M.E. (Water Resources & Hydraulic Engineering) Exam. (6 Sem.), 2024

(1st Semester)

FREE SURFACE FLOW

(Paper - VI)

Time : Three Hours Full Marks : 100

Answer any ***five*** questions.

1.(a) The velocity distribution in a wide rectangular channel may be approximated by the equation $u = 0.4 + 0.6\, y/h$ m/s. Find U, α and β if $h = 1.0$ m.

(b) The following pressures were measured on a wall. Find the force per unit length of the wall, pressure coefficient at the base of the wall and force in excess of the hydrostatic value.

Distance below free surface, mm	Pressure of water, mm
0	0
50	51
100	104
150	159
200	216
250 (Base of Wall)	275

(c) State whether the following flows are steady or unsteady and uniform or non-uniform:

i. River flow around a bridge pier.
ii. Flow in a long, prismatic irrigation canal.
iii. Movement of water around a boat in a lake.

8+9+3 = 20

2. (a) Deduce an expression of velocity distribution against shear velocity in case of fully turbulent flow of hydraulically smooth and rough boundaries.

b) Find the normal depth of flow in a triangular section with a bottom angle of 60° for Q = 3.2 m^3/s, n=0.015 and S= 2.1×10^{-3}. Also find the value of Chezy's coefficient.

3. (a) Show that the second hydraulic exponent N could be calculated approximately as

$$N = (2y)/3 * [5 * T/A - 2/P * dP/dy]$$

Where T is the top width, P is the perimeter, A is the area and y is the depth of water of the section

(b) Find the normal depth of flow in a circular conduit 5.5 m diameter carrying a discharge of 3.7 m^3/s if S= 2.6×10^{-3} and n=0.015. Also find the shear stress on the bottom of the conduit at a depth of h/4 from the water surface.

4. a) From the basic differential equation of GVF for a prismatic channel, derive the following relationships:

$$\frac{\partial y}{\partial x}=\frac{S_0-S_f}{1-\frac{\alpha Q^2 T}{gA^3}}=S_0\frac{1-\left(\frac{K_0}{K}\right)^2}{1-\left(\frac{z_c}{z}\right)^2}=S_0\frac{1-\left(\frac{Q}{Q_n}\right)^2}{1-\left(\frac{Q}{Q_c}\right)^2}=S_0\frac{1-\left(\frac{y_0}{y}\right)^N}{1-\left(\frac{y_c}{y}\right)^M}$$

where M and N are the first and second hydraulic exponents, respectively.

b) Find out the differential equation of GVF for a wide rectangular channel if the Chezy formula is used.

15+5= 20

5. Describe M, S, C and A type GVF profiles with neat sketches.

6+6+4+4=20

6. a) Establish that the GVF profile in a frictionless rectangular channel is given by

$$x=\frac{y}{S_0}\left[1+\frac{1}{2}\left(\frac{y_c}{y}\right)^3\right]+\text{Const.}$$

b) Show that for a wide horizontal channel, by assuming Chezy's C = constant,

$$x=\frac{C^2}{g}\left[y-\frac{y^4}{4y_c^3}\right]+\text{ Const.}$$

c) In a very long, wide rectangular channel the discharge intensity is 3 m^3/s per meter width. The bed slope of the channel is 0.004 and Manning's n = 0.015. At a certain section in this channel, the depth of flow is observed to be 0.90 m. What type of GVF profile occurs in the neighbourhood of this section?

7+8+5 = 20

7. a) Establish a relationship to evaluate the loss of energy in hydraulic jumps.

b) How you will estimate the upstream Froude number (F_1) of a hydraulic jump if only the discharge intensity (q) and energy loss (E_L) are known?

c) A sluice gate discharges water into a horizontal rectangular channel with a velocity of 10 m/s and a depth of flow of 1 m. Determine the depth of flow after the jump and consequent loss in total head.

d) A rectangular channel carrying a supercritical flow is to be provided with a hydraulic jump type of energy dissipator. The energy loss required in the hydraulic jump is 6.0 m and the inlet Froude number is 10. Determine the sequent depths.

. 5+5+5+5 = 20

8. a) Define open channel flow

b) What do you mean by choke in connection to a condition when there is a gradual rise in the channel bottom elevation?

c) A rectangular channel 6 m wide with a depth of flow of 3 m has a mean velocity of 1.5 m/s. The channel undergoes a smooth, gradual contraction to a width of 4.5 m.

i. Calculate the depth and velocity in the contracted section.

ii. Calculate the net fluid force on the walls and floor of the contraction in the flow direction.

2+6+12=20

9. a) Differentiate between open channel flow and pipe flow.

b) For an approach flow in rectangular channel with depth 2.0 m and velocity of 2.2 m/s. Determine the depth of flow over a gradual rise in channel bottom of Δ_z =0.25 m. Repeat the solution for Δ_z =0.50 m.

4+16=20