TURBO MACHINERY
(MEC3142)

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) $\frac{gH}{N^2D^2}$ is known as
(a) Pressure coefficient (b) Head coefficient
(c) Flow coefficient (d) Power coefficient

(ii) In an axial flow turbomachine, the direction of flow of fluid is
(a) parallel to the shaft (b) perpendicular to the shaft
(c) 45° inclined to the shaft (d) both (b) and (c)

(iii) Geometric similarity between model and prototype means the
(a) similarity of force (b) similarity of shape
(c) similarity of motion (d) similarity of discharge

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

(v) In the inlet part of the jet impinging on a Pelton bucket, the velocity of whirl is equal to
(a) Absolute flow velocity at inlet (V_1) (b) Relative flow velocity at inlet (V_{r1})
(c) Peripheral speed of wheel (u) (d) none of these

(vi) The main function of the governor is to maintain the turbine _____ constant irrespective of load on the turbine
(a) Head (b) Power
(c) Discharge (d) Speed

(vii) Which of the following pump is preferred for flood control and irrigation application?
(a) radial flow pump (b) axial flow pump
(c) mixed flow pump (d) reciprocating pump

(viii) For finding shut-off head, a centrifugal pump is started with its delivery valve kept
(a) fully open (b) fully closed
(c) partially open (d) 50% open

(ix) Inducer is placed in the centrifugal compressor before
(a) Volute casing (b) Impeller eye
(c) Diffuser vane (d) Both diffuser vane and volute casing

(x) For a centrifugal fan with the diameter D, having discharge Q and rotational speed N, according to Fan Laws
(a) $Q \propto N$ (b) $Q \propto N^2$
(c) $Q \propto N^3$ (d) $Q \propto N^5$

Fill in the blanks with the correct word

(xi) Two hydraulic machines are similar and homologous when they are geometrically similar and have the same _____.

(xii) An example of a reaction turbine is _____.

(xiii) Slip loss in a centrifugal pump, occurs at the _____ of impeller blade.

(xiv) Thoma's cavitation parameter is defined as the ratio of _____ and working head (H).

(xv) For a centrifugal air compressor, the curvature of blades at the impeller exit is _____

Group - B

2. (a) Explain the differences between turbo machine and positive displacement machine. *[(CO1)(Remember/LOCQ)]*

(b) A hydro-turbine is required to give 25 MW at 50 m head and 90 rpm runner speed. The laboratory facilities available permit testing of 20 kW model at 5 m head. What should be the model runner speed and model to prototype scale ratio? *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

3. (a) A centrifugal pump delivers 2.5 m^3/s under a head of 14 m and runs at a speed of 2010 rpm. The impeller diameter of the pump is 125 mm. If a 104 mm diameter impeller is fitted and the pump runs at a speed of 2210 rpm, what is the volume flow rate? Determine also the new pump head. *[(CO4)(Apply/IOCQ)]*

(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 litre/second against a head of 15 m. Determine the head and impeller diameter of the other pump to deliver half the discharge. *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) A Francis turbine with an overall efficiency of 75% is required to produce 149.26 kW. It is working under a head of 7.62 m. The speed ratio is 0.26 and flow ratio at

inlet is 0.96. The wheel runs at 150 rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine: (i) Guide blade angle, (ii) Wheel vane angle at inlet, (iii) Diameter of the wheel at inlet, and (iv) Width of the wheel at inlet. *[(CO3)(Analyse/IOCQ)]*

(b) A Pelton wheel having a mean bucket diameter of 1.0 m is running at 1000 rpm. The net head on the Pelton wheel is 700 m. If the side clearance angle is 15° and discharge through the nozzle is 0.1 m^3/s, determine power available at the nozzle and hydraulic efficiency of the turbine. *[(CO6)(Analyse/IOCQ)]*

6 + 6 = 12

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

(b) A Kaplan turbine develops 15 MW of power at a head of 30 m. The diameter of the hub is 0.35 times the diameter of the runner. Assuming a speed ratio of 2.0, flow ratio of 0.65 and an overall efficiency of 90%, calculate the (i) diameter of the runner, (ii) rotational speed, and (iii) specific speed of the turbine. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) What is slip in a centrifugal pump? With a sketch explain it. *[(CO2)(Understand/LOCQ)]*

(b) The impeller of a centrifugal pump having external and internal diameters 500 mm and 250 mm respectively, width at outlet 50 mm and running at 1200 rpm. It works against a head of 48 m. The velocity of flow through the impeller is constant and equal to 3.0 m/s. The vanes are set back at an angle of 40^0 at the outlet. Determine: (i) Inlet vane angle, (ii) Work done by the impeller on water per second, and (iii) Manometric efficiency. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) When a laboratory test was carried out on a pump, it was found that for a pump total head of 36 m at a discharge of 0.05 m^3/s, cavitation began when the sum of the static pressure plus the velocity head at inlet was reduced to 3.5 m. The atmospheric pressure 750mm Hg and the vapour pressure of water is 1.8 kPa. If the pump is to operate at a location where atmospheric pressure is reduced to 620 mm Hg and the vapour pressure of water is 830 Pa, what is the value of the cavitation parameter when the pump develops the same total head and discharge? Is it necessary to reduce the height of the pump above the supply and if so, by how much? *[(CO3)(Apply/IOCQ)]*

(b) Briefly explain the phenomenon of cavitation in centrifugal pump. What are the effects of cavitation? *[(CO2)(Remember/LOCQ)]*

6 + 6 = 12

Group - E

8. (a) Explain surging, choking and stalling related to centrifugal compressor. *[(CO5)(Understand/LOCQ)]*

(b) Determine the pressure ratio developed and the specific work input to drive a centrifugal air compressor with an impeller diameter of 0.5 m and running at 7000 rpm. Assume zero whirl at the entry and T_{1t} = 290 K. The slip factor and power input factor to be unity, the process of compression is isentropic and for air, γ = 1.4, c_p = 1000 J/kg-K. *[(CO3)(Analyze/IOCQ)]*

6 + 6 = 12

9. (a) Show that the stagnation temperature ratio at the diffuser vane outlet and the impeller inlet of a centrifugal compressor may be expressed as $\frac{T_{3t}}{T_{1t}} = 1 + \frac{\psi\sigma U_2^2}{C_P T_{1t}}$ (Symbols have usual meaning). *[(CO5)(Understand/LOCQ)]*

(b) Air at a stagnation temperature of 27^0C enters the impeller of a centrifugal compressor in the axial direction. The rotor which has 15 radial vanes rotates at 20000 rpm. The stagnation pressure ratio between the diffuser outlet and the impeller inlet is 4 and the isentropic efficiency is 85%. Determine (i) the impeller tip radius and (ii) power input to the compressor when the mass flow rate is 2 kg/s. Assume a power input factor of 1.05 and a slip factor $\sigma = 1 - \frac{2}{n}$ where n is the number of vanes. For air, take γ = 1.4, R = 287 J/kg K. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	50	12.5