Tribology Ph.D. Qualifying Exam
Fall 2012

Instructions:

1. You must solve all three problems. They are of equal weight.

2. Write your work clearly in dark ink. Define clearly your variables. If you need to make an assumption you must briefly justify it. Do not assume that the examination committee can "guess" what you "mean."

3. Budget your time. Concentrate on concepts and setting up the solution first. Then work out the math.

Problem 1

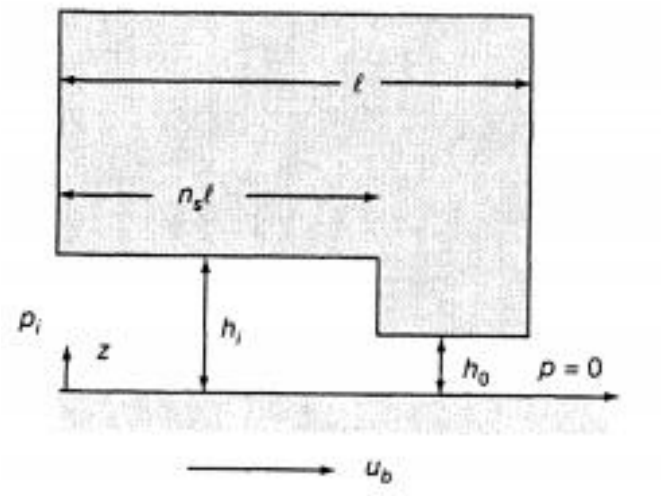
A smooth perfectly elastic sphere with constants E and ν of radius R is to be dropped against a rigid flat from a height h, where h is measured from the rigid flat to the bottom of the sphere. Determine the maximum interference. Assume that quasistatic conditions apply so that Hertzian analysis can be used describe the deformation during impact. Assume also that the maximum interference is negligibly small compared to h.

$$a = \left(\frac{3WR}{4E'} \right)^{\frac{1}{3}} \qquad a^2 = R\delta$$

Problem 2

A parallel-step thrust bearing is shown below. Side leakage is neglected. The inlet pressure is p_i, which can be greater than zero. The outlet pressure is zero, $p_o=0$. [These pressures are gauge.] The inlet and outlet film thicknesses are h_i, and h_o, respectively, where s_h is the step height, such that $s_h=h_i-h_o$. The bearing length is l, and n_s represents a fraction of that length.

(a) Determine the maximum pressure, p_m, and plot schematically the pressure profile along the bearing
(b) Determine the velocity of the fluid across the film while in the inlet and outlet regions.
(c) Do the velocity profiles depend on the location along the bearing? Explain your answer.
(d) Plot schematically the velocity profiles across the film in the two regions for two cases (i) $p_i>0$ & $u_b=0$, and (ii) $p_i=0$ & $u_b>0$



Problem 3

Friction is very important in the cutting and grinding of materials since it is involved in the process of materials deformation and removal. One particular mode of cutting is the use of diamond impregnated wires and blades to cut silicon into wafers. The wire is pulled over the surface of the silicon and the diamonds contact the silicon and deform it.

a. First, ignore the coefficient of friction and draw a schematic of this process assuming a single diamond particle contacts the surface of the silicon. Derive an expression for the volume removed by a single particle assuming the silicon deforms plastically.
b. Next assume that there is friction between the diamond and the silicon and show how this will affect the volume of material removed.