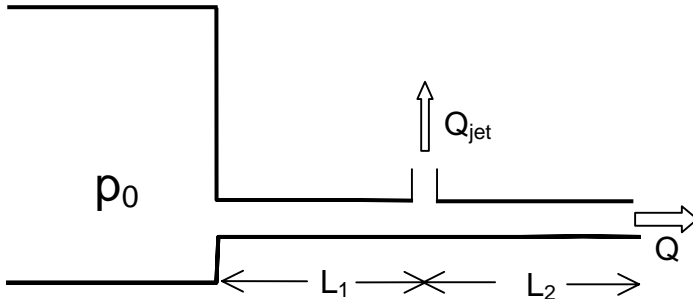


Comprehensive Exam, Example 2
CE100

During construction of the CITRIS building, a water main was broken, leading to a jet of water into the air (that eventually flooded O'Brien Hall). Consider an analog for this system where a chamber under pressure $p_0 = 200$ kPa discharges into a pipe (1 meter diameter, roughness coefficient $f = 0.01$) that discharges volume flow Q to the atmosphere as a free jet.



Assume that $L_1 = 500$ m, $L_2 = 1000$ m and the loss coefficient for the junction where the break occurred is 2 (applied just downstream of the junction). Further, assume that the pipe entrance has a loss coefficient of 0.5 and that the velocity of water in the pressurized chamber upstream is approximately zero.

For these conditions, calculate the initial height that the jet of water will reach, immediately after the main is broken. You may assume the water density is 1000 kg/m³.

Equations:

$$\frac{\partial M_{cv}}{\partial t} = \sum_i \rho (\pm V_i A_i)$$

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_p = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + h_p + h_L$$

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

$$\sum \vec{F} = \frac{\partial}{\partial t} \int_{cv} \rho \vec{v} dV + \sum_i \rho \vec{v} (\pm V_i A_i)$$

$$Q = \frac{1}{n} A R_h^{2/3} S_0^{1/2}$$

$$h_f = f \frac{L V^2}{D 2g} + \sum K \frac{V^2}{2g}$$