CENG101A: Introductory Fluid Mechanics Fall Quarter 2006
http://maecourses.ucsd.edu/mae210a

Homework III.

Due *Friday October 13, 2006*, in fourth hour.

Read: Chapters 5 and 6

Problems:

1. Show that in one-dimensional steady flow
$$\frac{\mathrm{d}A}{A} + \frac{\mathrm{d}v}{v} + \frac{\mathrm{d}\rho}{\rho} = 0.$$
Now show that $\mathrm{d}F = Q\,\mathrm{d}v$.

2. Fluid occupying the boundary layer $0 < y < \delta$ flows over a plate at $y = 0$ with velocity field $u = 0$ at the left end of the plate and $u = U(2y/\delta - y^2/\delta^2)$ at the right end of the plate. Calculate the mass flow rate across the edge of the boundary layer. Compute values for $\delta = 5$ mm, $\rho = 1.24$ kg m^{-3}, $w = 0.6$ m (spanwise width), $U = 30$ m s^{-1}.

3. Compute the force on the plate per unit area for the flow in the previous question, first in terms of the parameters and then numerically.

4. A horizontal jet of water with velocity U and density ρ strikes a plate inclined at an angle θ to the horizontal. The water then flows away both sides of the plate. Calculate the components of the force necessary to hold the plate in position, assuming the flow is frictionless. For what angle θ is the horizontal component of the force twice the vertical component?

5. Exercise 5.29 discusses a hydraulic jump. How would you set up the problem for the kitchen faucet where the flow away from the center of the sink is radial? Assuming that the jump is at radius R, do the question.

Comments:

Chapter 5 and 6 treat the conservation equations appropriate to macroscopic control volumes that are used to analyze systems. The Reynolds Transport Theorem is applied to obtain equations for the conservation of momentum (5-4) and energy (6-10).

You should be able to apply compute the relevant flux integrals when you are given the velocity distribution. Note that these integrals can often be replaced by algebraic results related to average properties.

Chapter 6 ends with the Bernoulli equation (6-11). This is a very important engineering equation. We shall see it again in Chapter 14.