B.E. Mechanical Engineering - Second Year - Second Semester 2025

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) Define fluid machines.

   (ii) Classify, with examples, fluid machines based on a) work done, b) direction of fluid flow.

   (iii) Differentiate between positive displacement machines and rotodynamic machines or turbomachines.

   (iv) With the help of a simple schematic diagram and necessary assumptions, derive the one dimensional Euler's equation of turbomachinery.

   [2+5+3+10]

2. (i) Explain the role of buckets in the working of Pelton turbine.

   (ii) Evaluate the maximum wheel efficiency of the Pelton turbine after deriving the expression of efficiency. State necessary assumptions needed for the derivation.

   (ii) A double jet Pelton wheel has a specific speed of 14 and is required to deliver 1000kW. The turbine is supplied through a pipeline from a reservoir whose level is 400m above the nozzles. Allowing 5% for friction loss in the pipe, calculate (a) speed in rpm, (b) diameter of the jets, (c) mean diameter of the bucket circle. Take Cv = 0.98, Speed ratio = 0.46 and overall efficiency = 85%.

   [2+10+8]

3. (i) With usual notations, sketch a typical velocity diagram at the inlet and outlet of a Francis turbine. Explain the physical significance of the different angles in the velocity diagram.

   (ii) What are the possible variations of velocity triangles at the runner outlet?

   (ii) A Francis turbine of specific speed 100 develops 20 MW under a head of 200m. The hydraulic and overall efficiencies are 0.9 and 0.85 respectively. The flow velocity is 10m/s constant. The ratio of width to diameter of wheel at the inlet is 0.2 and the area occupied by the thickness of blades is 7% of the area of flow. Calculate guide vane angle, peripheral velocity and the whirl velocity at the inlet.

   [6+4+10]

4. (i) With the help of a neat schematic diagram of a typical Kaplan turbine, obtain the net head available across the turbine.

   (ii) A Kaplan turbine develops 20,000kW at a head of 35m and a rotational speed of 420rpm. The outer diameter of the blades is 2.5m and the hub diameter is 0.85m. If the overall efficiency is 85% and the hydraulic efficiency is 88%, calculate the discharge, the inlet flow angle and the blade angle at the inlet.

   [10+10]

5. (i) Draw a schematic of a rotodynamic pumping system, with proper labelling and obtain the expression of total head developed by the pump.

   (ii) A centrifugal pump delivers water against a net head of 10m at a design speed of 1000rpm. The vanes are curved backwards and make an angle of 300 with the tangent at the outer periphery. The impeller diameter is 30cm and has a width of 5cm at the outlet. Determine the discharge of the pump if the manometric efficiency is 95%.

   [10+10]

6. (i) With the help of a neat schematic diagram of a pumping system employing a single acting reciprocating pump, explain its working principle.

(ii) What is the role of acceleration head in cavitation of reciprocating pump?

(iii) Define slip stream. Using actuator disc theory, derive Froude efficiency for a propeller.

[8+4+(2+6)]

7. (i) A single acting reciprocating pump has cylinder diameter 10cm, stroke 25cm. The static suction head is 4.0m, diameter of the suction pipe is 5.0cm and the length is 6.0m. The static delivery head is 16.0m, diameter of the delivery pipe is 5.0cm and the length is 25.0m. If the crank speed is 30rpm, estimate the pressure head on the piston at the mid of the suction stroke and at the end of the delivery stroke. Assume atmospheric pressure as 10.0m of water (abs) and the friction factor as 0.02.

(ii) A wind turbine, 12m in diameter, operates at sea level in a wind of 20 m/s. The wake velocity is measured as 8m/s. Estimate the thrust on the turbine and the power being generated by the turbine.

[12+8]

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

i) Specific Speed
ii) Surge Tank
iii) Thomas's cavitation factor
iv) Manometric head
v) Draft tubes
vi) Air Vessel