FLUID MACHINERY
(MECH 2202)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The hydraulic efficiency of a centrifugal pump takes into account the losses in
(a) pump impeller (b) bearings and windage
(c) pipes (d) all of the above.

(ii) Shut-off head of a pump is the head developed at
(a) zero impeller speed (b) zero input power
(c) zero discharge (d) maximum efficiency.

(iii) Efficiency of an ideal Pelton wheel will be maximum if the ratio of jet velocity to tangential velocity of the wheel is
(a) ½ (b) 1 (c) 2 (d) 4

(iv) Inlet Guide Vane (IGV) is used in
(a) Centrifugal pump (b) Francis turbine
(c) Pelton turbine (d) Axial flow pump.

(v) A Kaplan Turbine is ideally suited for
(a) low-head and high discharge
(b) high-head and high discharge
(c) low head and low discharge
(d) medium head and medium discharge.

(vi) Muschel curves belong to the category of
(a) main characteristic curves of a turbine
(b) operating characteristic curves of a turbine
(c) constant efficiency curves of a turbine
(d) operating characteristics of a pump.

(vii) Adjustable runner blades are found in
(a) Francis turbine (b) Pelton turbine
(c) Kaplan turbine (d) Propeller turbine.

(viii) An air vessel at the delivery side of a reciprocating pump
(a) maintains steady discharge output
(b) prevents cavitation in the system
(c) enables suction head to be increased
(d) enables the pump to run at higher speed.

(ix) 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.

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

Fill in the blanks with the correct word

(xi) An example of reaction turbine is _____.

(xii) The specific speed of a turbine is given by _____.

(xiii) For operating characteristics of centrifugal pump, the parameter that is kept constant, is _____.

(xiv) Cavitation in centrifugal pump generally occurs at _____.

(xv) In a reciprocating pump without air vessel, the friction head in the delivery pipe is maximum at the crank angle θ = _____.

Group - B

2. (a) Define the terms suction head, delivery head, static head and manometric head . *[(CO3)(Remember/LOCQ)]*

(b) A centrifugal pump delivers water against a total head of 10 m at a design speed of 1000 rpm. The vanes are curved backwards and make an angle of 30° with the tangent at the outer periphery of the impeller. The impeller diameter is 30 cm and has a width of 5 cm at the outlet. (i) If the manometric efficiency is 0.95%, estimate the discharge of the pump, (ii) Assuming an overall efficiency of 76%, estimate the power required to drive the pump. *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

3. (a) Describe the need for priming of centrifugal pumps. How is it achieved? *[(CO3)(Analyse/HOCQ)]*

(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)(Apply/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) Draw the operating characteristics (*H-Q, P-Q*, η-*Q*) of a centrifugal pump. Show the system resistance curve in the same diagram and locate the operating point and design point. *[(CO6)(Understand/LOCQ)]*

   (b) Two homologous pumps A and B are to run at the same speed of 600 rpm. Pump A has an impeller of 50 cm diameter and discharges 0.4 m^3/s of water under a net head of 50 m. Determine the diameter of impeller of pump B and its net head, if it is to discharge 0.3 m^3/s of water. *[(CO4)(Analyze/HOCQ)]*

6 + 6 = 12

5. (a) With neat sketches, explain the characteristics curves of two dissimilar centrifugal pumps operated (i) in series and (ii) in parallel. *[(CO6)(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) (i) Draw a neat sketch of a Pelton turbine setup and show different parts. (ii) Which turbine is suitable to run under the head of 60 m, justify your answer. *[(CO1)(Remember/LOCQ)]*

   (b) A Pelton wheel is receiving water from a penstock with a gross head of 480 m. One-third of gross head is lost in friction in the penstock. The rate of flow through the nozzle fitted at the end of the penstock is 2.2 m^3/s. The angle of deflection of the jet is 165°. Determine: (i) The power given by water to the runner, and (ii) Hydraulic efficiency of the Pelton wheel. Take $C_v = 1.0$ and speed ratio = 0.45. *[(CO2)(Apply/IOCQ)]*

(4 + 2) + 6 = 12

7. (a) With the help of a figure, explain the spear regulation governing system of a Pelton turbine. *[(CO1)(Remember/LOCQ)]*

   (b) A Kaplan turbine has a runner of 4.0 m diameter and its hub has a diameter of 1.2 m. The discharge through the turbine is 70 m^3/s. The hydraulic and mechanical efficiencies can be assumed to be 0.9 and 0.93 respectively. Assuming the absence of whirl at the outlet and the discharge is free at the outlet, estimate the (i) net available head on the turbine and (ii) power developed. *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) Write the definition of the specific speed of centrifugal pump and turbine. Explain how it is useful in practice. *[(CO6)(Understand/LOCQ)]*

(b) A double acting reciprocating pump operating at 55 rpm has a piston diameter of 0.2 m. The stroke of the piston is 0.3 m. The suction and delivery heads are 5 m and 20 m, respectively. Determine (i) the theoretical discharge and (ii) power required to drive the pump. *[(CO5) (Evaluate /HOCQ)]*

4 + 8 = 12

9. (a) Discuss the cavitation phenomenon in hydraulic turbine. Also state two methods to prevent cavitation in hydraulic turbine. *[(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)]*

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	45.83	20.84

Course Outcome (CO):

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.*