# M.E. (Water Resources & Hydraulic Engineering) Examination, 2025

(1st Semester- Supplementary Examination)

**FREE SURFACE FLOW**

(Paper – VI)

Time: Three Hours                                                                 Full Marks: 100

1. (a) Define open channel flow/free surface flow and distinguish between open channel flow and pipe flow.

   (b) 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.

   In each case identify any assumption that you make.

4+16=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) A trapezoidal channel has a bottom width of 2.50 m and depth of flow of 0.80 m. The side slope is 1.5 horizontal: 1 vertical. The channel is lined with bricks ($k_s$ = 3.0 mm). If s the longitudinal slope of the channel is 0.0003, estimate (i) the average shear stress, (ii) the hydrodynamic nature of the surface, (iii) Chezy's Constant by using f, (iv) Manning's Constant.

10+10=20

3. (a) "Uniform flow of an ideal fluid on a sloping channel is impossible", justify this statement.

   (b) State the difference between 1-Dimensional Flow, 2-Dimensional flow and 3-Dimensional Flow.

   (c) Deduce the expression for calculating the equivalent roughness of a channel.

5+5+10=20

4. (a) Find the normal depth of flow in a circular conduit 5.5 m diameter carrying a discharge of 3.7 m³/s if $S = 2.6 \times 10^{-3}$ 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.

   (b) Find the normal depth of flow in a triangular section with a bottom angle of 60° for Q = 3.2 m³/s, $n$=0.015 and $S = 2.1 \times 10^{-3}$. Also, find the value of Chezy's coefficient.

10+10=20

[ Turn over

5. (a) Derive the relationship required for the Standard Step Method from the differential energy equation of GVF

   (c) In a wide river, the depth of flow at a section is 3 m, bed slope is 1 in 5000 and the discharge intensity is 40 $m^3/s$ per meter width. If the Chezy formula with C = 75 is used, estimate the slope of the water surface relative to the bed at that section of the river.

14+6 = 20

6. (a) Find out the GVF differential equation by Direct Integration Method.

   (b) Find out the basic equation to calculate the water surface elevation in the case of GVF using the Direct Step Method.

11+9 = 20

7. (a) Derive the basic differential equation of GVF.

   (b) Describe mild and steep type GVF profiles with neat sketches.

10+10 = 20

8. (a) Establish a relationship to evaluate the loss of energy in hydraulic jump.

   (b) A hydraulic jump occurs in a rectangular channel and the depths of flow before and after the jump are 0.75 m and 2.25 m respectively. Calculate the critical depth of flow.

   (c) A spillway discharges a flood flow at a rate of 7.95 $m^3/s$ per metre width. At the upstream horizontal apron, the depth of flow was found to be 0.52 m. What tailwater depth is needed to form a hydraulic jump? If a jump is formed, find its (a) type of jump (b) head loss (c) energy loss as a percentage of the initial energy.

   (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