FLUID MACHINERY
(MECH 2202)

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) Which of the following pumps is preferred for flood control application?
(a) Centrifugal pump (b) Axial flow pump
(c) Mixed flow pump (d) Reciprocating pump.

(ii) Shut off head of a centrifugal pump is head developed at
(a) zero flow rate (b) zero power input
(c) maximum flow rate (d) maximum efficiency.

(iii) The specific speed of a Fluid machines
(a) is the speed of a machine having unit dimension
(b) has the dimension of rotational speed
(c) remains unchanged under different conditions of operation
(d) relates the shape rather than the size of the machine.

(iv) The reaction turbines as compared to impulse turbines have
(a) low speed (b) high speed
(c) equal speed (d) none of the above.

(v) Which of the following statement is incorrect for a Kaplan turbine?
(a) It has blades of small chamber to avoid separation
(b) It has adjustable blades
(c) It has large guide blade angles than of a Francis turbine
(d) It has mixed flow velocity.

(vi) For a negative value of 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.

(vii) Air vessel in a reciprocating pump is used
(a) to obtain a continuous supply of water of uniform rate
(b) to reduce suction head
(c) to increase the delivery head
(d) none of these.

(viii) The series operation of a pump results in
(a) reduced power (b) higher discharge
(c) low speed (d) high head.

(ix) The maximum hydraulic efficiency of an impulse turbine is
(a) $(1+\cos\alpha)/2$ (b) $(1-\cos\alpha)/2$ (c) $(1+\sin\alpha)/2$ (d) $(1-\sin\alpha).2$

(x) Generally, reciprocating pumps are best suited
(a) where constant heads are required despite fluctuation in discharge
(b) where constant supplies are required despite fluctuation in pressure
(c) for pumping large liquid flows for medium heads at high speeds
(d) none of the above.

Group- B

2. (a) With a neat sketch show the main components of a centrifugal pump and write their functions. [(CO1)(Remember/LOCQ)]

(b) The external and internal diameters of the impeller of a centrifugal pump are 0.4 m and 0.2 m, respectively. The centrifugal pump runs at 1200 rpm and its vanes at the exit are set back at an angle of 25°. If a constant radial flow through the impeller is maintained at 2.5 m/s, then determine (i) the inlet vane angle, (ii) angle made by absolute velocity at the outlet and (iii) work done by the impeller per unit weight of water. [(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

3. (a) Compare axial flow, mixed flow and radial flow pump in terms of head developed, discharge and performance characteristic curves. [(CO1)(Remember/LOCQ)]

(b) A centrifugal pump is to discharge 0.118 m^3/s at a speed of 1450 rpm against a head of 25 m. The impeller diameter is 250 mm, its width at the outlet is 50 mm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller. [(CO2)(Analyze/IOCQ)]

6 + 6 = 12

Group – C

4. (a) Write a short note on (i) Multistage Pump (ii) System resistance curve. [(CO6)(Understand/LOCQ)]

(b) Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump has an impeller diameter of 0.30 m and lifts water at a rate of 20

litres /second against a head of 15 m. Determine the head and impeller diameter of the other pump to deliver half the discharge. [(CO4)(Analyze/HOCQ)]

6 + 6 = 12

5. (a) A centrifugal pump is to deliver water from a tank against a static lift of 40 m. The suction pipe is 50 m long and 25 cm diameter and friction factor f =0.02. The delivery pipe is of 20 cm diameter,1600 m long and friction factor f =0.022. The pump characteristic is given as $H_P = 100 - 6000Q^2$ where H_P = pump head in m. Neglecting the minor losses; calculate the operating head and discharge of the pump. [(CO3)(Analyze/IOCQ)]

(b) The relations between the total head developed H in m and the discharge Q in m^3/s for two centrifugal pumps 1 and 2 are given by $H_1 = 20 - 80Q_1^2$ and $H_2 = 30 - 270Q_2^2$ respectively. For parallel operation of the pumps, find

(i) The discharge up to which only second pump would contribute flow to the system.

(ii) The total discharge corresponding to zero head. [(CO4)(Analyze/IOCQ)]

6 + 6 = 12

Group - D

6. (a) Draw the velocity triangles of an inward flow reaction turbine and derive the work done per unit weight of water. [(CO2)(Remember/LOCQ)]

(b) A pelton wheel has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litres/s under a head of 30 m. The bucket deflects the jet through an angle of 160º. Calculate the power and efficiency of the turbine. (Assume C_v = 0.98). [(CO3)(Analyze/HOCQ)]

6 + 6 = 12

7. (a) What is draft tube? Why is it used in a reaction turbine? Describe with net sketch two different types of draft tube. [(CO1)(Understand/IOCQ)]

(b) An inward flow reaction turbine develops 320 kW shaft power with an overall efficiency of 85% when working under a net head of 72 m. The hydraulic efficiency of the turbine is 95% and the runner speed is 650 rpm. The ratio of wheel width to wheel diameter at the inlet is 0.1 and the ratio of inner diameter to outer diameter is 0.5. If the flow ratio is 0.17 and flow velocity is constant, then determine the dimensions and blade angles of the turbine. Assume radial discharge at the outlet and neglect area blockage by blades. [(CO4)(Analyze/IOCQ)]

6 + 6 = 12

Group – E

8. (a) Compare between centrifugal and reciprocating pumps. [(CO5)(Understand/LOCQ)]

(b) A single acting reciprocating pump having a cylinder diameter of 150 mm and stroke of 300 mm is used to raise the water through a height of 20 m. Its crank

rotates at 160 rpm. Find the theoretical power required to run the pump and theoretical discharge. If actual discharge is 5 litres/s, find the percentage slip. If delivery pipe is 100 mm in diameter and is 15 m long, find the acceleration head at the beginning of the stroke. [(CO5)(Analyse/IOCQ)]

6 + 6 = 12

9. (a) What is cavitation of a centrifugal pump? How do you reduce the effect of cavitation? [(CO6)(Remember/LOCQ)]

(b) A single-acting reciprocating pump has a 25 cm cylinder with a stroke of 40 cm. The diameters of suction and delivery pipes are 15 cm and 20 cm respectively. If the crank makes 40 revolutions per minute, estimate the maximum velocity and acceleration of water in the suction and delivery pipes. [(CO5)(Analyse/IOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	43.75	25

Course Outcome:

After the completion of the course students will be able to

1. Select different types of fluid machines and list their components.
2. Implement the working principle of rotodynamic machines for evaluating different flow parameters.
3. Identify losses in fluid machines and relate different efficiencies.
4. Compare performance characteristics of various fluid machines.
5. Examine different components and working principles of a positive displacement machine.
6. Describe different processes and phenomena involving operation of fluid machines.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question