

Name: _____

Box #: _____

Midterm Exam

CM 3110

19 October 2009

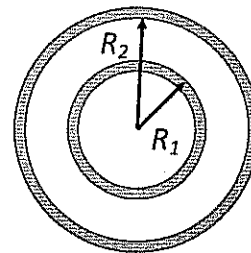
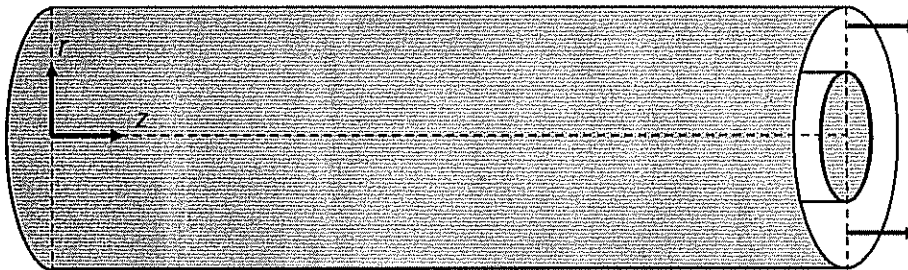
Note: 90 minutes

Significant figures count.

Please box your final answers.

Please be neat.

1. (20 points) A simple shear flow is investigated, and we seek the shear stress τ_{yz} for the flow. The expression τ_{yz} represents the flux of momentum. In the expression τ_{yz} , what direction is the momentum we are considering? In what direction is the flux of momentum we are considering? Write Newton's law of viscosity for τ_{yz} .
2. (20 points) What is the equivalent hydraulic diameter (D_H) of the flow shown below? The flow takes place in the z -direction in the annular gap between the two cylinders.



3. (20 points) What is the largest average velocity in a 1/4 inch type-L copper pipe (true inner diameter = 0.315 in) for which laminar flow of water ($25^\circ\text{C}=77^\circ\text{F}$) is produced? Please give your answer in ft/s . Significant figures count.

4. (20 points) For steady turbulent flow in a tube of radius R , researchers have measured the velocity profile and fit it to the function given below, where A is a constant. Calculate the average velocity for this flow. You may leave your answer as an integral over r .

$$v_z(r) = A \left(1 - \frac{r}{R}\right)^{\frac{1}{7}}$$

5. (20 points) Water (density= $62.25 \text{ lb}_m/\text{ft}^3$, viscosity= $6.01 \times 10^{-4} \text{ lb}_m/\text{ft s}$) flows in an expanding bend whose geometry is shown below. The upstream pressure is 14.5 psig and the downstream pressure is calculated from the mechanical energy balance to be 15.2 psig . The inlet velocity is 12.23 ft/s and the outlet velocity is 3.61 ft/s . What is the y -component of the force on the bend in lb_f ? You may neglect gravity; the flow is turbulent. Give your answer in the coordinate system shown.

