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10CV45

Fourth Semester B.E. Degree Examination, July/August 2022

Hydraulics and Hydraulic Machines

Time: 3 hrs. Max. Marks:100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1 a. Give examples of dimensionally homogeneous and non-homogeneous equations. **(04 Marks)**

b. Fluid of density 'ρ' and viscosity 'μ' flows at an average velocity 'V' through a circular pipe of diameter 'D'. Show by using Buckingham's π-theorem of dimensional analysis, that the shear stress 'τ' at the pipe wall :

$$\tau = \rho V^2 \phi\left(\frac{\rho VD}{\mu}\right)$$ **(08 Marks)**

c. A 8 m high and 15m long spillway discharges 100 m^3/s under a head of 2m. If 1:10 scale model of this spillway is to be constructed, determine model dimensions, head over spillway model, and model discharge. If model experiences a force of 5 kN, determine the force on the prototype. **(08 Marks)**

2 a. What is an open-channel? Give the types of open-channel. **(06 Marks)**

b. Derive the conditions under which the rectangular section of an open-channel will be most economical. **(07 Marks)**

c. Design a most economical earthen trapezoidal channel for water having a velocity of 0.5 m/s. The side slope of the channel 1.5:1 and quantity of water flowing is 3 m^3/s. Assume 'C' in Chezy's formula as 65. **(07 Marks)**

3 a. Define specific energy. Does it vary at different sections for uniform flow through a channel? **(04 Marks)**

b. A rectangular channel 1m wide and the discharge of water through it, is estimated to be 1530 m^3/hr. The depth of flow at a section is 10 cm. If a hydraulic jump occurs, calculate:
(i) Froude number before and after the jump.
(ii) Height and length of hydraulic jump
(iii) Loss of head and power dissipated. **(08 Marks)**

c. Show that in an open-channel of constant width, the slope of water surface with respect to bed is given by,

$$\frac{dy}{dx} = \frac{(S_o - S_f)}{\left[1 - \left(\frac{V^2}{gy}\right)\right]}$$

where 'y' is the depth of flow; 'S_o' is the slope of the channel bed; 'S_f' is the friction loss per unit length; 'V' is the velocity flow. **(08 Marks)**

4 a. Differentiate between the force exerted by a jet of water on a fixed vertical plate and moving vertical plate with neat sketches. **(06 Marks)**

b. A 75 mm diameter jet having a velocity of 20 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate.
   (i) When the plate is stationary
   (ii) When the plate is moving with a velocity of 10 m/s in the direction of jet, away from the jet. Also determine the power and efficiency of the jet when the plate is moving. **(08 Marks)**

c. A jet of water 25 mm diameter strikes a hinged flat plate normally at 30 m/s, at a point 150 mm below the hinged plate. What force should be applied 100 mm below the axis of the jet, in order to keep the plate vertical? **(06 Marks)**

PART – B

5 a. Prove that for a jet striking a moving curved vane tangentially at one tip and leaving at the other tip. The work done per second per unit weight is given by, $W.D = \frac{1}{g}\left[V_{W_1} \pm V_{W_2}\right] \times u$. Assume vanes are smooth. **(12 Marks)**

b. A jet of water 60 mm diameter strikes a curved vane at its centre. The curved vane is moving with a velocity of 10 m/s in the direction of jet. If the velocity of jet is 22 m/s and it is deflected through an angle of 160°. Assuming plate to be smooth, determine:
   (i) Force exerted on the vane in the direction of the jet.
   (ii) Power of the jet.
   (iii) Efficiency of the jet. **(08 Marks)**

6 a. How do you classify hydraulic turbines? Give one example for each type. **(10 Marks)**

b. A pelton wheel has to be designed for the following data:
   (i) Power to be developed : 6000 KW
   (ii) Net available head : 300 m
   (iii) Speed of turbine : 555 RPM
   (iv) Ratio of jet diameter to wheel diameter : $\left(\frac{1}{10}\right)$
   (v) Coefficient of velocity for nozzle : 0.98
   (vi) Speed ratio : 0.46
   Find the number of jets, diameter of the wheel and the quantity of water required. **(10 Marks)**

7 a. List the advantages of Kaplan turbine over Francis turbine. **(04 Marks)**

b. The following data refers to the runner of a Kaplan turbine which yields 8850 KW at the turbine shaft:
   (i) Net available head = 5.5 m
   (ii) Speed ratio (K_u) = 2.1
   (iii) Flow ratio (K_f) = 0.67
   (iv) Ratio of hub diameter to outside diameter = 0.35.
   Calculate the runner diameter and its rotational speed. **(06 Marks)**

c. A conical draft tube having an inlet and outlet diameters of 1.2 m and 1.8 m discharges water at outlet with a velocity of 3 m/s. The total length of draft tube is 7.2 m. The length of draft tube immersed in water is 1.44 m. If the atmospheric pressure head is 10.3 m of water and loss of head due to friction is equal to 0.2 × velocity head at outlet of the tube, determine:
   (i) Pressure head at the inlet of the draft tube
   (ii) Efficiency of draft tube. **(10 Marks)**

8 a. Explain the following terms with respect to centrifugal pump
   (i) Static head
   (ii) Manometric head
   (iii) Multistage pumps in series
   (iv) Multistage pumps in parallel
   (v) Overall efficiency of a pump **(10 Marks)**

b. A centrifugal pump impeller having external and internal diameters 500 mm and 250 mm respectively is running at 1000 rpm. The rate of flow through the pump is 0.06 m^3/s and velocity of flow is constant and equal to 2.5 m/s. The diameters of the suction and delivery pipes are 180 mm and 120 mm respectively, and suction and delivery heads are 6.2 m (absolute) and 30.2 m (absolute) respectively. If the power required to drive the pump is 25 KW and the outlet vane angle is 45°. Determine:
   (i) Inlet vane angle
   (ii) The overall efficiency of the pump
   (iii) Manometric head
   (iv) The manometric efficiency of the pump **(10 Marks)**

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