GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1998

Tribology
EXAM AREA

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

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

Please **p r i n t** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

Question #1

The governing equation, in cylindrical polar coordinates, for an axisymmetric hydrostatic bearing with an incompressible lubricant is

$$\frac{d}{dr}\left(rh^3\frac{dp}{dr}\right)=0$$

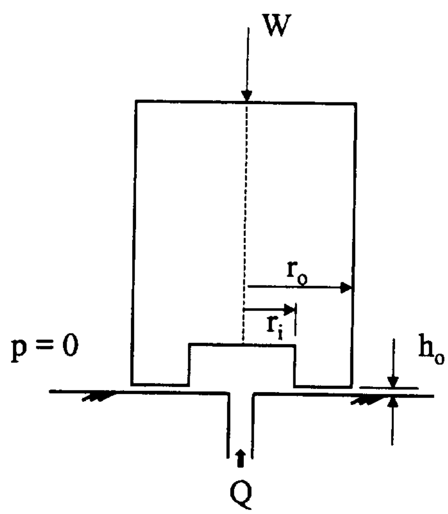
The radial volumetric flux per unit circumferential length is given by

$$q_r=-\frac{h^3}{12\mu}\frac{dp}{dr}$$

(a) For the cylindrical hydrostatic step bearing below, derive an expression for the load support in terms of the total flow rate, Q, the viscosity and the geometrical parameters. Hint: You may assume constant pressure in the recessed portion of the bearing.

Note:

$$\int r\ln r=\frac{r^2}{2}\left(\ln r-\frac{1}{2}\right)$$



(b) For what types of applications might you consider a hydrostatic bearing instead of a hydrodynamic bearing?

Question #2

The autocorrelation function (ACF), $R(\tau)$, of a surface profile, $z(x)$, having zero mean is defined by

$$R(\tau) = \lim_{L\to\infty} \frac{1}{L}\int_0^L z(x)z(x+\tau)dx$$

Where L is the length of the profile. In practice, L must be taken as finite. Suppose a simulated surface profile is given by

$$z(x) = a\cos\omega x$$

where a and ω are constants.

(a) Find $R(\tau)$ for $L = 10\pi/\omega$ and $L = 20\pi/\omega$.
(b) Describe the physical significance of the ACF—what does it measure?
(c) How might the ACF be used in the analysis of elastic surface contact.

Note:

$$\cos A\cos B = \frac{1}{2}\left[\cos(A+B)+\cos(A-B)\right]$$

Question #3

Consider an automobile disc-brake system with the following characteristics and conditions:

- brake pad area = 30 cm^2
- typical pad pressure while braking = 2.0 MPa
- loss in pad thickness after 75,000 km driving = 8.0 mm
- percentage of driving distance spent braking = 3.5%
- mean radial distance to the center of the pad = 12 cm
- tire radius = 30 cm
- disc-pad coefficient of friction = 0.3

(a) Find the wear rate (volume/sliding distance), Q,

(b) Find the minimum tire-road coefficient of friction necessary to prevent wheel lock in the absence of an anti-lock braking system (ABS). Assume a car mass of 1500 kg and 2 pads per wheel.