M.E. Ph.D. Qualifier Exam
Spring Semester 2001

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GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2001

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

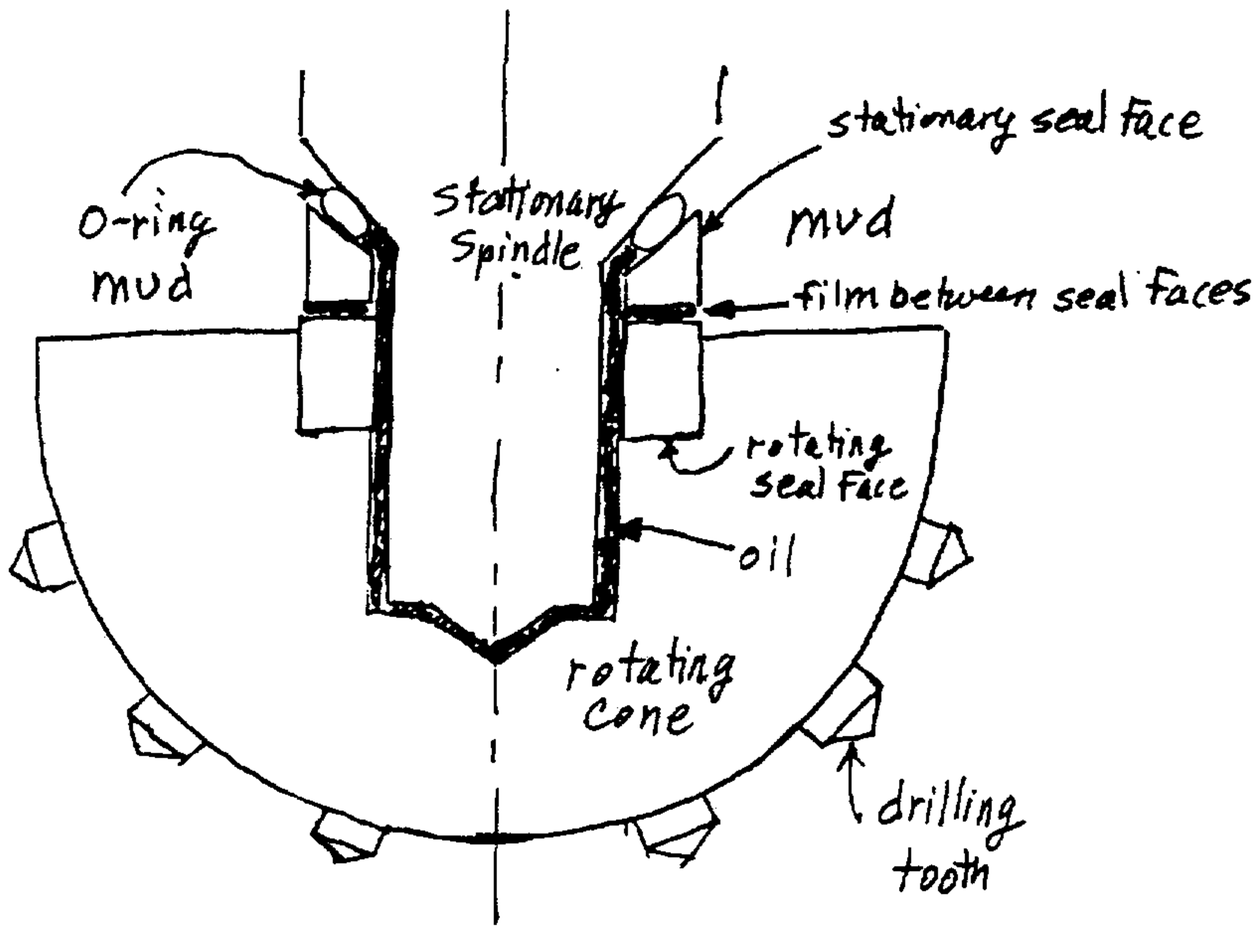
Two basic modes of wear are adhesive wear and abrasive wear.

