ChBE 3200
Transport Phenomena I
Fall 2013

Exam I
September 20, 2013

This exam is closed-book, closed-notes. Some equations and other relevant information are provided. The use of wireless devices (e.g. cell phones, IR transmitters/receivers) is not permitted. The use of programmable calculators is only allowed if all relevant content has been erased from the calculator memory.

To receive full credit on each problem, it is advised to start with the appropriate full form of the balance equation(s) needed to solve the problem. Label all variables and equations. Include a brief word description to explain each step in your problem if appropriate. State all your assumptions clearly. Present your solution clearly. Numerical answers without units or explanations will not receive credit.

Name: _____
(PLEASE WRITE YOUR NAME ALSO ON THE BACK OF THE EXAM.)

The work presented here is solely my own. I did not receive any assistance nor did I assist other students during the exam. I pledge that I have abided by the above rules and the Georgia Tech Honor Code.

Signed: _____

Problem I _____/20

Problem II _____/50

Problem III _____/30

Total _____/100

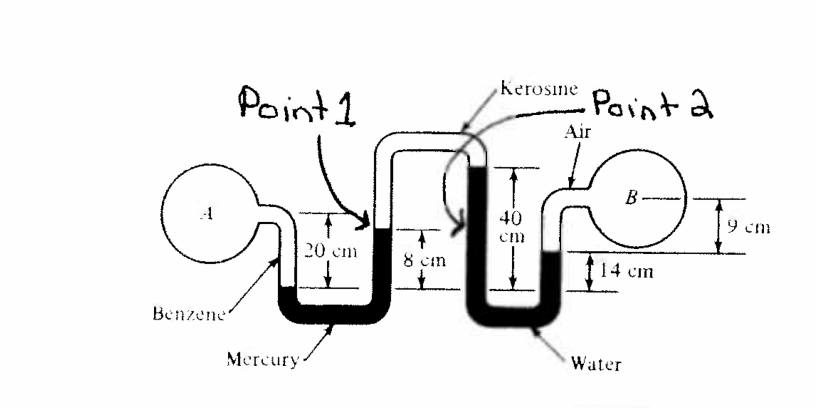
PLEASE SCAN THROUGH THE ENTIRE EXAM BEFORE WORKING ON IT.

Problem I (20 points)

1. Power law can be used to describe non-Newtonian fluids; therefore it is inappropriate to describe a Newtonian fluid using power law. TRUE/FALSE
   (If false, please provide explanation.) (3 pts)

2. Steady state flow means that the density is not a function of space (e.g. x, y, z). TRUE/FALSE
   (If false, please provide explanation.) (3 pts)

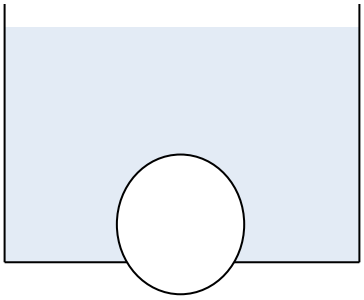
3. Observe the manometer below. The pressure at point 1 equals the pressure at point 2. TRUE/FALSE
   (If false, please provide explanation.) (3 pts)



4. Normal stresses are defined as positive in tension. TRUE/FALSE
   (If false, please provide explanation.) (3 pts)

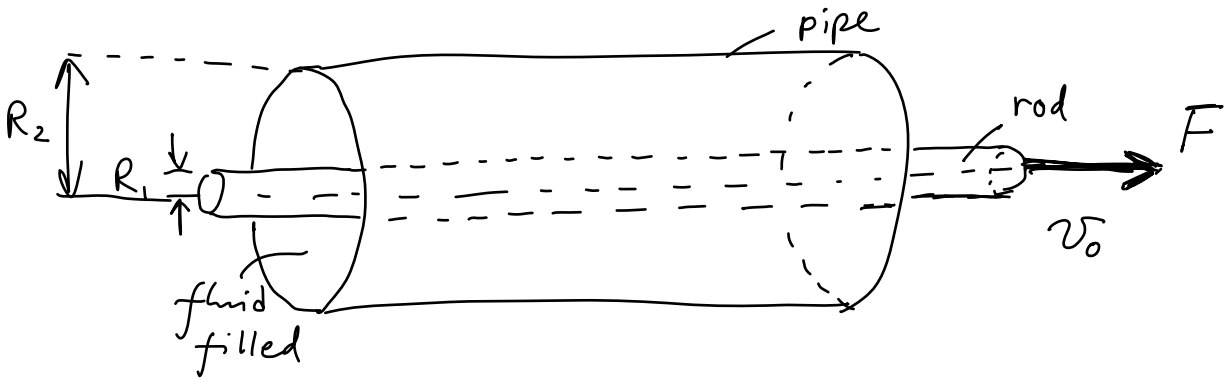
5. All stresses in a static fluid are zero. TRUE/FALSE
   (If false, please provide explanation.) (3 pts)

6. Under what circumstance can an air balloon be used to plug a hole on the bottom of a tank filled with water? (5 pts)



Problem II (50 points).

One way to determine the viscosity of a Newtonian fluid is as sketched below: the fluid occupies the annulus between a pipe (of inner radius R_2 and length L) and a thin rod (of radius R_1). The rod and the pipe are concentric. If a force F is used to move the rod at a constant velocity v_0, show that $\mu = \frac{F}{2\pi v_0 L} ln\left(\frac{R_2}{R_1}\right)$. The system is open to atmosphere. You may neglect end effects and gravitational effects. (Hint: you may wish to determine the velocity and shear profiles in the process of deriving the viscosity.)



Bonus: sketch the velocity and the shear profiles. (5 points, no partial credits)

Problem II (30 points).

A Newtonian, incompressible oil (density = 880 kg/m^3) enters a pipe bend as shown below with a velocity of 4 m/s and a pressure of 300kPa (absolute). The flow is steady, and frictional losses and gravitational forces can be neglected. The picture below represents a section of pipe; you *cannot* assume that the pressure P_2 is atmospheric pressure.

a) Determine the pipe velocity at point 2.
b) Determine the pressure at point 2.
c) Determine the x-component of force required to hold the bend in place.