II B.Tech. II Semester Regular Examinations, April/May -2005
HYDRAULICS AND HYDRAULIC MACHINERY
(Civil Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the terms rapidly varied flow and gradually varied flow.
   (b) A trapezoidal channel with side slopes of 1:1 has to be designed to convey 10 m^3/s at a velocity of 2 m/s, so that the amount of concrete lining for the bed and sides is the minimum.
      i. Calculate the area of lining required for one metre length of the canal.
      ii. If the Rugosity coefficient n = 0.015, calculate the bed slope of the canal for uniform flow.

2. (a) Fluid flows with out friction over a horizontal bed with velocity V and depth d such that $\overline{V} > \sqrt{gd}$. To what height must the channel bottom be raised to make the flow just critical?
   (b) A rectangular channel is reduced gradually from 2 m to 1.5 m and the floor is raised by 25cm at a given section. When the approaching depth of flow is 1.5 m, what rate of flow will be indicated, if the flow at the contracted section is at critical depth?

3. A rectangular channel 6 metres wide has a uniform slope of 1 in 2000. Normal flow occurs when there is a constant depth of 0.90 metre and the quantity flowing is 8.50 cumec. A dam placed across the channel raises the depth just upstream of the dam to 1.89 metre when 8.50 cumec is flowing. Find how far the depth will be 1.50 metre.

4. The resistance R, to the motion of a completely submerged body is given by $R = \rho v^2 \ell^2 \phi \left(\frac{v\ell}{\gamma}\right)$.where ρ and g are the density and the kinematic viscosity of the fluid while l is the length of the body and v is the velocity of flow. If the resistance to the motion of a one-eight scale air ship model when tested in water at 12 metres per second is 22 kg, what will be the resistance to the motion in air of the airship at the corresponding speed? Kinematic viscosity of air is 13 times that of water and density of water is 810 times that of air.

5. A jet of water having a velocity of 60m/sec is deflected by a vane moving at 25m/sec in a direction at 30^0 to the direction of jet. The water leaves the vane normally to the motion of the vane. Draw the inlet and outlet velocity triangles and find out the vane angles for no shock at entry and exit. Take the relative velocity at the exit as 0.8 times the relative velocity at the entrance.

6. A Pelton wheel is required to develop 12000 kw when working under a head of 300m. It rotates at a speed of 540 rpm. Assuming the jet ratio as 10 and overall efficiency as 84%, calculate

(a) The diameter of the wheel

(b) The quantities of water required and

(c) The number of jets.

7. (a) What do you understand by specific speed of a turbine? What is its use?

(b) What is the necessity of governing the turbines?

(c) How do you say that geometrically similar velocity triangles assure kinematic similarity.

8. (a) What is the principle behind a centrifugal pump and derive an expression for the minimum starting speed of a centrifugal pump.

(b) The internal and external diameters of the impeller of a centrifugal pump are 20 cm and 40 cm respectively. The pump is running at 1200 rpm. The vane angles of the impeller at inlet and outlet are 20^0 and 30^0 respectively. The water enters the impeller radially and velocity of flow is constant. Determine the work done by the impeller per kg. of water.

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1. (a) Derive the conditions for the most economical triangular channel section.
   (b) A sewer pipe is laid on a slope of 1 in 3000 and is to carry 2.5 m^3/s when the pipe flows full. What size pipe should be used if n in Manning formula is 0.015?

2. (a) Show that the discharge formula for a trapezoidal channel having Manning?s coefficient n = 0.0126 and carrying maximum flow is given by :

$$\mathrm{Q} = 100\mathrm{y}^{8/3}\left(\sqrt{1+z^2} - \frac{\mathrm{Z}}{2}\right)\mathrm{S}_0^{1/2}$$

   Where Q is discharge in cubic meters per second, y is depth of flow in the channel of side slope 1 vertical to Z horizontal and S_0 is the bed slope of the channel.
   (b) A field drain of triangular section has side slopes of 1 upon 2 and carries water at a normal depth of 0.75m. Chezy's C for the channel is 45. Determine the longitudinal slope of the drain for a discharge of 1.2 cumecs. Determine the Froude number and identify the state of flow. Assume α= 1.16.

3. Water flows at a steady and uniform depth of 2 m in an open channel of rectangular cross - section having base width equal to 5 m and laid at a slope of 1 in 100. It is desired to obtain critical flow in the channel by providing a hump in the bed. Calculate hump height and sketch the flow profile. Consider the value of Mannings rugosity coefficient n = 0.02 for the channel surface.

4. (a) State whether the following equations are dimensionally homogeneous
      i. Q = Πdbv
      ii. Q = C_d a $\sqrt{2gh}$
      iii. Q = Ac $\sqrt{mi}$
   (b) What are the fields of application of Froude's Law and Mach Law?

5. (a) Define the term: impact of jets. Obtain an expression for the force exerted by a jet of water on a fixed vertical plate in the direction of the jet.
   (b) Find the force exerted by a jet of water of diameter 100mm on a stationary flat plate, when the jet strikes the plate normally with a velocity of 30m/sec.

6. An outward flow reaction turbine has inner and outer diameter of the wheel as 1000mm and 2000 mm respectively. The water enters the vane at an angle of 20^0 and leaves the vane radially. If the velocity of flow remains constant at 10m/sec and the speed of the wheel is 300rpm, find the vane angles at inlet and outlet.

7. (a) What is Thoma's cavitation factor? What is its significance?

