Problems 1-6 will be graded on effort alone. You may collaborate freely with others to work these problems.

1. A fire hydrant is installed off of a water main by a “Tee” fitting (see drawing below). Thrust blocks are installed at the Tee as shown. If flow from the left into the Tee is 5 cfs and water is taken from the hydrant at 500 gal/min, what is the magnitude and direction of the force on the thrust block? (1 ft³ = 7.4805 gal)

2. A pump station is being built to lift water from a reservoir to a distribution canal above it. The reservoir water elevation is 348 m, and the water elevation in the canal is 522 m. If a flowrate of 45 m³/s is desired, what will be the energy consumption of the pump station in kilowatts assuming perfect efficiency? What if gross efficiency is 65%?
3. One of the ways that pressure is maintained in municipal water distribution systems is through the use of elevated storage tanks (a.k.a., “water towers”). Most domestic plumbing is designed for use with water pressures in the range of 35 to 80 psi. What would be the height above ground level required for a water tower so that water users at ground level had pressure at the high end of this range? Assuming a water tower built to that height, what would be the maximum height of a building where water users would still have pressure within the acceptable range?

4. We have discussed friction in pipe flows as a loss of energy. This energy is converted to entropy as “waste heat,” which causes a very slight temperature increase in the fluid, pipe walls, and ambient air. For a 20 cm diameter new cast iron pipe with a flow of 0.45 m³/s, what is the rate of energy loss for a 100 m length of pipe expressed in units of watts? If all of this energy were absorbed by the water in the flow, what would be the change in water temperature in ºC? (1 cal = 4.1868 Joules)

5. Drawn on the next page is a pipeline between a pair of reservoirs with 2 possible pump locations (shown as green and pink, respectively) along the pipeline to move water from the lower to the upper reservoir. The pipe is 8 inch diameter and built in 3 sections. The first section shown in yellow has a roughness diameter of 0.05 inches; the second and third sections (white and orange) have roughness diameters of 0.02 and 0.10 inches, respectively. If the flow in the pipe is 0.85 cfs, what must be the head input into the flow by the pump? Draw the HGL and EGL on the scale drawing for each pump location. What are the maximum and minimum pressures in the flow for each pump location?
6. The sketch below is from preliminary model fabrication plans for a pump station model built and studied here at TAMU in 2008 (many of the dimensions are approximate). Water will flow through the 6 inch pipe starting at the right side of the U-shaped structure (upwards at first) and then turn through a 45° bend, a 90° bend, and a 45° bend to flow down through the left side. The flowrate will be 179 gpm. What restraints should be installed to resist momentum forces generated in this structure?