Week 8: Momentum conservation and control volumes

I. READING

This week you should read re-read Chapters 7 from my notes.

II. MOMENTUM AND CONTROL VOLUMES

1. A jet pump is shown below. Find the velocity of the exit in terms of V_1, V_j, and A_j/A. Find the pressure drop over the pump. Is the exit at a higher or lower pressure than the inlet. Assume the flow is uniform as shown.

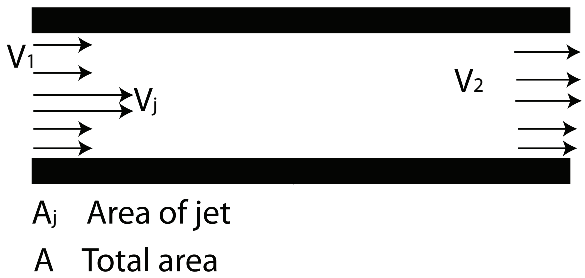

FIG. 1 Schematic for problem 1.

2. A circular jet of water of diameter D and velocity V strikes a rectangular block as shown. The block has a height H, width W, and a mass M. The jet strikes the block in the center. What is the minimum jet velocity needed to tip the block over.

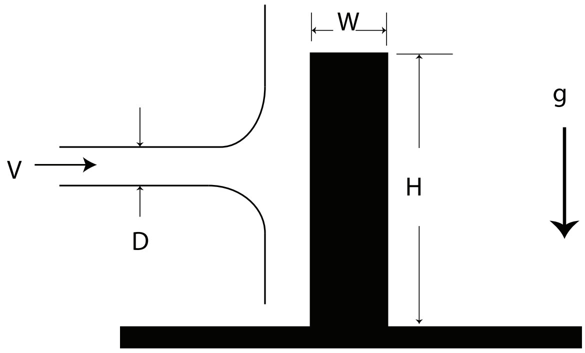

FIG. 2 Schematic for problem 2.

3. Water flows over a flat plate. At the leading edge of the plate there is uniform velocity U_∞. At the trailing edge we measure the velocity boundary later that has developed across the plate, $u(y)$. We measure the velocity as a function of y, the distance from the plate. The boundary layer has the conditions that $u(y = 0) = 0$ and $u(y > d) = U_\infty$. Using an appropriate control volume, measure the drag force on the plate as a function of the free stream velocity, the measured velocity profile, the boundary layer thickness, an any relevant fluid properties. Your answer will be in terms of an integral which you could evaluate numerically if you made the measurement.

4. The hydraulic jump can be observed in the bottom of a sink. Notice that as the water spreads radially, that there is point where the height of the water suddenly increases. This jump can be observed in the spillways of dams

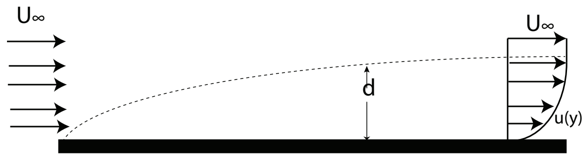

FIG. 3 Schematic for problem 3.

and in rivers. The transition from height h_1 upstream can be related to the height h_2 downstream. Assume the upstream velocity, U_1, and the downstream velocity U_2 are constant across the layer depth. Determine the relationship between the upstream and downstream heights. Try to rearrange everything such that $h_2/h_1 = f(Fr)$ where the Froude number is, $Fr = U_1/\sqrt{gh_1}$.

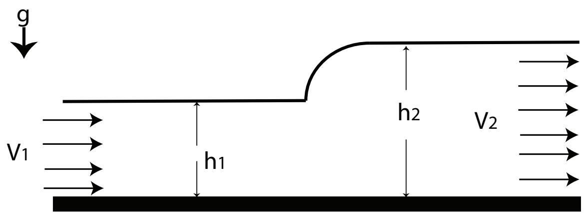

FIG. 4 Schematic for problem 4.