   (b) A Francis turbine working under a head of 5 m at a speed of 210 rpm develops 75 KW when the rate of flow of water is 1.8 m^3/ sec. If the head is increased to 16 m, determine the speed, discharge and power.

8. (a) Define specific speed of a centrifugal pump.

   (b) A centrifugal pump discharges 1200 lit/minute against a head of 16.5 m when the speed is 1500 rpm. The diameter of the impeller is 35 cm and the power required is 6 h.p. A geometrically similar pump of 45 cm is to run at 1750 rpm. Assuming equal efficiencies, find

      i. the head developed

      ii. the discharge and

      iii. power developed by the 45 cm pump.

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1. (a) Show that the theoretical discharge of an open channel may be expressed as:

$$Q = A_2 \sqrt{\frac{2g(\Delta y - hf)}{\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]}}$$

Where A_1 and A_2 are the cross sectional areas of flow at sections 1 and 2 respectively. Δy is the drop in the water surface between two sections and h_f is the energy head loss between the two sections.

(b) Find the diameter of a circular sewer pipe which is laid at a slope of I in 8000 and carries a discharge of 800 liters /s when flowing half full. Take, the value of Manning's N = 0.020.

2. (a) Show that relation between the alternate depths y_1 and y_2 in a rectangular channel can be expressed by:

$$\frac{2Y_1^2\, Y_2^2}{(y_1 + y_2)} = Y_c^3$$

(b) A trapezoidal channel has a bed width of 5 m, side slopes of 1 upon 1.5 and Manning's n = 0.015. Compute the critical slope and the corresponding discharge for a critical depth of 2 m.

3. Explain the phenomenon of hydraulic jump and the significance of froude number. Derive the required equations.

4. Prove that the resistance F of a sphere of diameter d moving at a constant speed ν through a fluid of density ρ and dynamic viscosity μ may be expressed as $F = \frac{\mu^2}{\rho}\ \phi\ \left[\frac{vd\rho}{\mu}\right]$

5. A jet of water having a velocity of 15m/sec strikes a curved vane which is moving with a velocity of 5m/sec. The vane is symmetrical and it is so shaped that the jet is deflected through 120^0. Find the angle of the jet at inlet of the vane so that there is no shock. What is the absolute velocity of the jet at outlet in magnitude and direction and the work done per second per kg of water? Assume the vane to be smooth.

6. Differentiate between :

(a) The impulse and reaction turbines

(b) The radial and axial slow turbines

(c) The inward and outward radial flow turbines

(d) Kaplan and propeller turbines

7. (a) A hydraulic turbine has an output of 6600 KW when it works under a head of 25 m and runs at 100 rpm. What is the type of turbine. What would be speed and power when it works under a head of 16m.

   (b) What is the use of developing constant speed characteristic curves of a turbine?

8. (a) What do you understand by the following :

   i. Minimum starting speed of a pump

   ii. Priming of pump

   iii. Manometric head

   iv. Stage of a pump

   (b) A centrifugal pump has an impeller of 40 cm diameter. The discharge at the outlet is radial. The diameter ratio is 2. Calculate the manometric efficiency of the pump if the total lift is 25 m. Also calculate the blade angle and relative velocity at the inlet.

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1. (a) Explain how the velocity is distributed in an open channel section.
   (b) An open channel of trapezoidal section, 2.5 m at the base and having sides inclined at 60^0 to the horizontal, has a bed slope of 1 in 500. It is found that when the flow is 1.5 m^3/s the depth of water in the channel is 0.5 m. Assuming the validity of the Manning's formula., calculate the flow when the depth is 0.7 m.

2. (a) Show that the discharge formula for a trapezoidal channel having Manning?s coefficient n = 0.0126 and carrying maximum flow is given by :

$$\mathrm{Q} = 100\mathrm{y}^{8/3}\left(\sqrt{1+z^2} - \frac{\mathrm{Z}}{2}\right)\mathrm{S}_0^{1/2}$$

   Where Q is discharge in cubic meters per second, y is depth of flow in the channel of side slope 1 vertical to Z horizontal and S_0 is the bed slope of the channel.
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3. Water flows at a steady and uniform depth of 2 m in an open channel of rectangular cross - section having base width equal to 5 m and laid at a slope of 1 in 100. It is desired to obtain critical flow in the channel by providing a hump in the bed. Calculate hump height and sketch the flow profile. Consider the value of Mannings rugosity coefficient n = 0.02 for the channel surface.

4. The efficiency η of a fan depends on the density ρ, the dynamic viscosity μ of the fluid, the angular velocity ω, diameter D of the rotor and the discharge Q. Express η in terms of dimensionless parameters.

5. (a) Define the term: impact of jets. Obtain an expression for the force exerted by a jet of water on a fixed vertical plate in the direction of the jet.
   (b) Find the force exerted by a jet of water of diameter 100mm on a stationary flat plate, when the jet strikes the plate normally with a velocity of 30m/sec.

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7. (a) A turbine develops 7460 KW under a head of 25m at 135 rpm. What is the specific speed. What would be its normal speed and power under a head of 18m.
   (b) What are the components in governing mechanism of a turbine?
   (c) Distinguish between unit speed and specific speed.

8. (a) Discuss various methods adopted to increase the efficiency of a centrifugal pump by altering the shape of the casing.
   (b) A centrifugal pump having an overall efficiency of 80% delivers discharge 1850 lpm, working against a height of 20 m through a pipe of 10 cm diameter and 95 m long. Calculate HP required to drive the pump. f = 0.0075

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