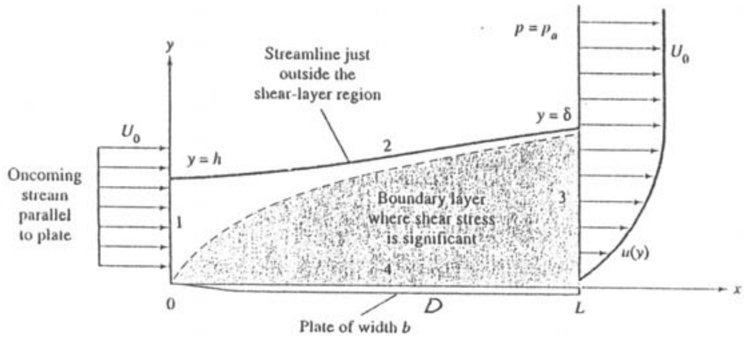
1. Briefly describe key differences between "system" approach and "control-volume" approach. Explain them in terms of "Lagrangian" and "Eulerian" viewpoints. 8%
2. State and explain the Reynolds Transport Theorem. 10%
3. What is the concept of total time derivative (or substantial derivative) in fluid mechanics? Derivative it for the case of the total time derivative of velocity in cartesian coordinates. What then are the local acceleration and convective acceleration? 12%
4. Derive the governing equations for a two-dimensional, incompressible potential flow in cartesian coordinates. How to determine the pressure for this flow? 15%
5. Determine the viscous drag force, D, on a flat plate due to a steady, incompressible boundary layer flow as shown below. Find D in terms of $\rho, U_0, \delta, u, L,$ and b. 15%



6. The pressure drop due to friction for flow in a long smooth pipe is a function of average flow velocity, density, viscosity, and pipe length and diameter: $\Delta p = fcn(V, \rho, \mu, L, D)$. We wish to know how Δp varies with V. Apply the Buckingham pi theorem to rewrite this function in dimensionless form. 12%
7. What is Reynolds' Time-Averaging Concept for a turbulent velocity? Show that the time-averaging velocity of incompressible turbulent flow satisfies the same laminar continuity relation. 12%
8. Give $\tau = \frac{1}{2} r \frac{d}{dx}(p + \rho g z) = (CONST)(r)$, where $\tau = \mu \frac{du}{dr}$ for an inclined pipe flow. Show that V (average velocity) = $0.5\, u_{\max}$. Show that $\Delta p = \frac{8\mu L Q}{\pi R^4}$ for a horizontal pipe. $\tau, \mu, u, r, x, p, \rho, g, z, L, R, Q$ are Laminar shear, viscosity, velocity, radial distance, axial distance, pressure, density, gravity, elevation, pipe length, pipe radius, and volume flow, respectively. 16%

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