Full Marks: 70   **Time: 3 Hours**

All questions carry equal marks.
Answer any <u>three</u> questions from each half.

1st Half

1.(a) Water flows through a horizontal conical pipe 2m long and having a diameter of 20 cm at the inlet and 15 cm at the exit. The friction factor, f, is 0.04 and the discharge is 40 litre/s. What is the head lost in the pipe?

1.(b) A cylindrical tank of radius, **R**, and length, **L**, lies on its side with its axis horizontal. The tank has a small orifice of area, **A**, at its bottom and is exactly half filled with water. Obtain an expression for the time required for emptying the tank. If **R** = 1 m, **L** = 3 m, **A** = 100 cm² and C_d = 0.6, compute the numerical value of the time required to empty the tank?

2. (a) A sharp-crested rectangular weir in a rectangular open channel of width 3.2 m carries a certain discharge with a head of 0.18 m over the crest of the weir. If the coefficient of discharge is 0.67, compute the discharge over the weir. Neglect the approach velocity.

2. (b) Write down the expressions for specific speed for pump, N_{sp}, and for turbine, N_{st}, explaining clearly the notations used. What are the dimensions of N_{sp} and N_{st} in **MLT** and **FLT** system and unit in SI and CGS?

3. (a) A centrifugal pump running at 1500 rpm delivers water at a net head of 15 m. At the outlet of the impeller, the vanes make an angle of 45° with the tangential direction. The impeller has an outer diameter of 35 cm and the width is 7 cm at the outlet. Assuming an overall efficiency of 1, calculate the discharge.

3. (b) Two homologous pumps are operated at the same speed of 1500 rpm. One pump has an impeller diameter of 0.43 m and lifts water to a head of 20 m with a discharge of 0.05 m³/s. If the second pump discharges 0.03 m³/s, determine its output water head and its impeller diameter.

4. (a) Using diagrams wherever necessary, write short notes on the following:
(i) Draft tubes in reaction turbines, (ii) Wicket gates in Francis turbines, (iii) Speed regulation in turbines.

4. (b) A centrifugal pump has an impeller of outer diameter 30 cm whose width at the outer periphery is 6.0 cm. The radial component of velocity through the impeller is constant throughout and is 3.0 m/s. If the rotational speed of the pump is 1000 rpm and the hydraulic efficiency is 0.8, calculate the head produced and the discharge through the pump.

5. Using diagrams wherever necessary, write short notes on the following:
(i) Homologous series of pumps and turbines, (ii) Spiral casing in Francis turbines, (iii) Multi-stage centrifugal pumps.

6. a) What is 'centre of pressure'? Show that the 'centre of pressure' of a plane immersed surface (inclined at an angle θ with respect to the free surface) always lies below its centroid

b) A siphon has a uniform diameter of 200 mm and consists of a bent pipe with its crest 3 m above the water level and discharging into atmosphere at a level 6 m below water level. Find the velocity of the flow, the discharge and the absolute pressure at crest level if atmospheric pressure is equivalent to 10 m of water. Neglect losses due to friction.

7. a) Derive an expression for the minor head loss when a horizontal pipe of diameter d suddenly expands to a pipe having a larger diameter D. Assume that the flow is steady and incompressible. Discharge Q is known. State all other assumptions clearly.

b) Two large plane surfaces are 10 mm apart and the gap contains oil of viscosity 0.6 Pa.s. A 'thin' plate located 4 mm above the bottom surface is to be pulled through the gap at a constant velocity of 0.3 m/s. Neglecting edge effects, estimate the force required for pulling the plate. Area of the plate is 0.5 m^2.

8. a) Starting from the fundamentals and clearly stating the assumptions made, derive Bernoulli's equation for fluid flow along a streamline.

b) A venturimeter with 300 mm diameter inlet and 150 mm diameter throat is used for measuring flow of oil of specific gravity 0.9. The readings from the pressure gauges connected to the inlet and throat are 137.7 kN/m^2 and 375 mm of mercury (vacuum), respectively. If 4% of the differential head is lost between the gauges, calculate the discharge considering the venturimeter to be horizontal.

9. a) Write a short note about stream function.

b) A long wooden block is pivoted along one edge. The block is in equilibrium when immersed in water to the depth shown (refer to Fig. 1). Evaluate the specific gravity of the wood, if friction in the pivot is negligible.

10. a) Write short notes on i) Rheological diagram, ii) Newton's law of viscosity.

b) Water flows steadily through a reducing pipe bend, as in Fig. 2. Known conditions are: $p_1 = 350$ kPa (abs), $D_1 = 25$ cm, $V_1 = 2.2$ m/s, $p_2 = 120$ kPa (abs), and $D_2 = 8$ cm. Atmospheric pressure (p_a) is 100 kPa. Neglecting bend and water weight, estimate the total force which must be resisted by the flange bolts.
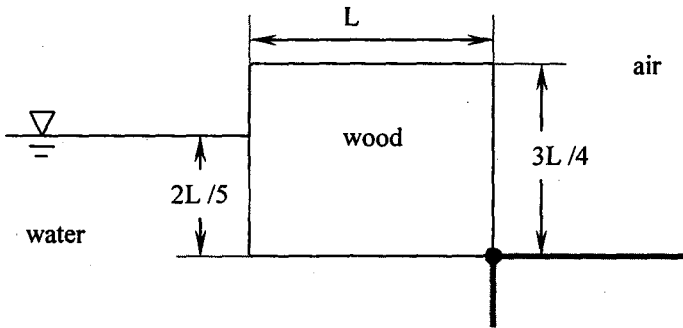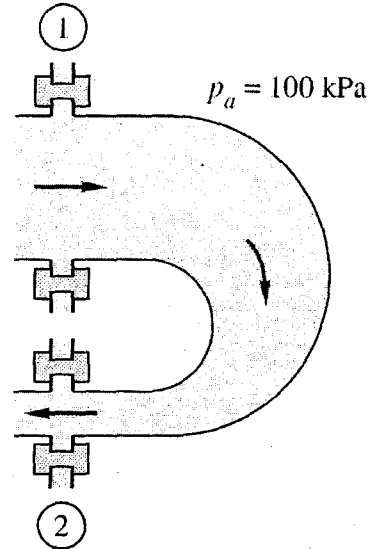
Fig. 1

Fig. 2