for backward curved blades. Explain why the ideal and actual curves deviate?

3 + (6 + 3) = 12

3. (a) A centrifugal pump has an impeller of 80cm diameter at outlet and it delivers 1.1m³/s of water against a head of 70m. The impeller runs at 1000 r.p.m and its width at exit is 8cm. If the leakage loss is 4% of the discharge, external mechanical loss is 10 kW and hydraulic efficiency is 82%, calculate the blade angle at outlet and overall efficiency.
- (b) Define the terms: (i) shut-off head (ii) manometric head for a centrifugal pump.

8 + (2 + 2) = 12**Group - C**

4. (a) What is the function of spiral casing in case of Francis turbine? Describe and sketch different types of draft tube.
- (b) A Kaplan turbine develops 20MW when running at 130 r.p.m under a head of 20m. The outer diameter of the runner is 4m and hub diameter is 1.8m. The hydraulic and overall efficiency of the turbine are 90% and 85% respectively. Determine the discharge through the turbine and the blade angles at inlet and outlet, measured at mean radius of the runner.

(2 + 4) + 6 = 12

5. (a) The inlet and outlet diameters of an inward flow reaction turbine are 100cm and 80cm respectively and its breadth at inlet is 20cm. 10% of the flow area is blocked by the blade thickness. The flow velocity at the inlet is 2.5m/s and runner speed is 200rpm. The guide vanes at the inlet make an angle of 12° to the wheel tangent. Assuming the discharge is radial and inlet and outlet flow velocity is same, find out
 (i) Flow rate through runner
 (ii) Blade angles at inlet and outlet
 (iii) Absolute and relative velocities of water entering the runner blade.
- (b) A power house is equipped with Pelton type impulse turbines. Each turbine delivers a power 14 MW when working under a head of 900m and running at 600 r.p.m. Find the diameter of the jet and mean diameter of the turbine wheel. Assume that the overall efficiency 89%, velocity coefficient of the jet 0.98 and speed ratio 0.46.

6 + 6 = 12**Group - D**

6. (a) In case of a general pumping system from a low to high level reservoir, using Bernoulli's equation show that the net head developed by a centrifugal pump is given by

$$H = H_{static} + \sum h_{loss} \text{ where } H_{static} = \text{Static lift}$$
- (b) Draw main characteristics, operating characteristics and constant efficiency curves of a reaction turbine.

6 + 6 = 12

7. (a) Define specific speed of a centrifugal pump and deduce an expression for it, in terms of the head H , discharge Q , and the speed N .