ME19a. **HOMEWORK.** **Oct. 1, 2009. Due Oct. 6**

PROBLEM 1

A shaft which is 2 cm in diameter and 20 cm long is concentrically located in a journal of the same length and 2.02 cm in diameter. The gap between the shaft and the journal is filled with oil whose dynamic viscosity is 0.1 $kg/m\ s$. Find the torque (in $kg\ m^2/s^2$) and the power (in $kg\ m^2/s^3$; note that 1 $watt$ = 1 $kg\ m^2/s^3$) required to turn the shaft at 6000 rpm (revolutions per minute). Note: treat this as a Couette flow neglecting the curvature of the gap geometry.

PROBLEM 2

A body with a typical length, L, is dragged through a viscous fluid (viscosity, μ, and density, ρ) at a velocity, U. By utilizing only the known dimensions of these quantities (in terms of kg, m and s if you wish) construct two groupings of these quantities which have the units of force. One should contain μ but not ρ; the second should include ρ but not μ.

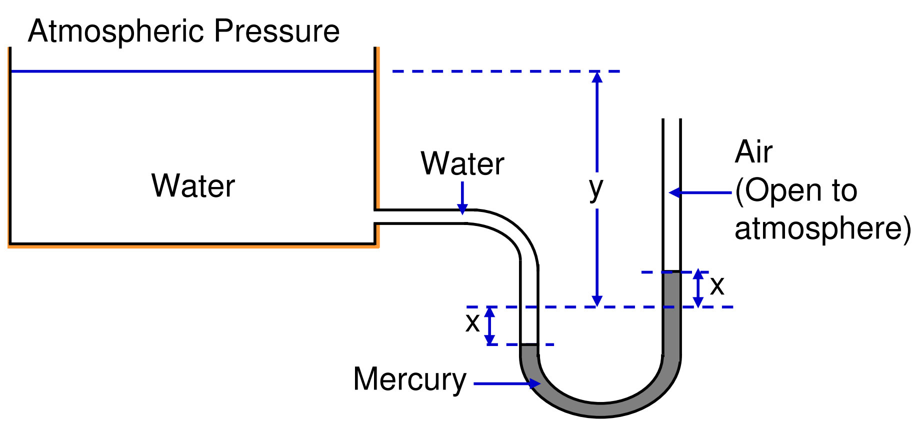
It could then be argued that the force required to drag the body through the fluid should be related to these two "typical forces". The one which includes μ is a viscous force (F_v) and the other is an inertial force (F_i). Identify the parameter which we can use to determine the conditions under which either F_v or F_i are dominant.

PROBLEM 3

It is often conjectured that the earth was, at one time, comprised of molten material. If the acceleration due to gravity, $g(r)$, at a radius, r, within this fluid sphere (radius, $R = 6440\ km$) varied linearly with r, if the density of the fluid was uniformly 5600 kg/m^3 and if $g(R) = 9.81\ m/s^2$, find the pressure at the center of this fluid earth.

PROBLEM 4

A mercury manometer is connected to a large reservoir of water as shown in the figure. The difference in elevation



between the free surface of the reservoir and the mean position of the two mercury levels in the manometer is denoted by y. The difference in the elevation between the two mercury levels is denoted by $2x$. Determine the ratio x/y if mercury is 13.6 times more dense than water.