B.E. Mechanical Engineering - Second Year - Second Semester 2024

FLUID MACHINERY – 1

Time: Three Hours **Full Marks: 100**

Assume any relevant data** if necessary **with suitable justifications.
***SYMBOLS** should be **properly described** along with the **necessary SKETCHES** whenever applicable.*
Symbols used in this question paper if any, carry their usual meanings.

Answer any FIVE Questions.
All the parts of a question** must be **answered together.

1. (i) With proper examples for each, classify fluid machines based on different criteria.

   (ii) With necessary assumptions and sketch, derive the governing equation of turbomachinery.

   [10+10]

2. (i) Obtain the expression of power transmitted by the fluid on the wheel of a Pelton turbine through appropriate analysis. Under what condition the wheel efficiency of the turbine will become $(1 + kCos\beta_2)/2$. Symbols carry their usual meaning.

   (ii) A Pelton wheel is working under a head of 45 m and the discharge is 0.8 m^3/s. The mean bucket speed is 14 m/s. Find the overall efficiency and the power produced if the jet is deflected by the blades through an angle of 165°. Assume the coefficient of velocity is 0.985 and mechanical efficiency is 0.95.

   [(10+2)+8]

3. (i) Sketch a layout of a typical Kaplan turbine installation with proper labelling and obtain the difference in head across the turbine.

   (ii) What is the role of a draft tube in the working of a reaction turbine?

   (iii) A Francis turbine has an inlet diameter of 2 m and an outlet diameter of 1.2 m. The breadth of the blades is constant at 0.2 m. The runner rotates at a speed of 250 rpm with a discharge of 8 m^3/s. The vanes are radial at the inlet and the discharge is radially outwards at the outlet. Calculate the angle of guide vane at the inlet and blade angle at the outlet.

   [(6+4)+2+(4+4)]

4. (i) With the help of a neat schematic show the Static Lift for a general pumping system.

   (ii) Obtain the expression of manometric efficiency of a centrifugal pump using the velocity vector diagram, if necessary.

   (iii) A centrifugal pump lifts water under a static lift of 40 m, of which 4 m is the suction lift. The suction and delivery pipes are 50 cm and 36 cm in diameter respectively. The friction losses in suction pipe is 2 m and in delivery pipe it is 6 m. The impeller is 0.5 m in diameter and 3 cm wide at outlet and runs at a speed of 1200 rpm. The exit blade angle is 20°. If the manometric efficiency of the pump is 85%, determine the pressures at the suction and delivery ends of the pump and the discharge.

   [6+4+10]

5. (i) Illustrating the working of a single acting reciprocating pump, obtain a general expression of its friction head in terms of angular displacement of the crank.

   (ii) A single acting reciprocating pump has a stroke length of 45 cm and a cylinder diameter of 30 cm. The suction pipe is 6 m long and has a diameter of 15 cm. The water level in the sump is 3 m below the cylinder. (a) Calculate the maximum speed of the pump, if cavitation is known to occur at 2.5 m of water (abs). (b) If an air vessel is fitted on the suction side at a length of 2 m from the cylinder, calculate the admissible maximum speed and the percentage change in the discharge. Assume atmospheric pressure as 10 m of water (abs) and the friction factor as 0.02.

[(6+4)+(5+5)]

6. (i) Using actuator disc theory, show that half the change of velocity of the wind passing through a wind turbine occurs upstream and half in the wake of the turbine. State the necessary assumptions.

   (ii) An outboard drives a small marine propeller. The propeller has a diameter of 250 mm and discharges 0.5 m^3/s. The propeller forward speed is 8.30 m/s. Determine the thrust and power of the propeller and the pressure rise across the propeller. Take water density as 1000 kg/m^3.

[10+10]

7. Write short notes on the following. (ANY FOUR) **[5×4 = 20]**

   i) Degree of reaction
   ii) Surge Tank
   iii) Froude efficiency
   iv) Jet Pump
   v) Performance curves of Centrifugal Pump at constant speed
   vi) Indicator diagram