GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2002

Tribology
EXAM AREA

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Assigned Number (DO NOT SIGN YOUR NAME)

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

Question #1

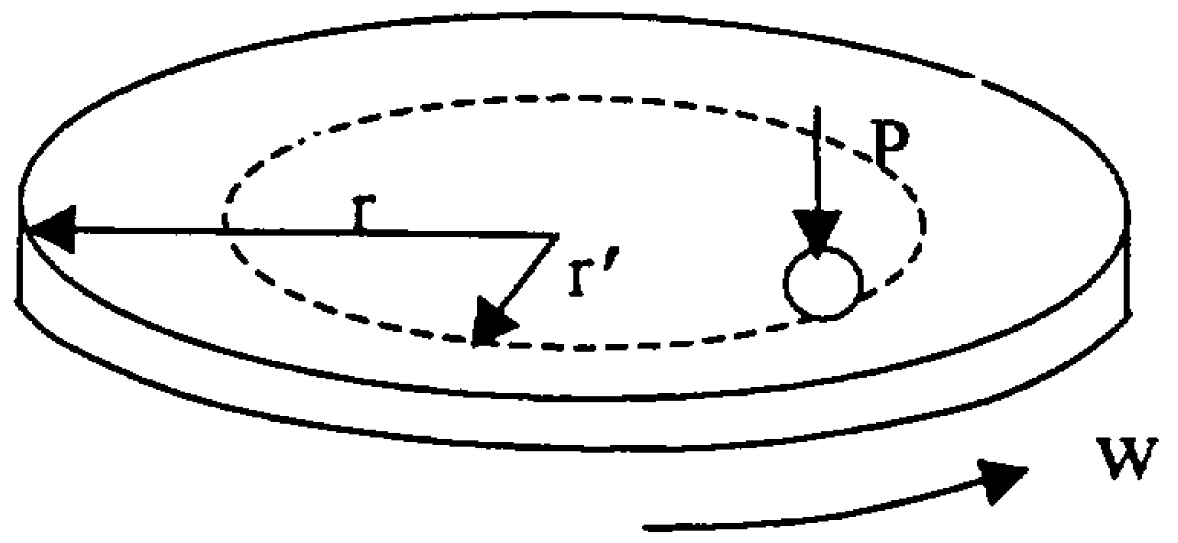
Suppose a rough surface has a surface height distribution given by

$$\phi(z) = \alpha \exp\left(-\frac{|z|}{\beta}\right)$$

Express α and β in terms of the rms roughness, σ.

Question #2

Many laboratories use a pin-on-disk apparatus as an accelerated wear test. A schematic diagram of this apparatus is shown below:



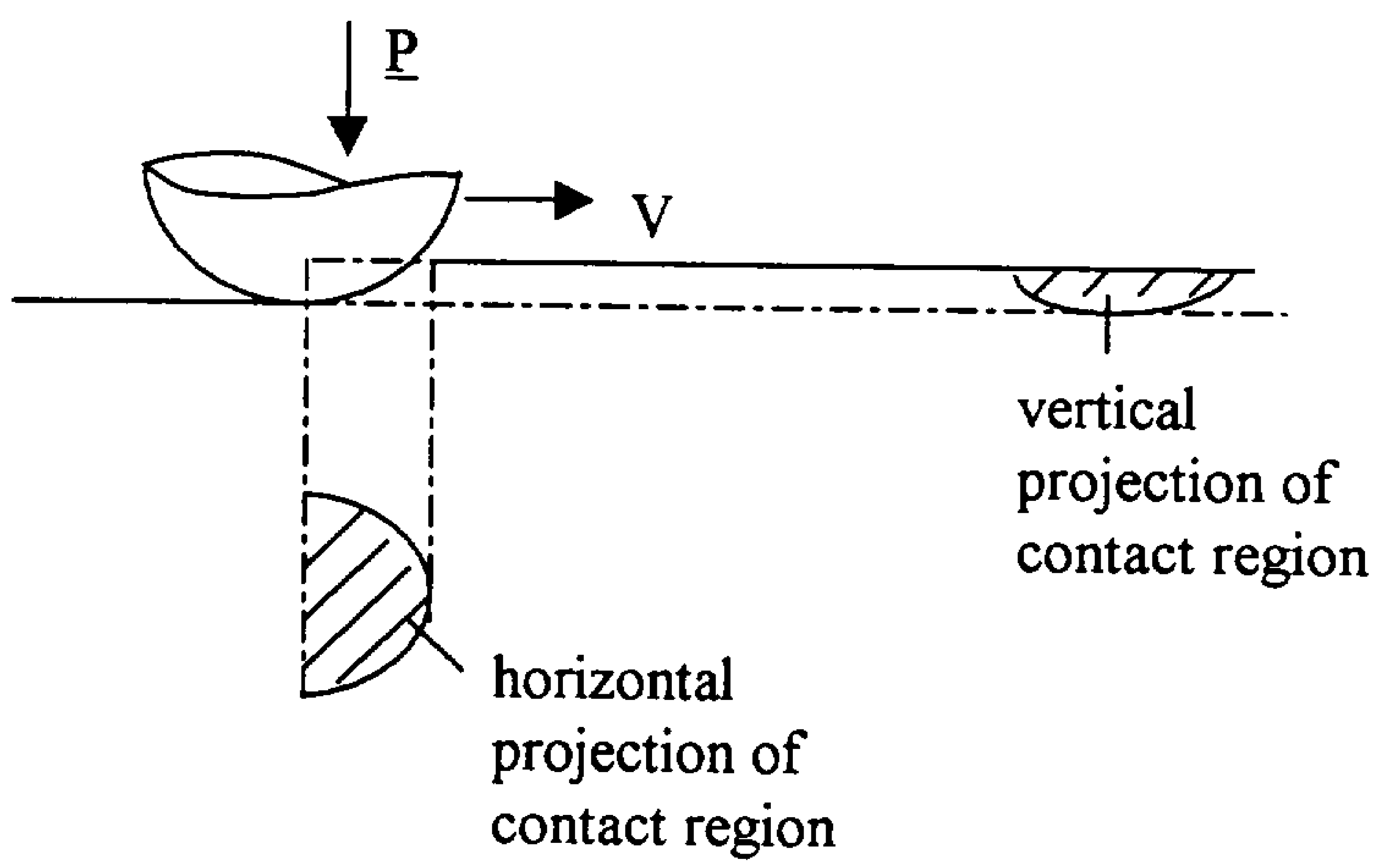
a. Under light loads and with smooth, non-adhering surfaces, the contact may be assumed to be Hertzian. Neglecting the roll of friction, draw a schematic diagram of the pin/disk cross section indicating the Hertzian contact zone whose radius is given by

