GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1995

TRIBOLOGY
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EXAM AREA

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Assigned Number **(DO NOT SIGN YOUR NAME)**

-- Please sign your name on the back of this page --

GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEEERING
Ph.D. QUALIFYING EXAM-TRIBOLOGY
SPRING, 1995

QUESTION NO. 1

In Hertzian contact analysis, we have, for point contact:

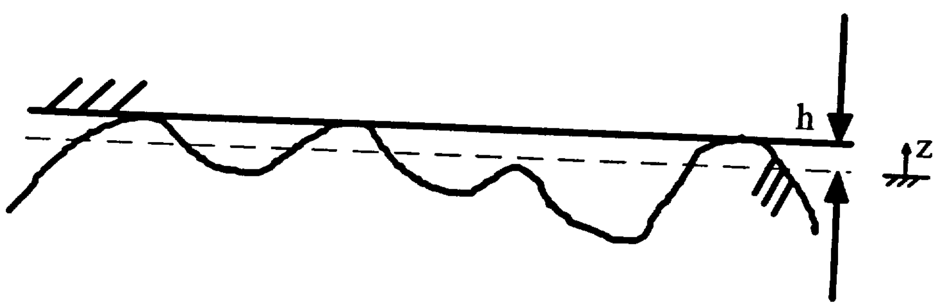
$$a = \left(\frac{3}{4}\frac{WR}{E'}\right)^{\frac{1}{3}} \qquad \delta = \frac{a^2}{R} \qquad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{E'} = \frac{1-\nu_1^2}{E_1} + \frac{1-\nu_2^2}{E_2}$$

where,

a = contact area half-width
R = reduced radius of curvature
δ = interference = deformation at center of contact
W = load
E' = reduced modulus

Suppose an interface consists of a rough surface with rms roughness, σ, in contact with a smooth, rigid flat. Suppose also that the rough surface has an asperity height distribution, $\phi(z)$, and that there are η asperities per unit area. With reference to the figure below, derive an (integral) expression for the relationship between load and surface separation, h, as measured from the asperity mean height.



QUESTION NO. 2

You are to design an hydrodynamic air-journal bearing for a high-speed dental drill (100,000 rpm). Under steady-state operation, the governing eqn. is given by:

$$\frac{\partial}{\partial x}\left(ph^3\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(ph^3\frac{\partial p}{\partial y}\right)=6\mu U\frac{\partial(ph)}{\partial x}$$

For very high rotational speeds, it is often argued that ph = const (approx.).

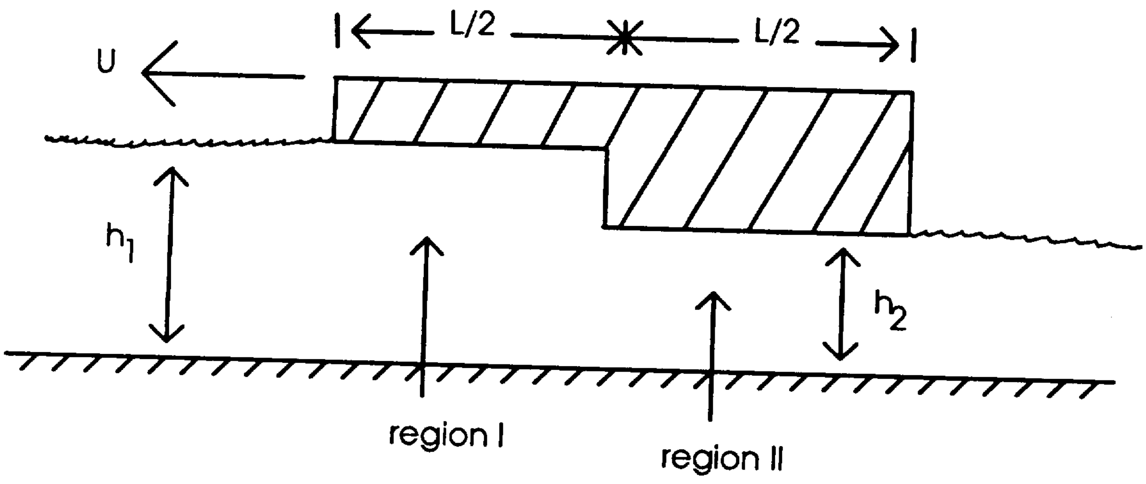
(a) Justify this approximation based on the equation.

(b) What kinds of loads do you expect for such a device in practice?

(c) Suppose the journal is 6 mm in diameter and has a 6-mm axial length. Estimate the mean pressure that the bearing must generate in order to support the loads that you suggested above.

(d) Given the approximation above, estimate the clearance required to support the loads.

QUESTION NO. 3



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

a). Find the velocity profile in the fluid film in regions I and II

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

c). Find the maximum pressure in the film as a function of the relevant parameters (e.g. U, h_1, h_2 etc.)

d). Find the load which can be supported by the slider as a function of the relevant parameters

HINT: The flow in each region of the film can be approximated by a combination of plane Poiseuille Flow and Couette Flow