M.E. Ph.D. Qualifier Exam
Spring Semester 2003

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2003

Tribology
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

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

GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEERING
Ph.D. QUALIFYING EXAM
TRIBOLOGY
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Instructions:

1. You must solve **all three** problems.

2. Write your work clearly in dark ink. Define clearly your variables. If you need to make assumptions you must briefly justify those. Do not assume that the examination committee can "guess" what you "mean."

3. Budget your time, concentrate on concepts first, and only then work out the math as time allows.

Problem 1

Sometimes I go up and down the stairs as fast as I can, and I slide my hand along the banister railing. I have noticed the following things while doing this; my hand on the banister gets hot, sometimes so hot it feels like I will get a burn blister (but I never have gotten one), it seems that my hand gets hotter when I am going down the stairs than when I am going up the stairs, although the room temperature (and therefore the banister temperature) is always within a few degrees at the same temperature that the high temperature feeling on my hand varies depending on the banister material (wood, steel - painted or unpainted, or aluminum), and if the janitorial staff has recently cleaned and waxed the banister there is a difference. I want to analyze the situation. What concepts should I use, what assumptions should I make, what material properties do I need and where will I get them? Outline how you would attack this problem and give me a 'gut reaction' estimate of the maximum temperature you think my hand will reach. Finally, how do you explain each of the observations I made about my experience as stated above?

The lower surface moves to the right, with speed, U, and the fluid properties (ρ, μ) are constant. At $x = 0$ and L, $p = p_{ambient} = 0$. Initially, we will ignore cavitation.

i) Show that the pressure distribution shown on the sketch satisfies the Reynolds equation.

ii) Find p_{max} in terms of the fluid properties, U, L, h_{max} and h_{min}.

iii) Find the load support per unit depth, W.

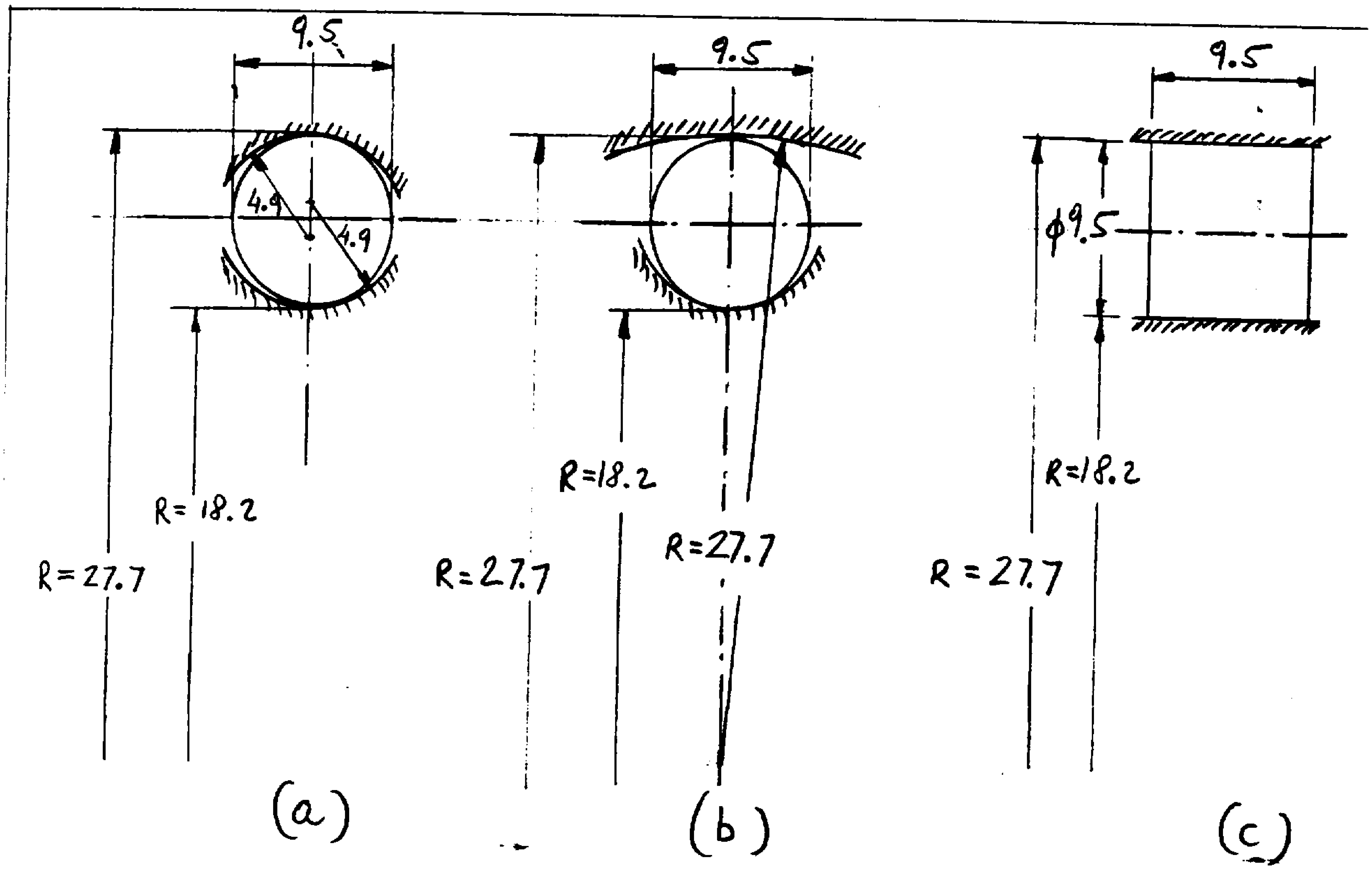
Now assume that cavitation occurs when the pressure falls below the ambient pressure.

iv) Find an expression for the load support per unit depth, W, using the simplest mathematical model possible.

v) What is wrong with the simple mathematical model you used in (iv)?

Problem 2

Three types of bearings are described in the figure: (a) a deep groove ball bearing, (b) a self-aligning ball bearing, and (c) a roller bearing. All bearings parts are made of the same steel. The inner and outer radii for all three bearings are 18.2 mm and 27.7 mm, respectively. The rolling element is either a ball of 9.5 mm in diameter, or a roller of 9.5 mm in diameter and 9.5 mm in length. Based upon Hertzian theory classify the three bearings from best to worst for the purpose of carrying a given radial load.



Problem 3

Consider a rough surface sliding over a smooth surface, with the two surfaces separated by an oil film. It is known that the asperities on the rough surface can produce small amounts of load support.

To study this effect we consider a simple two-dimensional model of an asperity, as shown below.