CWR 5235 Open Channel Hydraulics
Homework 3, Spring 2021
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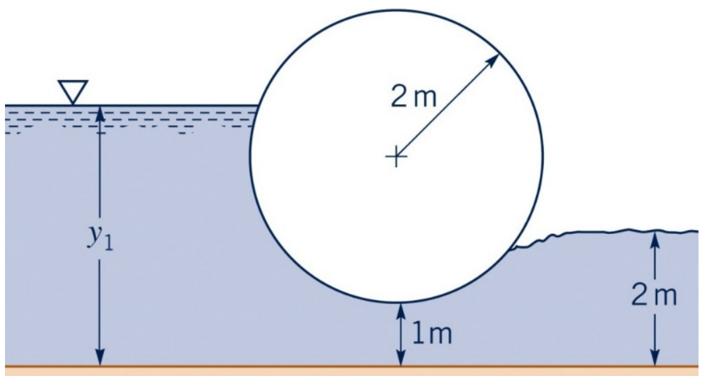
1. (10 points) Water flows under a sluice gate in a channel of 10-ft width. If the upstream depth remains constant at 5ft, plot the flowrate as a function of the distance between the gate invert and the channel bottom as the gate is slowly opened. Assume free outflow.

2. (10 points) A water-level regulator (not shown) maintains a water depth of 2.0 m downstream from a 10-m-wide drum gate, as shown in the figure below. Plot a graph of flowrate, Q, as a function of water depth upstream of the gate, y_1, for $2.0 \le y_1 \le 5.0$ m. Hint: Obtain C_d from the figure shown in class for discharge coefficients for underflow gates.



3. (30 points) An ogee spillway has a crest height of 50 ft and a maximum head of 15 ft. A minimum pressure of -1.5 psi is allowed. The maximum discharge is 16,000 cfs. Determine the spillway's crest length assuming a compound circular curve for the upstream crest shape. What is the pressure at the *crest* for the maximum discharge? Plot the complete spillway *crest* shape.

4. (30 points) The following three problems demonstrate how to 'design' a stilling basin by selecting the proper floor elevation and how to 'analyze' the stilling basin's performance by computing the conjugate depth curve over a range of flows. Assume that you have a reservoir spillway that has its crest at an elevation of 180 ft. The spillway width, and the width of the (rectangular) channel downstream of the basin, is 50 ft. The downstream channel has a slope of 0.001, a Manning roughness of 0.03, and the channel bottom's elevation (often called the invert) at the entrance is 65 ft.

4(a) First, consider a specified design discharge of 5000 cfs. Recalling that the flow over the spillway crest is critical, determine the proper basin floor elevation. By 'proper,' we mean that the water surface elevation after the hydraulic jump in the basin will match the water surface elevation at the downstream channel entrance, at this design flow. **Hints**: you will need to make use of the following tools:

a. The energy equation between the spillway crest and the supercritical flow at the spillway base (assume no losses).
b. The hydraulic jump equation.
c. The Manning's equation for the downstream channel).

4(b) Next, we are interested in comparing the tailwater and the conjugate depth (y_2 predicted by the theoretical jump equation) curves over the range of flows from 2000 to 7000 cfs. To that end, first, repeatedly apply the Manning equation to the downstream channel to determine (and plot) the stage-discharge relationship (i.e., the tailwater curve). Note that you must plot water surface elevation (relative to the datum for everything else) and not just the water depth.

4(c) Finally, making use of the basin floor elevation found in part (a), compute (and plot; please superimpose this upon the tailwater curve) the water surface elevation over the range of discharges (one point every 1000 cfs will suffice) given above.

5. (*10 points*) A 0.91 m diameter corrugated metal pipe culvert (n = 0.024) has a length of 90 m and a slope of 0.0067. The entrance has a square edge in a headwall. At the design discharge of 1.2 m^3/s, the tailwater is 0.45 m above the outlet invert. Determine the head on the culvert at the design discharge.

6. (*10 points*) A 3-ft by 3-ft concrete (n = 0.012) box culvert has a slope of 0.006 and a length of 250 ft. The entrance is a square edge in a headwall. Determine the head on the culvert for a discharge of 50 cfs and a discharge of 150 cfs. The downstream tailwater elevation is 0.5 ft above the *outlet invert* at 50 cfs and 3 ft above the *outlet invert* at 150 cfs.