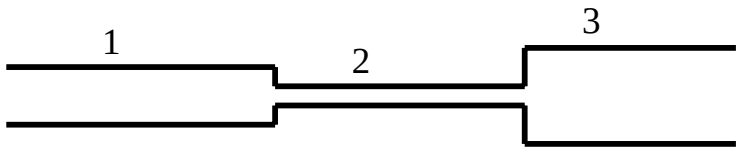
HANDOUT ON PIPES IN SERIES



$Q = Q_1 = Q_2 = Q_3$

$h_L = h_{L1} + h_{L2} + h_{L3}$

Equivalent-Velocity-Head Method for Finding the Flow Q for Pipes in Series

1. The total head loss h_L is given, as are the sizes and lengths of the pipes.

2. Estimate reasonable values of f for each pipe: you might use the "rough-pipe" equation to obtain your initial estimate of the f values.

3. Write the Darcy-Weisbach equation for the head loss in each length of pipe including the local losses in each section (ΣK):

$$h_L = f_1 \frac{L_1}{D_1} \frac{V_1^2}{2g} + f_2 \frac{L_2}{D_2} \frac{V_2^2}{2g} + \ldots \Sigma K \frac{V_1^2}{2g} + \Sigma K \frac{V_2^2}{2g} + \ldots$$

4. Write all the velocity heads in terms of one of the velocity heads, using the continuity equation to do so. For example, to express the velocity heads in terms of the velocity head of the first section of pipe:

$$Q = A_1 V_1 = A_2 V_2 = \ldots$$

solving for the velocities in the various sections of pipes:

$$V_2 = \frac{A_1}{A_2} V_1$$

5. Rewrite the Darcy-Weisbach equation in terms of one velocity head and sum up all the headlosses (including local losses):

$$h_L = f_1 \frac{L_1}{D_1}\left(\frac{A_1}{A_1}\right)^2 \frac{V_1^2}{2g} + f_2 \frac{L_2}{D_2}\left(\frac{A_1}{A_2}\right)^2 \frac{V_1^2}{2g} + \ldots \Sigma K\left(\frac{A_1}{A_1}\right)^2 \frac{V_1^2}{2g} + \Sigma K\left(\frac{A_1}{A_2}\right)^2 \frac{V_1^2}{2g} + \ldots$$

or:

$$h_L = \left[\left(f_1 \frac{L_1}{D_1} + \Sigma K\right)\left(\frac{A_1}{A_1}\right)^2 + \left(f_2 \frac{L_2}{D_2} + \Sigma K\right)\left(\frac{A_1}{A_2}\right)^2 + \ldots\right]\frac{V_1^2}{2g}$$

6. Solve for V_1:

$$V_1 = \sqrt{\frac{2gh_L}{\left[\left(f_1 \frac{L_1}{D_1} + \Sigma K\right)\left(\frac{A_1}{A_1}\right)^2 + \left(f_1 \frac{L_1}{D_1} + \Sigma K\right)\left(\frac{A_1}{A_1}\right)^2 + \ldots\right]}}$$

7. Once V_1 is determined, calculate the other velocities in each section of pipe using the continuity equation.

8. Calculate R and calculate the new values for f using Swamee and Jain's equation.
If the new values of f are within 5% of the previously estimated values of f, quit. If not, replace the estimated values for f with the calculated values and repeat the procedure until the f's converge.