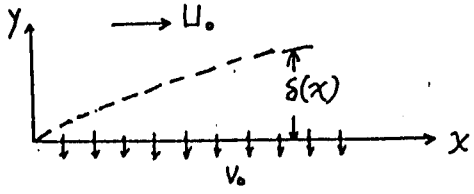
1. A laminar incompressible boundary layer forms on a porous flat surface which removes fluid from the main flow at a constant velocity v_0 as shown. Using the Von-Karman momentum integral method and assuming $u/U_0 = f(y/\delta)$, show that

$$c_f = \frac{2\tau_w}{\rho U_0^2} = \frac{2d\alpha}{dx}\delta + \frac{2v_0}{U_0},$$

where $\alpha = \int_0^1 (f - f^2) d(\frac{y}{\delta})$ (15%)



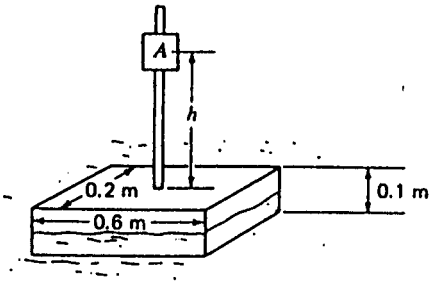
2. A spherical particle of diameter,D,and density,ρ_s,is suspended by a thread in a liquid of density ρ_f. Suddenly the thread is cut and particle starts to fall($\rho_s > \rho_f$). Write a differential equation relating the velocity of the particle,v,to time t. State the initial conditions necessary to solve for v(t). (7%)

3. A semi-infinite body of fluid with constant density ρ and viscosity μ is bounded by a flat plate. The plate is in the xy plane. The system is initially at rest.The plate is suddenly set in motion in the y-direction with a constant velocity v_0. Assuming parallel flow,write the governing differential equation plus boundary and initial conditions. (10%)

4. What is the critical Reynolds number for a fluid flow ? Please discuss the following factors how to affect the critical Reynolds number (a) pressure gradient (b) wall roughness (c) the radius of curvature of a concave surfaces. (8%)

5. Consider a long circular cylinder with its axis perpendicular to the direction of incoming flow (a)If the fluid is assumed to be invicid,sketch the pattern of streamlines. (b) If the fluid is assumed to be viscous,sketch the pattern of the streamlines. (c) Explain the difference between (a) and (b). (10%)

6. A wooden block having a specific gravity of 0.7 is floating in water. A light rod at the center of the block supports a cylinder A whose weight is 20 N. At what height h will there be neutral stability? (15%)



7. Given the following velocity field

$$\vec{V} = 10x^2y\,\vec{i} + 20(yz+x)\,\vec{j} + 13\,\vec{k} \quad m/s$$

what is the strain rate tensor at (6, 1, 2) m. (15%)

8. A pump, mounted on a boat, transmits M_p of work to each kilogram of water passing through it. The pump then discharges through a nozzle at a jet velocity c relative to the nozzle as shown. The pump suction line is so arranged that the pump may take water either from the sea (as shown), or from a large reservoir tank inside the boat. The boat is traveling at a speed V.

(a) Neglecting losses and elevation changes, derive an expression for a jet velocity relative to the boat, for each of the two cases.

(b) For a mass flow rate m through the nozzle, find the thrust on the boat for each of the two cases, assuming the jet velocity to be in a direction opposite to that of the boat velocity.

(20 %)