Tribology Ph.D. Qualifying Exam
Fall 2018

Instructions:

1. You must solve all problems. They are of equal weight.
2. Write your work clearly in dark ink. Define all your variables. If you need to make assumptions, justify those briefly. 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 as necessary.

Problem 1

Suppose a rough, elastic surface has a linear asperity height distribution for which the measured asperity heights range from $-z_o$ to z_o, where z_o is the maximum measured asperity height (above the mean of asperity heights). Such a distribution can be expressed mathematically as

$$\phi(z) = \begin{cases} \phi_o\left(1 - \frac{|z|}{z_o}\right) & \text{for } |z| \le z_o \\ 0 & \text{for } |z| > z_o \end{cases}$$

(a) What must be the value of ϕ_o? Hint: plot the distribution.

(b) This surface is to contact a rigid flat. In the context of the Greenwood-Williamson (GW) contact model, assume that the following parameters are known (from measurement at a particular sampling resolution):

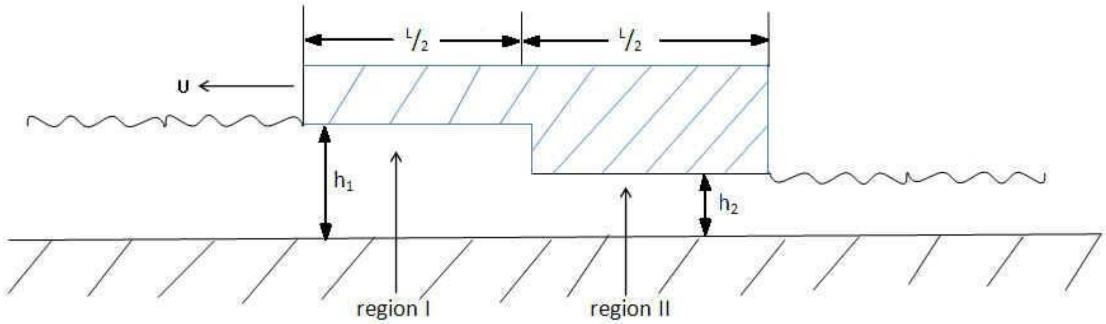
- the nominal contact area (A_n)
- total number of asperities within the nominal contact area (*N*)
- the maximum asperity height (relative to mean of asperity heights) (z_o)
- the minimum asperity height (relative to mean of asperity heights) ($-z_o$)
- the composite elastic modulus E^*
- the mean radius of curvature of the asperities (*R*)

Using the GW model, find an analytical expression for the real area of contact for a mean surface separation equal to *h*. If you were not able to do part (a), express your answer for this part in terms of ϕ_o.

(c) Suppose the surface is sampled again, but at a *higher* resolution (i.e., smaller distances between samples) than that of the original sampling. Describe the effect of using the higher resolution on the values of the listed parameters and justify your answer:

- the maximum asperity height (relative to mean of asperity heights) (z_o)
- total number of asperities within the nominal contact area (*N*)
- the mean radius of curvature of the asperities (*R*)

Problem 2



Consider the 2-D step slider bearing, shown above. It moves with speed U over a liquid film of constant density ρ and viscosity μ.

(a) Find the velocity profile in the liquid film in regions I & II.

(b) Find the pressure distribution in the film and sketch it.

(c) Find the maximum pressure in the film as a function of μ, L, U, h_1 and h_2.

(d) Find the load that can be supported by the bearing as a function of μ, L, U, h_1 and h_2.

Note: Flow can be approximated by a combination of Poiseuille & Couette Flows.

Problem 3

A damaged gear is shown in the figure below.

(a) What type of surface damage is observed on the gear teeth?

(b) Is this damage associated mainly with the rolling or sliding motion? Why?

(c) How does lubrication affect this damage? Why?

(d) What method(s) would you suggest to increase the service life of gears subjected to this type of damage? Why?