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

(1st Semester)

FLUVIAL HYDRAULICS

(Program Elective 2)

Time : Three Hours | Full Marks : 100

Answer any ***five*** questions.

1. a) Find out the expression for average shear stress (τ_0) considering steady uniform flow in a rectangular channel and equilibrium of a water prism under various forces acting on it.
   b) An irrigation channel is to be constructed in coarse alluvium gravel with d_{75} size of 4.5 cm. The channel has to carry 3.5 cumec of discharge and the longitudinal slope is 0.015. The banks of the channel will be protected by the grass against scouring. Find out the depth of the channel for which the bed particles just begins to move. Assume specific gravity of the bed particles is 2.65.
   c) Deduce the relationship between total shear stress and bed shear stress for a steady flow having zero pressure gradient in the x-direction (with stream wise slope θ). Assume the flow is uniform.

   6+6+8 = 20

2. a) Classify hydraulically smooth, rough and transitional flow based on Nikuradse's Experiment.
   b) In case of a fluid flow over a solid boundary classify different flow layers like laminar sub layer, buffer layer, turbulent logarithmic layer and turbulent outer layer using a suitable sketch.

   Then show the depth wise variation of turbulent shear stress and viscous shear stress with respect to total shear stress. Also, draw the velocity profiles of different layers.
   c) Find out the Linear-Law in viscous sub-layer.

   6+8+6=20

3. a) Derive and explain the Prandtl's Mixing Length Theory with a neat sketch.
   b) Derive the Reynolds' Averaged Navier Stokes Equations (RANSE) for an incompressible fluid flow in the Cartesian coordinate system.

   6+14=20

4. a) Find out the relation between critical Shields' parameter and critical Reynolds' number due to critical shear velocity in case of a steady flow over a bed composed of non-cohesive sediment particles.
   b) Define the term "incipient motion" and briefly describe the concept of "threshold condition" in sediment transport.

   13+7= 20

5. What do you mean by (i) sediment, (ii) alluvial river dynamics, (iii) roundness, (iv) nominal diameter, (v) sedimentation diameter and (vi) sphericity?
   b) Differentiate between aggradation and degradation.
   c) What are the assumptions made in the derivation of Stokes' law?
   Derive the Stokes' law for the terminal fall velocity of a spherical sedimentary particle. Then find out the Stokes' number.

   9+3+8= 20

6. a) Differentiate between Eulerian method and Lagrangian Method.
   b) Consider a fluid element of lengths dx, dy and dz in the direction of x, y and z. let u, v and w are the inlet velocity components in the x, y and z directions respectively. Then derive the continuity equation in case of steady, incompressible flow.
   c) Derive the Euler's equation of motion. Show that the integration of Euler's equation yields Bernoulli's equation.

   2+8+10 = 20

7. a) What is clear water scour and live bed scour? Explain with figure the time to reach equilibrium scour condition for clear water scour and live bed scour.
   b) What is bridge pier scour? What are the three types of scour that affect bridges?
   c) What is a block ramp? Explain why block ramps are preferred over check dams in mountainous rivers.
   d) What is the difference between Froude number and Densimetric Froude number?
   e) Discuss on the effect of sediment size on bridge pier scour.
   f) Explain the effect of approach flow depth on bridge pier scour

   6+ (1+3) +4+3+1.5+1.5 = 20