Lab 6: Open Channel Flow Demonstration

NOTE: The laboratory session Tuesday 10/20 will involve a demonstration of fluid motion and concepts related to open channel flow. You do not need to prepare a lab report.

LAB ACTIVITIES:
To begin, your TA will write Manning’s Equation on the board. Manning’s equation is used to compute the flow rate \( Q \) corresponding to a given slope \( S_0 \) and the flow depth \( y_n \). Here \( y_n \) represents the normal depth which occurs under uniform flow conditions. Students will consider how \( Q \) changes with slope.

1. The TA will discuss computations for critical depth \( y_c \). For subcritical flow in the channel, the TA will point out the flow passing through critical depth near the downstream end of the tank, just above the free outfall. (Critical depth \( y_c \) should occur a distance of about \( 4y_c \) above the free outfall.)

2. For the same flow rate, the TA will use the movable sluice gate to illustrate subcritical flow upstream of the gate and supercritical flow downstream of the gate. Students will then consider the relative values of the specific energy upstream and downstream of the sluice gate. (The specific energies should be about the same. Why might they be different?)

3. For the same flow rate, students will consider the value of the Froude number. Before the TA places an object (pencil) in the water, students will predict whether or not the disturbance will travel upstream. The TA will then adjust the slope to illustrate the disturbance propagation under the alternative flow regime (either subcritical or supercritical).

4. Keeping the flow rate fixed, the TA will make the channel horizontal and demonstrate subcritical flow over a hump. Note that critical depth, and hence minimum specific energy occurs at the critical hump height. If the hump height is less than the critical height, there will be a depression in the water surface over the hump. (Why? The TA will draw the specific energy diagram on the board, and have students consider the fact that the hump causes \( E \) to decrease while \( q \) is constant.) If the hump is raised enough, water is dammed behind the hump, which now acts like a broad-crested weir.

5. Now the TA will increase the channel slope to demonstrate supercritical flow over the hump. At small hump heights, with no damming effect, the water surface rises as flow goes over the hump. (Why? Again, consider the specific energy diagram.)

6. The TA will demonstrate effects of channel contraction on subcritical flow. With one short plate inserted, depth should decrease through the contraction (similar to the hump, except that the contraction causes \( q \) to increase and therefore \( y \) to decrease for nearly constant \( E \).
7. The TA will demonstrate effects of channel contraction on supercritical flow. Flow depth will increase as the amount of contraction is increased until critical depth is reached.

8. In a horizontal channel, the TA will demonstrate flow over a weir with a hydraulic jump downstream.

9. While maintaining the hydraulic jump, the TA will add a sluice gate downstream to move the jump back to the weir (the jump will now be "submerged"). The TA will demonstrate the effect on a “swimmer” (match stick) caught in the eddy.

10. The "drowning swimmer" may be a good place to stop, but if time allows the TA will use weirs and sluice gates to illustrate some gradually varied flow profiles (with mild, steep, horizontal, and adverse slopes).

As time allows, the TA will demonstrate flow patterns in the large flume in Dillman 110. What differences do you observe in gradual vs. abrupt contractions/expansions? What does this suggest for the movement of water around road and bridge crossings?