Homework VI.

Due *Friday November 3, 2006*, in fourth hour.

Read: Chapter 10

Problems:

1. Redo Ex (8.11) from class, this time including gravity in the viscous flow in the outlet tube. What is the change in the calculated kinematic viscosity?

2. Obtain the solution for steady fully-developed flow down an inclined plane using the Navier–Stokes and continuity equations.

3. Find the velocity profile for flow between two coaxial rotating cylinders. The inner cylinder has radius R_1 and angular velocity Ω_1; the outer cylinder has radius R_2 and angular velocity Ω_2.

4. Calculate the torques on the two cylinders of the previous question.

5. Consider the velocity field

$$v_\theta = \begin{cases} \Omega r & r \le a, \\ \Omega a^2/r & r > a. \end{cases}$$

   Compute the pressure field and find the difference in height of the free surface between the origin and infinity equation. Why does Bernoulli's equation (9-25) not help?

Comments:

The material derivative D/Dt corresponds to riding with a particle as it moves. This is different from the partial derivative $\partial/\partial t$, which corresponds to sitting at a fixed point in space. Even when the flow is steady, which means that $\partial/\partial t = 0$, the value of a quantity can change as we move with the particle. For example acceleration becomes $\partial \mathbf{v}/\partial t + (\mathbf{v} \cdot \nabla)\mathbf{v}$. Make sure you know how to use vector operators so that you can compute material derivatives.