D-43

Minor 2 (Part A) Hydraulics

CEL-251

Max Marks 30

Q(1) Reduce the Navier Stokes equations (given below) to a dimensionless form by introducing non dimensional quantities with respect to some characteristic reference magnitudes of velocity, pressure, length and time.

From the above, discuss what form the Navier Stokes equation takes at steady state with negligible body force when:

a) Reynolds # is large and b) Reynolds # is small

(10 marks)

Q(2) Starting with the continuity equation and steady state equations of motion (Navier Stokes equations given below) for 2 D (x-y plane) flow over a flat plate with negligible body forces, derive the Boundary layer equations by conducting an 'order of magnitude' analysis.

Also, show how the Boundary Layer equations are simplified with only two variables instead of three as in the Navier Stokes equations.

(8 marks)

Q(3) A broad crested weir with an upstream sharp square corner and spanning the entire width of the channel is to be installed in the channel as a flow measuring device. Discuss how it can be used as a discharge measuring device and derive the expression for discharge as a function of the upstream water surface elevation. approach vel. = 0

(7 marks)

Q(4) Derive the Dynamic Equation for Gradually Varied Flow using **Chezy's equation** for a very wide rectangular channel that gives slope of the water surface at any depth of flow as a function of channel bottom slope, normal depth and critical depth.

(5 marks)

Navier Stokes Equation:

$$\rho\left(\partial \vec{q} / \partial t\right) + \rho\left(\vec{q} \cdot \nabla\right)\vec{q} = \rho \vec{X} - \nabla P + \mu \nabla^2 \vec{q}$$

P.T.O for Hydrology

Part B: Hydrology

Max. Marks 10

Time: 20 mins

1) A coefficient of variation = 0.3 was observed in the rainfall data of 16 stations in a catchment. Determine the number of surplus or deficit raingauges in the catchment if permissible error in the estimation of the mean rainfall is limited within 10%. Also find the percentage error within which the existing raingauges are sufficient to estimate average rainfall in the catchment. **(2 marks)**

2) A soil mass of cross sectional area 150 cm^2 has an initial moisture content of 30% and porosity of 50%. If the suction head is 15 cm and hydraulic conductivity of the soil is 45 cm/day, determine the time in hours required for the water to penetrate to a depth of 55 cm from the top surface. Assume continuously ponded conditions. Solve using Green Ampt method. $F(t) = kt + \psi\Delta\theta \ln\left(1 + \frac{F(t)}{\psi\Delta\theta}\right)$ **(3 marks)**

3) Four raingauges A, B, C and D (located at 40 km radial distance from the centre in a circular catchment of radius 60 km) recorded rainfall depth as 40, 55, 50 and 60 cm respectively while the raingauge at O recorded 58 cm. Estimate the average rainfall in the catchment by the arithmetic mean and Theissen polygon methods. Why do these two averages differ although both the methods would give identical results in absence of the central raingauge at O? **(5 Marks)**