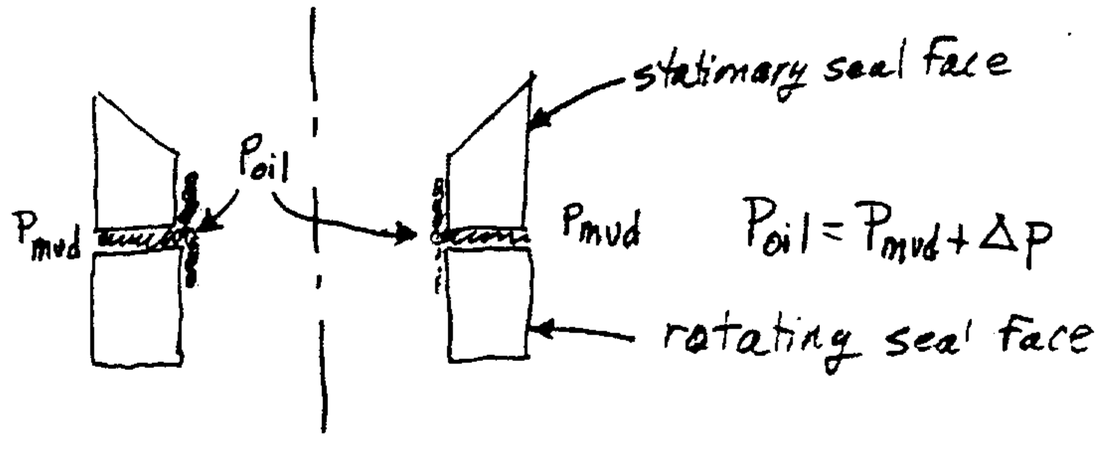
(a) Define each of these mechanisms and identify the conditions that favor one mechanism over the other.

(b) Consider scuff marks made by a rubber-soled shoe on a linoleum tile floor. Which wear mechanism is this? EXPLAIN.

(c) Consider Archard's Wear Law. What predictions does it really make? For each prediction that you identify, describe a means to test the prediction.

Question #2





Consider an oil well drill bit, consisting of a rotating "cone" that holds the drilling teeth and a stationary spindle. The clearance between the spindle and the cone is filled with oil. Drilling mud (a viscous, abrasive liquid) fills the oil well outside of the cone and spindle.

The drill bit is sealed with a mechanical seal consisting of a rotating seal face and a stationary face, both of which are metal annuli.

In order to prevent incursion of mud, the oil is maintained at a pressure $\Delta p = 0.35$ MPa above the mud pressure. However, it has been found that there is still incursion of mud into the clearance between the cone and the spindle.

The manufacturer has noticed that the stationary seal face surface is not perfectly flat, but has a slight waviness in the circumferential direction so that the film thickness between the faces is given by

$$h = h_o + h_1 \cos\frac{2\pi x}{\lambda}.$$

Since the width of the annulus, W, is much smaller than the radius, R, we can use Cartesian coordinates, where x is the circumferential location and λ is the wavelength of the waviness.

(a) Explain physically how the face waviness can produce incursion of the drilling mud.

(b) Show how you can calculate the incursion rate of the mud for given drill dimensions, waviness characteristics, and operating conditions. Carry the analysis as far as you can. Treat the drilling mud as if it has the same fluid properties as the oil.

NOTE: Since $W \ll R$ and $W \ll \lambda$, you can use the narrow bearing approximation.

Question #3

(a) Define the coefficient of friction - in two ways - first for your non-technical friend and second for the examining committee on this exam.

(b) Discuss what the coefficient of friction depends on, and what range of values are valid for the coefficient of friction.

(c) Since your father knows you have been studying tribology, what would you tell him if he asked you for the coefficient of friction between the tires of his car and the road? Note - "I don't know" is not an acceptable answer. He will think you have been wasting your time in school.