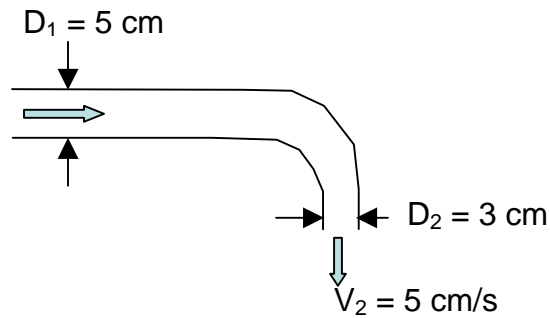


Comprehensive Exam, Example 1
CE100

Steady flow in a pipe encounters a horizontal bend as shown in the following diagram:



The pipe upstream of the bend has a diameter of 5 cm; downstream of the bend, the flow emerges as a free jet with a diameter of 3 cm and a velocity of 5 cm/s.

Assuming no headloss in the bend, calculate the force that the flow exerts on the bend.

Equations:

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

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

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

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

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

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