CM3215 Assignment 6:
System-head Curves for a Proposed Piping System
Under Conditions of Different Needle-Valve Positions

Due: Wednesday 23 March 2:05pm in Homework Box A
This is an individual assignment. Note the due time.

Complete all calculations described below; you may verbally consult with any of your classmates, but you must submit individual assignments that represent your own work; you may not exchange papers or electronic files. Deliver your submission with a memo of transmittal that clearly lists where to find your submitted answers to the assigned objectives. You must submit only your own work.

Overall objective: Determine the system-head curves (each will be function of flow rate) for a flow loop under three different operating conditions (three different needle valve settings) The three different systems are described below. Plot these curves as instructed.

In a future laboratory, you will predict the performance of a particular pump (the laboratory Lossy® pump) when it is installed to provide the flow energy to overcome the losses in the three systems described here. Week 12 you will “build” this system, “install” the Lossy® pump, and check the accuracy of your Assignment 6 predictions by measuring the actual performance of the Lossy® pump against the three systems.

1. Sketch the following system using Visio or by hand (make the sketch 8.5 by 11 inches, approximately). The system is a subset of our laboratory station.

The systems:
The three systems are three different metering valve settings for a flow loop containing:

- Source tank: 12.5 inch inner diameter; discharge through the bottom to 1" nominal copper tubing, type L
- 36.25 inches of 1” nominal, type L copper tubing; this tubing leads from the bottom of the source tank to the suction side of where the pump will be installed.
- Three, 90° elbows, 1” nominal, copper tubing
- A position for a constant-speed pump (1” connection available on suction side, ½” connection available on the discharge side)
- 98.5 inches of ½” nominal, type L copper tubing; this tubing conducts water from the discharge side of the pump through the rest of the system until exiting to the air above the destination tank.
- Two, ½ inch, 3-way ball valves
- Six 90° elbows, ½” nominal, type L copper tubing
• Destination tank: 12.5 inch inner diameter; receives efflux from the discharge of \( \frac{1}{2}'' \) nominal type L copper tubing discharging to air; the discharge point is 5" above the surface of the water in the tank. The tank is open to air.

• One Swagelock Integral-Bonnet Needle Valve, 18 series needle valve, regulating stem, 0.375" orifice, set to the three different positions described in note 2 (note: the valve orifice size is part of the specifications of the needle valve and identifies the valve model; the valve is not an orifice meter and has nothing to do with an orifice meter).

2. We are interested in three positions of the needle valve, \( \frac{1}{2} \) turn open (180° rotation), 1 turn open (360° rotation), and 2 turns open. For the Swagelock needle valve in brand-new condition, you need to determine the friction coefficient \( K_r \) for the three requested valve positions: \( \frac{1}{2} \) turn open, 1 turns open, and 2 turns open. Dr. Morrison’s handout shows how this calculation is done, and the answer at one valve position is given in her notes: [www.chem.mtu.edu/~fmorriso/cm3215/Cv_control_valves_2013.pdf](http://www.chem.mtu.edu/~fmorriso/cm3215/Cv_control_valves_2013.pdf)

3. Calculate system head versus capacity for the three flow systems. Determine equations (curve fits) for the system-head curves \( H_{system}(Q) \) for the flow loop metered by the Swagelock Needle Valve in the following three positions: \( \frac{1}{2} \) turn open, 1 turns open, 2 turns open. Give a table indicating the values of friction coefficients \( K_r \) you used for each of the fittings you included in your calculations. Give head in units of \( ft \) and capacity in units of \( gpm \).

4. On a single graph, plot the three system-head curves from item 3 as a function of capacity (volumetric flow rate in \( gpm \), which is gallons per minute). When choosing your plotting limits, for the flow rate use \( 0 \leq Q \leq 4gpm \) and use enough points to get a smooth curve. As always, include appropriate captions in your figures and tables. We are interested in system head of at most 100 \( ft \); limit your y-axis to 100 \( ft \).

Deliver your submission with a memo of transmittal that clearly lists where to find your submitted answers to the four assigned objectives.