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 centrifugal pump, the flow is
(a) radially inward (b) radially outward
(c) tangential to rotor blade (d) axial.

(ii) Head developed by a centrifugal pump is
(a) proportional to speed of impeller only
(b) inversely proportional to speed of impeller
(c) proportional to diameter of impeller only
(d) proportional to both speed and diameter of impeller.

(iii) The manometric efficiency of a centrifugal pump is given by
(a) $H_m/(gV_{w2}U_2)$ (b) $gH_m/(V_{w2}U_2)$
(c) $V_{w2}U_2/(gH_m)$ (d) $gV_{w2}U_2/(H_m)$.

(iv) In all reaction turbines, for maximum efficiency
(a) the velocity of swirl at entrance to runner must be zero
(b) the velocity of flow at outlet of runner must be zero
(c) the velocity of swirl at outlet of runner must be zero
(d) the velocity of flow at entrance to runner must be zero.

(v) Pelton turbine is a
(a) impulse turbine (b) reaction turbine
(c) may either impulse or reaction turbine (d) axial flow turbine.

(vi) For operating characteristics of centrifugal pump, the parameter that is kept constant, is
(a) speed (b) discharge (c) head (d) power.

(vii) The unit speed N_u of a turbine of rotational speed N and head H is equal to
(a) $N\sqrt{H}$ (b) $N/\sqrt{H}$ (c) $\sqrt{H}/N$ (d) $\sqrt{HN}$

(viii) Efficiency of Pelton wheel shall be maximum, if the ratio of jet velocity to tangential velocity of the wheel is
(a) 0.5 (b) 1 (c) 2 (d) 0.75

(ix) The reciprocating pumps are useful for the application of
(a) high head and low discharge (b) high head and high discharge
(c) low head and high discharge (d) low head and low discharge.

(x) During suction stroke of a reciprocating pump, the flow separation may take place
(a) at the end of suction stroke (b) in the middle of suction stroke
(c) in the beginning of suction stroke (d) separation never occur.

Group – B

2. (a) With sketch of velocity diagrams, show that in case of a centrifugal pump, the ideal head rise across impeller blade is given by

$$H = \frac{U_2^2 - U_1^2}{2g} + \frac{V_2^2 - V_1^2}{2g} + \frac{Vr_1^2 - Vr_2^2}{2g}$$

where U= tangential speed of impeller, V= absolute flow velocity V_r = relative flow velocity; 1: inlet to impeller blade, 2: outlet of impeller blade

(b) Compare radial, axial and mixed flow pump based on head developed and discharge. Explain why backward curved vane is preferred over forward curved vane in case of centrifugal pump impeller?

6 + (3 + 3) = 12

3. (a) A centrifugal pump impeller has an outer diameter of 30cm and inner diameter of 15cm. The pump runs at 1200 rpm. The impeller vanes are set at a blade angle of 30^0 at the outlet. If the velocity of flow is constant at 2 m/s, and if there is no swirl at impeller inlet, then calculate
(i) the absolute velocity of water at outlet.
(ii) head developed, by assuming manometric efficiency = 0.85
(iii) impeller blade angle at inlet.

(b) In case of centrifugal pump, briefly explain the terms:
mechanical efficiency, hydraulic efficiency, overall efficiency.

6 + 6 = 12

Group – C

4. (a) Differentiate between (i) Impulse and Reaction turbine (ii) Kaplan and Propeller turbine.

(b) The hub diameter of a Kaplan turbine working under a head of 12 m, is 0.35 times the diameter of the runner. The turbine is running at 100 rpm. If the vane angle of the extreme edge of the runner at outlet is 15° and flow ratio is 0.6, find (i) diameter of the runner and (ii) discharge through the runner. Given the velocity of whirl at outlet is zero.

(2 + 2) + (4 + 4) = 12

5. (a) Two jets strike the buckets of a Pelton wheel, which is having shaft power as 14,715 kW. The diameter of each jet is given as 150 mm. If the net head on the turbine is 500 m, find the overall efficiency of the turbine. Take $C_v = 0.98$.

   (b) A conical draft-tube having diameter at the top as 2.0 m and pressure head at 7 m of water(vacuum), discharges water at the outlet with a velocity of 1.2m/s at the rate of 25 m^3/s. If atmospheric pressure head is 10.3 m of water and losses between the inlet and outlet of the draft tubes are negligible, find the length of draft-tube immersed in water. Total length of the draft-tube is 5 m.

6 + 6 = 12

Group – D

6. (a) 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 $H_2 = 30 - 270Q_2^2$. 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.

   (b) Draw the operating characteristics (H-Q, P_{in}-Q, η-Q) of a centrifugal pump. Show the system resistance curve in the same diagram and locate the operating point and design point.

(3 + 3) + (3 + 3) = 12

7. (a) Define and derive the expression of 'unit discharge' and 'unit power' with reference to a hydraulic turbine.

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

(3 + 3) + 6 = 12

Group – E

8. (a) Explain the working principle of a single acting reciprocating pump.

   (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 60 rpm. Find the theoretical power required to run the pump and the theoretical discharge. If actual discharge is 5 litre/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.

4 + 8 = 12

9. (a) Draw and explain the diagram of rate of delivery vs crank angle for double acting reciprocating pump.

(b) Derive the expression of maximum value of head loss due to friction in suction or delivery pipe of a reciprocating pump

$\left(h_f\right)_{max} = \frac{flv^2}{2dg} \times \left[\frac{A}{a}\omega r\right]^2$, where the symbols have their usual meanings.

4 + 8 = 12

Department & Section	Submission Link
ME	https://forms.gle/Be4sHM4QnZvgtjqU9