M.E. (Water Resources & Hydraulic Engg.) Examination (6 Semester), 2024

(2nd Semester)

HYDRAULICS & SEDIMENT TRANSPORT

(Paper - III)

Time : Three Hours | Full Marks : 100

Answer any ***five*** questions.

1. a) What do you mean by sediment?
   b) Define the sphericity of a sediment particle.
   c) Define nominal diameter, tri-axial size, roundness and angle of repose.
   d) 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.

   2+2+8+8 = 20

2. a) What do you mean by "fluvial hydraulics"?
   b) What are the most important bulk properties of sediments?
   c) Define steady, non-steady, uniform and non-uniform flow.
   d) 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.
   e) Derive Euler's equation of motion.

   2+2+2+8+6=20

3. a) Derive the tangential and normal acceleration components in case of 1-D flow along a streamline, consider a fluid particle undergoing a small displacement ds in a short interval of time dt.
   b) Derive the Navier-Stokes Equations of Motion for a Newtonian Fluid of varying density and viscosity in a gravitational field.

   8+12= 20

4. a) Explain the Boussinesq equation.
   b) 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.
   c) Find out the linear law in the viscous sub layer.
   d) Draw a diagram to show the directions of three normal stresses in (x, y, z) directions and six shear stresses.

3+7+6+4= 20

5. a) What do you mean by competent velocity?
   b) Using the Navier Stokes equation and continuity equation for an incompressible fluid flow in the Cartesian coordinate system, prove that

$$\frac{\partial \bar{u}}{\partial t}+\bar{u}\frac{\partial \bar{u}}{\partial x}+\bar{v}\frac{\partial \bar{u}}{\partial y}+\bar{w}\frac{\partial \bar{u}}{\partial z}=g_x-\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x}+\nu\nabla^2\bar{u}-\frac{\partial}{\partial x}\left(\overline{u'u'}\right)-\frac{\partial}{\partial y}\left(\overline{u'v'}\right)-\frac{\partial}{\partial z}\left(\overline{u'w'}\right)$$

$$\frac{\partial \bar{u}}{\partial x}+\frac{\partial \bar{v}}{\partial y}+\frac{\partial \bar{w}}{\partial z}=0$$

2+18=20

6. a) An irrigation channel is to be constructed in coarse alluvium gravel with d_{50} size of 10 mm. The channel has to carry 5 m^3/s of discharge and the longitudinal slope is 0.0002. 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 begin to move. Assume the specific gravity of the bed particles is 2.65.
   b) Prove that the sediment concentration on mass basis (c) can be defined as the following form

$$c=\frac{\left(\frac{\rho_s}{\rho}\right)C}{1+\left(\frac{\rho_s}{\rho}-1\right)C}$$

   where, C is the sediment concentration by volume, ρ_s is the density of sediment and ρ is the density of water.
   c) A sample of 2.85×10^{-3} m^3 of river water is evaporated to collect suspended sediment of 5.1 N (dry weight), having d_{50} = 0.15 mm and Δ = 1.65. Determine (i) sediment concentration by volume (C), (ii) sediment concentration by mass (c), (iii) mass density of fluid sediment mixture (ρ_m), (iv) specific weight of water sediment mixture (γ_m), and

(v) kinematic viscosity of water sediment mixture (ν_m). Consider dynamic viscosity for a clear water (μ) as 10^{-3} Pa.s and $\mu_m = \mu(1-C)^{-(2.5+1.9C+7.7C^2)}$.

7+5+8=20

7. a) Differentiate between ripples and dunes?
   b) Define flow Froude number. At which flow Froude number, dunes are washed out?
   c) Derive the equation of bed load transport per unit time per unit width using DuBoys' Approach.

4+3+13=20