Full Marks : 70   **Time : 3 hours**

Answer any *FIVE* Questions
The questions are of Equal Value

1.(a) Derive the Hagen-Poiseuille equation for flow in straight tubes of circular cross-section, clearly stating the assumptions involved.
   (b) With specific reference to the Kozeny-Carman equation, discuss the (i) permeant characteristics and (ii) soil characteristics influencing permeability of soils.   (8+6)

2.(a) State the generalized form of Darcy's law in three-dimensions and discuss its range of validity.
   (b) Derive the equation of continuity in three dimensions and hence deduce the Laplace equation.   (6+8)

3.(a) Show that the stream function (ψ) as well as the velocity potential (ϕ) satisfies Laplace equation.
(b) Show also that the streamlines and the equipotential lines are mutually orthogonal.
(c) Show how an impervious boundary is represented by ψ = const. and a reservoir boundary by ϕ = const.
(d) $\phi+ky$ = const. represents both (i) line of seepage and (ii) surface of seepage. Are then (a) and (b) the same?   (3x4+2)

4.(a) Show that a stratified medium of thin homogeneous and isotropic layers can be converted into an equivalent single homogeneous and anisotropic layer. Show also that the coefficient of permeability is greater in the direction of stratification.
(b) Show that the square root of the directional coefficient of permeability for an homogeneous and anisotropic layer when plotted from a point will generate an ellipse.
(c) Show that the effects of anisotropy can be taken into account by a suitable transformation of spatial co-ordinates.   (8+2x3)

5.(a) Calculate the quantity of seepage through the homogeneous and anisotropic earth dam founded on an impervious base, having the following dimensions and soil permeabilities:
(i) Dam height = 50m, (ii) Top width = 15m, (iii) U/S side slope = 1V: 2.5 H; (iv) D/S side slope = 1V: 3H; Height of reservoir water level = 40m; (v) Vertical permeability k_z = 1×10^{-5} cm/sec, Horizontal permeability, k_x = 10 k_z .
(b) What will be the side slopes of a model dam to be constructed to study the seepage characteristics of the above prototype if the soil to be used in the model has a horizontal permeability 16 times that in the vertical direction?   (8+6)

7. (a) Considering the simple case of two-dimensional confined flow under a concrete dam of width 2b founded at the surface of an infinite, permeable medium, obtain a solution of the Laplace equation using Schwarz-Christoffel transformation. Derive the equations for the families of the streamlines and the equipotential lines, and, also draw the pattern of flownet   (14)

8. (a) Explain in detail the modifications needed for flownet diagram when flowing water moves from one medium to another of different coefficient of permeability.

(b) Show that from a flow net drawn on a transformed section in the case of an anisotropic soil having horizontal and vertical permeabilities k_x and k_z respectively, the flow quantity can be obtained by taking the coefficient of permeability $k' = (k_x k_z)^{0.5}$

(c) Describe exit correction from the parabolic shape of top flow line for dams without an underdrain. (2x5+4)