BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
COMPREHENSIVE EXAMINATION (1st SEMESTER) 2023-2024
HYDRAULIC ENGINEERING (CLOSE BOOK)

CE F312 **Dated: 15.12.2023**
Max. Marks: 40 **Max. Duration: 90 minutes**

1. A jet of water moving at 40 m/s impinges on a symmetrical curved vane shaped to deflect the jet through 120° (that is the vane angles θ and φ are each equal to 30°). The vane is moving at 10 m/s.

i. Find the angle of the jet so that there is no shock at the inlet.
ii. Find the inlet relative velocity.
iii. Find the absolute velocity of exit in magnitude and direction,
iv. The work done.
v. Draw velocity triangles at the inlet and outlet. **(15M)**

2. A cylinder with a diameter =1.5 m is rotated about its axis in air which is flowing with a velocity of 128 km/hr. A lift of 5886 N per meter length of the cylinder is developed on the body. Assume ideal fluid theory. Take $\rho_{air} = 1.24$ kg/m^3.

i. Find circulation Γ (m^2/s)
ii. Find the rotational speed N (r.p.m)
iii. The location of the stagnation points i.e. the angle θ of the point on the surface of the cylinder. **(10M)**

3. Water flows from an under-sluice gate into a very wide rectangular channel. For a wide rectangular channel, the hydraulic radius is approximated as the depth of flow. Assume the channel with a bed slope of 1 in 1000. The sluice is regulated to discharge 10 m^3/s/m, the depth at Vena-Contracta being 0.5 m. The slope of the energy line (S_f), is approximated by Manning's formula for gradually varied flow. Manning's n = 0.015.

i. Find the normal depth and critical depth
ii. What is the type of bed slope?
iii. Find the conjugate depth for the normal depth
iv. Find the specific energies at Vena-Contracta and the location of conjugate depth
v. Distance between the Vena-Contracta section and the section of conjugate depth **(10M)**

4. Write in brief: **(5M)**

i. Overall efficiency of hydraulic turbines
ii. Impulse turbine and reaction turbine
iii. Head race, tail race
iv. Gross head and net head
v. Flow ratio and speed ratio

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1. A 1:30 (L_m: L_p) scale model of a ship was tested in a towing tank. The model had the same Froude number as the prototype and seawater was used in the model. If the prototype is to have a speed of 10m/s, a length of 100 m, and a waterline wetted area of 1600 m^2. Consider the Similarity for gravity flow. The total drag is the sum of surface drag (F_s) and wave drag (F_w). p stands for prototype and m stands for model. The measured total drag of the model is 20N.

$$\rho = 1025 kg/m^3 and\ \mu = 1.07\times10^{-3} Pa.s$$

$$F_{wp} = \frac{F_{wm}}{\left(\frac{\rho_m L_m{}^3}{\rho_p L_p{}^3}\right)}.\ [\rho_m = \rho_p].,\ C_{Df} = \frac{0.074}{R_{eL}{}^{1/5}} - \frac{1700}{R_{eL}}.,C_{Df} = \frac{0.455}{(\log R_{eL})^{2.58}} - \frac{1700}{R_{eL}}.$$

i. Find the model speed,
ii. Find model length and waterline wetted area
iii. Find Reynolds numbers of prototype and model
iv. Find the surface and wave drag force for model
v. Find the surface drag, wave drag and total drag of prototype

(15M)

2. A severely corroded old concrete pipe with a diameter of D=2.0m, has an equivalent sand roughness of 15mm. A hydraulic engineer proposed to provide a 10 mm thick lining so that the roughness value reduces to 0.2 mm. A 6.0 m^3/s discharge is maintained in the pipe. Take kinematic viscosity $1x10^{-6}\ m^2/s$**.** Use the following.

$$\frac{1}{\sqrt{f}} = 1.14 - 2\log\left(\frac{\varepsilon_s}{D} + \frac{21.25}{R_e{}^{0.9}}\right)$$

i. Find the relative roughness before and after lining
ii. Find the head loss before and after lining and saving in head loss
iii. Calculate the power saved per kilometer of pipe due to the proposed lining. **(10M)**

3. A rectangular channel 5.5 m wide has a discharge of 10.0 m^3/s at a velocity of 1.5 m/s. At a certain section, the bed width is reduced to 3.0 m through a smooth transition. A smooth flat hump is required to build in this contracted section to cause critical flow for measurement purposes. Assume no loss of energy at the transition.

i. Estimate specific energy at the upstream section
ii. Find the flow condition in the upstream section
iii. Find critical depth at the contracted section
iv. Estimate the height of the hump necessary for this purpose. **(10M)**

4. Water flows in a triangular channel with a side slope of 1H:1V and a longitudinal slope of 0.0012 with a discharge of 0.25 m^3/s through it. Take Manning's n = 0.015.

i. Determine critical depth and normal depth
ii. Determine whether the channel is mild, steep, or critical
iii. Also write the range of depths for which the flow be on a type 1, 2 or 3 curve. **(5M)**