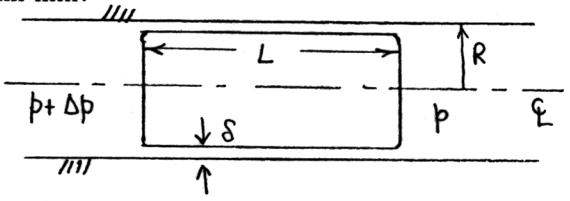
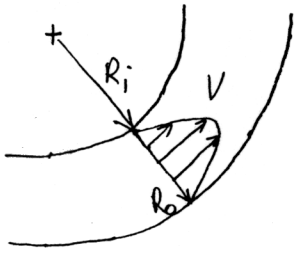
ME 106 Szeri Fall 2002

1. Blood cells in a tube. A chain of highly deformable red blood cells are being pushed through a narrow tube of radius R, by a pressure differential $\Delta p > 0$ across each cell. As they move along, there is a thin uniform film of plasma (liquid) lubricating their passage. If the blood cells are modeled as cylinders of radius $R - \delta$ and length L, (a) how fast do they move? (neglect any pressure driven flow in the thin film) (b) What is the rate of leakage of plasma through the thin lubricating layer around each cell? (here include the pressure driven flow in the thin film) (c) How significant is the pressure-driven flow in the thin film?

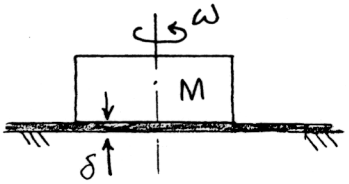


2. Round the bend. A liquid flows around a horizontal bend. Pressure taps on the inner and outer radius of the bend are connected to a mercury manometer. If the velocity profile is $V = cRn(R_o - R_i - n)$, where the radius is $R = R_i + n$, what is the reading on the manometer? Use the values $R_i = 1\text{m}$, $R_o = 2\text{m}$; $c = 1/(\text{m}^2/\text{sec})$ gives V the dimensions of velocity. The flowing fluid is water; the specific gravity of the manometer liquid is 2. Would this be an accurate way to measure the given velocity?



3. That sinking feeling. A cylindrical vessel of diameter D with an open top and a hole in the bottom of diameter $D_e \ll D$ is sunk to a depth H (constant). How long does it take for the water to fill the interior? Hint: the hole introduces a loss which could be conveniently represented by a loss coefficient k_L.

4. Spin. A heavy disk of mass M and radius R is set into rotation over a uniform thin film of oil with viscosity μ and thickness δ. The heavy disk spins more and more slowly. How long does it take (time T) before its angular velocity is reduced to half its original angular velocity? (a) First find an efficient form in which to write the general functional dependence among (M, R, μ, δ, T). (b) Then do an analysis of the problem to find the answer for T. (c) How is your answer of part (b) related to the result of part (a)?



5. Choked flow. Air from a reservoir at p_0 and $T_0 = (273.16 + 20)\text{K}$ is discharged through a choked converging-diverging nozzle. The ratio of the exit area to the throat area is 2, and the flow remains subsonic. (a) What is the exit flow Mach number? (b) If the flow exits to atmospheric pressure, what is the reservoir pressure required to drive the flow? (c) What is the mass flow rate in g/sec? The area of the exit is $1\,\text{cm}^2$. The gas constant for air is 287.05 J/Kg/K.