

Code No: 155SB

RA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year I Semester Examinations, January - 2025

HYDRAULICS AND HYDRAULIC MACHINERY

(Civil Engineering)

Time: 3 Hours

Max. Marks: 75

Note: i) Question paper consists of Part A, Part B.

ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.

iii) In Part B, Answer any one question from each unit. Each question carries 10 marks and may have a, b as sub questions.

**PART – A**

**(25 Marks)**

- 1.a) Define Reynolds number. [2]
- b) Illustrate the velocity distribution pattern in various channel sections. [3]
- c) What is meant by a positive surge? [2]
- d) List out the different types of channel bottom slopes. [3]
- e) Define dynamic similarity. [2]
- f) What are the dimensions of modulus of elasticity and kinematic viscosity? [3]
- g) Define the gross head of a hydraulic turbine. [2]
- h) What is 'cavitation' and Thoma's cavitation factor? [3]
- i) Define slip and negative slip. [2]
- j) List the advantages of centrifugal pumps over reciprocating pump. [3]

**PART – B**

**(50 Marks)**

- 2.a) Derive the correlation between roughness factor 'f' and Manning's coefficient 'n', in open channel flow.
- b) A channel has vertical walls 1.2 m apart and a semicircular invert. If the centerline depth is 0.9 m and the bed slope is 1 in 2500, find the discharge using Chezy's formula with  $C = 54$ . [5+5]

**OR**

- 3.a) An earthen channel with a base width 2 m and side slope 1 horizontal to 2 vertical carries water with a depth of 1 m. The bed slope is 1 in 625. Calculate the discharge if  $n = 0.03$ . Also calculate the average shear stress at the channel boundary.
- b) A trapezoidal channel having bottom width 6 m and side slopes of 2 horizontal to 1 vertical is laid on a bottom slope of 0.0016. If it carries a uniform flow of water at the rate of  $10 \text{ m}^3/\text{s}$ , compute the normal depth and the mean velocity of flow. Take Manning's  $n$  as 0.025. [5+5]

- 4.a) Explain the different types of hydraulic jumps with a neat illustration.
- b) A rectangular flume 2 m wide carries discharge at the rate of  $2 \text{ m}^3/\text{s}$ . The bed slope of the flume is 0.0004. At a certain section the depth of flow is 1 m. Calculate the distance of the section downstream where the depth of flow is 0.9 m. Solve by single step method. Assume rugosity coefficient as 0.014. Is the slope of the channel mild or steep? How is this type of surface profile classified? [5+5]

**OR**

- 5.a) A rectangular channel 7.5 m wide has a uniform depth of flow of 2.0 m and has a bed slope of 1 in 3000. If due to weir constructed at the downstream end of the channel, water surface at a section is raised by 0.75 m, determine the water surface slope with respect to horizontal at this section. Assume Manning's  $n = 0.02$ .
- b) State the practical applications of hydraulic jumps. [5+5]

- 6.a) Write a short note on Rayleigh method of dimensional analysis.  
b) A jet of water 75 mm diameter having a velocity of 20 m/s, strikes normally a flat smooth plate. Determine the thrust on the plate (i) if the plate is at rest, (ii) if the plate is moving in the same direction as the jet with a velocity of 5 m/s. Also find the work done per second on the plate in each case and the efficiency of the jet when the plate is moving. [5+5]

OR

- 7.a) What are the two main categories of hydraulic models, and how do they differ in purpose, methodology, and application?  
b) A jet of water moving at 20 m/s impinges on a symmetrical curved vane shaped to deflect the jet through  $120^\circ$  (that is the vane angles  $\theta$  and  $\phi$  are each equal to  $30^\circ$ ). If the vane is moving at 5 m/s, find the angle of the jet so that there is no shock at inlet. Also determine the absolute velocity of exit in magnitude and direction, and the work done. [5+5]

- 8.a) Determine the efficiency of a Kaplan turbine developing 3000 kW under a net head of 5 m. It is provided with a draft tube with its inlet (diameter 3 m) set 1.6 m above the tail race level. A vacuum gage connected to the draft tube indicates a reading of 5 m of water. Assume draft tube efficiency as 78%.

- b) A 90 MW hydroelectric plant is installed with reaction turbines with head = 26.5 m, overall efficiency = 85%, speed ratio (based on outer diameter) = 2.0, flow ratio = 0.65, diameter of boss = 0.35  $\times$  external diameter of runner. The turbine runner is of propeller turbine running at 192 r.p.m. Determine the specific speed of the turbine and the number of turbines needed. [5+5]

OR

- 9.a) A Pelton wheel has a mean bucket speed of 12 m/s and is supplied with water at a rate of 750 liters per second under a head of 35 m. If the bucket deflects the jet through an angle of  $160^\circ$ , find the power developed by the turbine and its hydraulic efficiency. Take the coefficient of velocity as 0.98. Neglect friction in the bucket. Also, determine the overall efficiency of the turbine if its mechanical efficiency is 80%.

- b) Calculate the value of Thoma's cavitation parameter for a Kaplan turbine having a non-dimensional specific speed of 19.36 and suction specific speed of 17.6. [5+5]

- 10.a) What are the various types of centrifugal pumps? Explain each type with the help of a clear diagram.

- b) A single-acting reciprocating pump has a piston of diameter 150 mm and a stroke of length 250 mm. The piston makes 50 double strokes per minute. The suction and delivery heads are 5 m and 15 m respectively. Find (i) discharge capacity of the pump in litres per minute; (ii) force required to work the piston during the suction and delivery strokes if the efficiency of suction and delivery strokes are 60% and 75% respectively; and (iii) power required to operate the pump. [5+5]

OR

- 11.a) What are the different types of losses in a centrifugal pump?

- b) A double acting pump has a bore of 0.2 m and stroke of 0.4 m. The suction pipe has a diameter of 0.1 m and is fitted with an air vessel. Find the rate of flow into or from the air vessel when the crank makes angles of  $30^\circ$ ,  $90^\circ$  and  $120^\circ$  with inner dead center. Determine also the crank angles at which there is no flow to or from the air vessel. Take the speed as 120 rpm, and assume that the plunger has simple harmonic motion. [5+5]