$$a^3 = \frac{3PR}{4E}$$

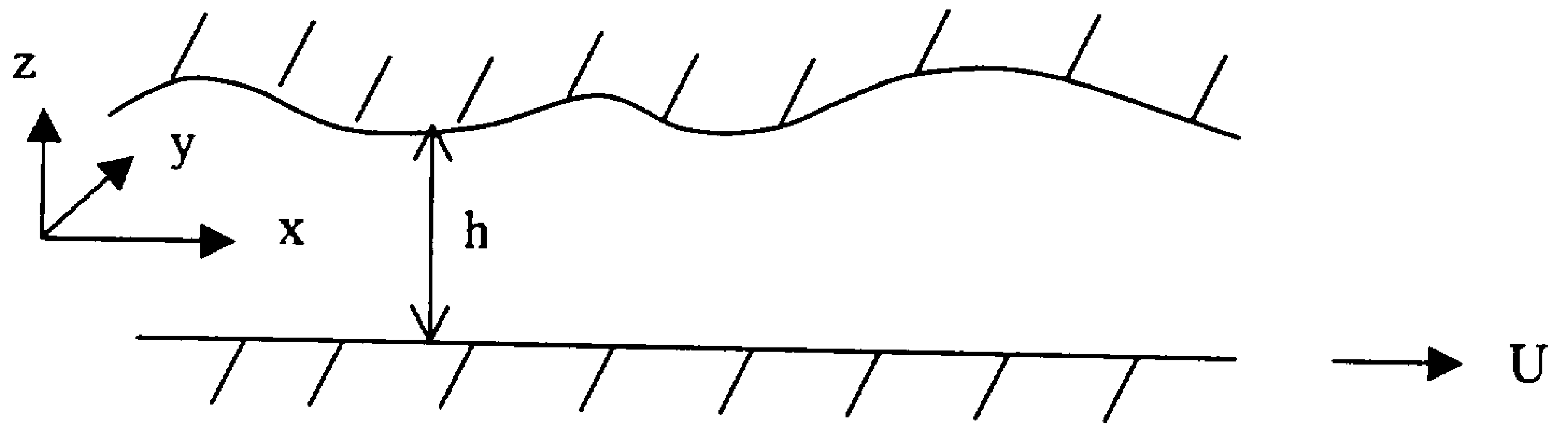
where R is the radius of the pin, and E is the reduced modulus of the pin and disk. Show that the maximum Hertzian contact pressure is given by

$$P_o = \left[\frac{6PE^2}{R^2\pi^3}\right]^{1/3}$$

b. Now consider a heavily loaded arrangement, whereby the deformation is fully plastic. Derive an expression for the wear rate as a function of load and hardness assuming that the pin is much harder than the disk. For this purpose consider the figure below, which identifies the relevant projected areas of contact.



Question #3



Consider the flow of a liquid lubricant between two surfaces separated by a distance h(x,y), with the lower flat surface moving in the x-direction with speed U, as shown above.

With conventional surfaces, the "no-slip" boundary condition is applied to the velocity at $z = \pm h/2$, resulting in the classical Reynolds equation, which governs the pressure distribution.

However, recent research has shown that unconventional surfaces can be constructed such that slip occurs between the liquid and the surface. The slip velocity is proportional to the shear stress at the surface.

Assume that the upper surface is such an unconventional surface, so that the liquid slips, with the boundary condition:

$$\text{At } z = h/2 \quad u = -\alpha \frac{\partial u}{\partial z}$$

The lower surface is a conventional (no-slip) surface.

Derive an equation governing the pressure distribution (analogous to the Reynolds equation).