

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**
- Fluid enter in a centrifugal pump impeller parallel to the shaft and leaves
 - parallel to the shaft axis
 - perpendicular to the shaft axis
 - 30° inclined to the shaft axis
 - 45° inclined to the shaft axis.
 - Head developed by a centrifugal pump is
 - proportional to N only
 - proportional to N and D both
 - proportional to D only
 - proportional to N² and D² both.
 - The manometric efficiency of a centrifugal pump is given by
 - $H_m/(gV_{w2}U_2)$
 - $gH_m/(V_{w2}U_2)$
 - $V_{w2}U_2/(gH_m)$
 - $gV_{w2}U_2/(H_m)$.
 - Two hydraulic pumps are similar and homologous when they are geometrically similar and have the same
 - unit speed
 - Froude number
 - specific speed
 - rotational speed.
 - Kaplan turbine is a/an
 - impulse turbine
 - reaction turbine
 - (a) or (b)
 - mixed flow turbine.
 - The movable wicket gates of a reaction turbine are used to
 - control the flow of water passing through the turbine
 - control the pressure under which the turbine is working
 - strengthen the casing of the turbine
 - reduce the size of the turbine.
 - $\frac{P}{\rho N^3 D^5}$ is known as
 - head coefficient
 - power coefficient
 - flow coefficient
 - velocity coefficient.

- NPSH is the abbreviation of
 - Net Pressure and Suction Head
 - Nominal Positive Suction Head
 - Net Positive Suction Head
 - Net Positive Static Head.
- Discharge of a single acting reciprocating pump is
 - $\frac{ALN}{60}$
 - $\frac{AL}{N \times 60}$
 - $\frac{AN}{L \times 60}$
 - $\frac{LN}{A \times 60}$.
- The indicator diagram is a graph for one complete revolution between
 - pressure head and stroke length
 - discharge and stroke length
 - power and stroke length
 - suction height and delivery height

Group – B

2. (a) Define fluid machine. Stating the assumptions, obtain an expression of work done by impeller of a centrifugal pump on water per unit time per unit weight of water.
- (b) Show that the pressure head rise in the impeller of a centrifugal pump is given by

$$\frac{1}{2g} [V_{f1}^2 + U_2^2 - V_{f2}^2 \csc^2 \beta_2]$$

where V_{f1} and V_{f2} are velocity of flow at inlet and outlet respectively, β_2 is the blade angle at outlet. Assume no swirl at inlet and neglect frictional and other losses in the impeller.

(2 + 4) + 6 = 12

3. (a) A centrifugal pump is running at 1000/rpm. The outlet blade angle is 30° and velocity of flow at outlet is 3 m/s. The pump is working against a total head of 30 m and the discharge through the pump is 0.3 m³/s. If the manometric efficiency of the pump is 75%, determine
- the diameter of the impeller at outlet and
 - the width of the impeller at outlet.
- (b) In case of centrifugal pump, briefly explain the terms: mechanical efficiency and overall efficiency

(5 + 3) + 4 = 12

Group – C

4. (a) Differentiate between impulse and reaction turbine
- (b) An inward flow reaction turbine runner has an external diameter and internal diameter of 1.0m and 0.5m respectively. The hydraulic efficiency of the turbine is 85% when the head on the turbine is 30m. The velocity of flow at outlet is 2.0 m/s and the discharge at outlet is radial. If the blade angle at outlet is 15° and width of the runner is 200mm both at inlet and outlet, determine (i) the inlet guide vane angle (ii) speed of the turbine (iii) blade angle of the runner at inlet (iv) discharge of the turbine (v) power developed.

2 + 10 = 12

5. (a) Obtain an expression for the power transmitted by the fluid to a Pelton wheel. Hence find the expression of wheel efficiency η_w in terms of the jet speed V_1 , bucket speed U , blade friction coefficient K and outlet angle of the bucket β_2 .
- (b) A Pelton wheel is to be designed for the following specification: shaft power = 12000 kW, head = 350 m, speed = 750 rpm, overall efficiency = 86%, jet diameter is not to exceed one sixth of the wheel diameter. Determine
 (i) wheel diameter
 (ii) number of jets required
 (iii) diameter of jet
 Take coefficient of velocity is 0.985 and speed ratio 0.45.

(4 + 2) + 6 = 12**Group – D**

6. (a) Describe the cavitation phenomenon in a centrifugal pump. State two methods to prevent cavitation in centrifugal pump.
- (b) A centrifugal pump is to deliver water from a tank against a static lift of 40m. The suction pipe is 50m long and 25 cm diameter and friction factor $f = 0.02$. The delivery pipe is of 20cm diameter, 1600m long and friction factor $f = 0.022$.
 The pump characteristics is given as $H_p = 100 - 6000Q^2$
 Where H_p = pump head in metres and Q = discharge in m^3/s . Neglecting the minor losses, calculate the operating head and discharge of the pump.
7. (a) A turbine develops 8000 kW when running at 100 rpm. The head on the turbine is 30m. If the head is reduced to 18m, determine the speed and power developed by the 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.

6 + 6 = 12**Group – E**

8. (a) A single acting reciprocating pump with a bore of 25 cm and stroke of 40 cm runs at 30 rpm. It discharges water at the rate of $0.009 m^3/s$. The suction and delivery heads are 7 m and 15 m respectively. Determine (i) the theoretical discharge, (ii) the % slip, (iii) the coefficient of discharge, (iv) force required to work the piston during the suction stroke and (v) the theoretical power required for driving the pump.

- (b) Draw the ideal indicator diagram of a reciprocating pump and prove that work done by the pump is directly proportional to area of indicator diagram.
9. (a) What are the functions of air vessels used in a reciprocating pump? What is negative slip of a reciprocating pump?
- (b) A single acting reciprocating pump operating at 50 rpm has a piston diameter of 30 cm and stroke length of 60 cm. The delivery pipe is 15 cm in diameter and 20 m long. Find the frictional head at the beginning of the delivery stroke. Assume Darcy's friction factor $f = 0.015$.

6 + 6 = 12**(3 + 2) + 7 = 12**