# GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

**Ph.D. Qualifiers Exam - Fall Quarter 1997**

Tribology
EXAM AREA

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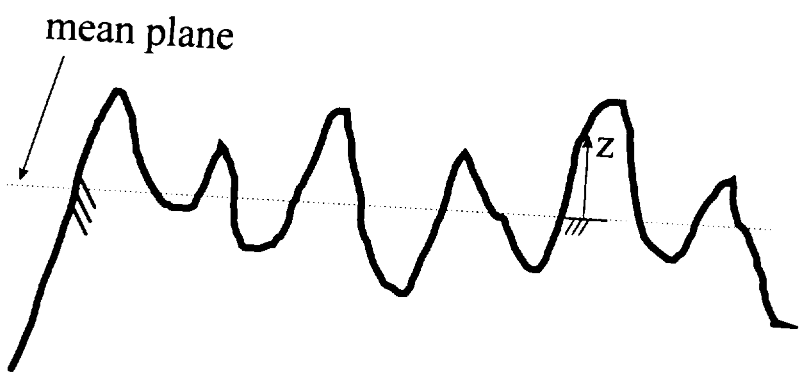
**Assigned Number (DO NOT SIGN YOUR NAME)**

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

**Problem #1**

In the most simple model of asperity contact--the so-called truncation model--it is assumed that the asperities of a rough surface are flattened (plastically) when it is placed in contact with a rigid flat, so that the profile is essentially truncated by the rigid flat. (There is no account of where the material "goes" during flattening.) Consider a rough surface (see below) that has a surface height distribution about its mean given by:

$$p(z) = \frac{1}{2\sigma} e^{-\frac{|z|}{\sigma}}$$




Using the data in the table below, determine:

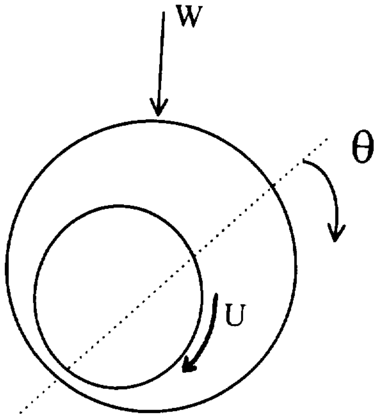
(a) The real area of contact at a load of 50 kg.

(b) The mean surface separation at a load of 50 kg.

HINT: The probability that a point on the surface is in contact is equal to the probability that its original height is greater than the mean surface separation.

| *Item* | *Description/Value* |
|---|---|
| Stand. dev. of surface heights, $\sigma$ | 4.0 μm |
| Nominal area of contact, $A_n$ | 0.015 $cm^2$ |
| Hardness, H | 1.8 GPa |

**Problem #2**




Consider a journal bearing of radius R, length L, clearance C and eccentricity ratio $\varepsilon$. The surface speed is U and the viscosity is $\mu$.

Using the short bearing assumption, find simple expressions for the pressure distribution and load capacity W in terms of the bearing parameters.

You may leave the expression for load capacity in terms of $\theta$ - integrals.

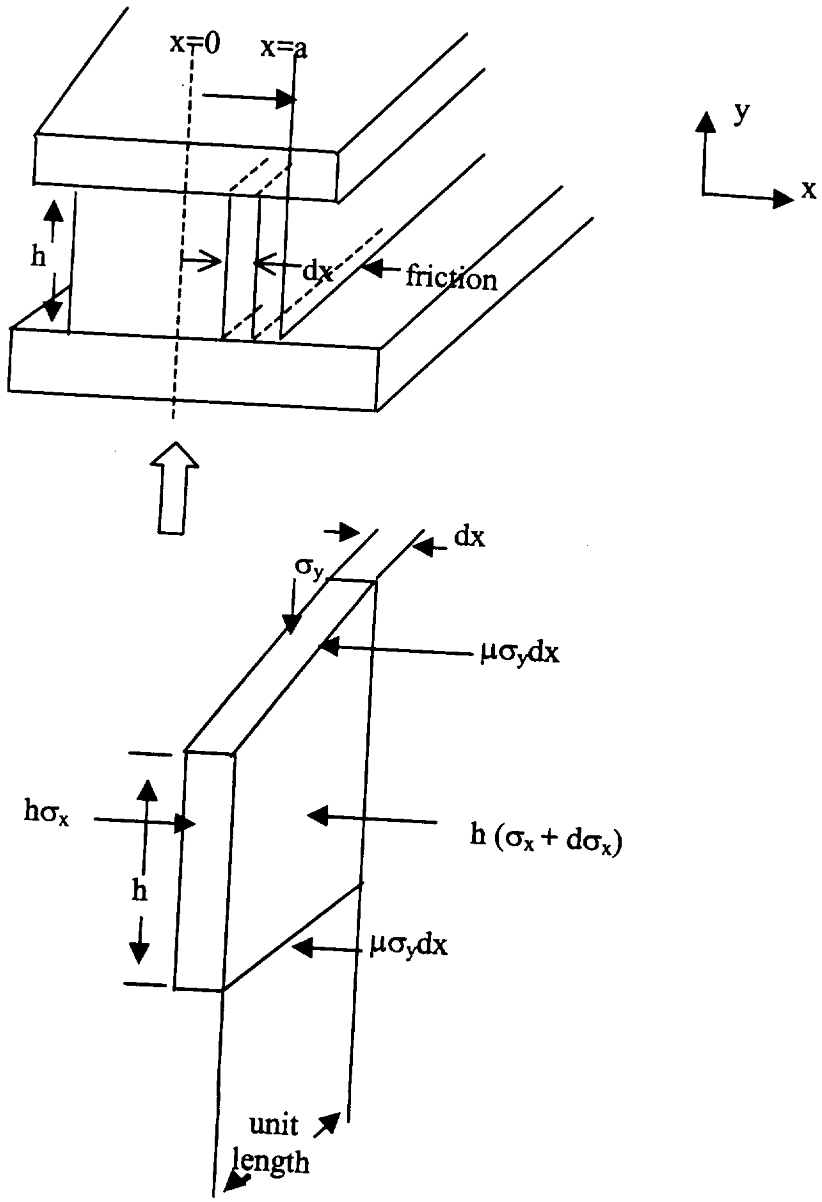
Note: The film thickness can be expressed as $h = C(1 + \varepsilon\cos\theta)$

Problem #3

Friction is critical to all metal deformation processes. In some cases, such as forging, there is a limit to the frictional force that can be generated at the die-workpiece interface since the shear yield strength cannot be exceeded. This limiting condition is reached when the metal sticks to the die. There is then no relative motion between the tooling and the workpiece and deformation is forced away from the die-metal interface.

(a.) Making this assumption, calculate $\sigma_y$, the normal stress for the case of sticking friction by replacing $\mu\sigma_y$ with $\bar{k}$, the average shear yield stress.

(b.) What is the largest value of the coefficient of friction if $k = 118$ MPa and $\bar{Y}$, the uniaxial yield strength is 220 MPa as would be the case for steel.



Hint:

Balancing the horizontal forces on the element:

$h(\sigma_x + d\sigma_x) + 2\mu\sigma_y dx = h\sigma_x$

rearranging

$2\mu\sigma_y dx = -hd\sigma_x$

and

$$\frac{d\sigma_x}{\sigma_y} = -\frac{2\mu}{h}dx$$

using the Tresca criterea gives

$\sigma_y - \sigma_x = \overline{Y}$

Where $\overline{Y}$ is the uniaxial yield strength.

Solve for $\sigma_y$ using the boundary conditions.