# Example: Fire Hose with a Bend

Building on the analysis of a simple nozzle we consider the application of the momentum theorem to a fire hose with a $90^o$ bend and a nozzle as sketched in Figure 1. For simplicity, it is assumed that the velocity magnitudes, $q_1$ and $q_2$, are uniform across the inlet area, $A_1$, and the jet area, $A_2$, respectively. The fluid is incompressible with density $\rho$ and viscous losses within the hose and the nozzle are negligible as are the effects of gravity. We wish to evaluate the forces $F_1^*$ and $F_2^*$ required to hold the structure in place as shown in the figure.

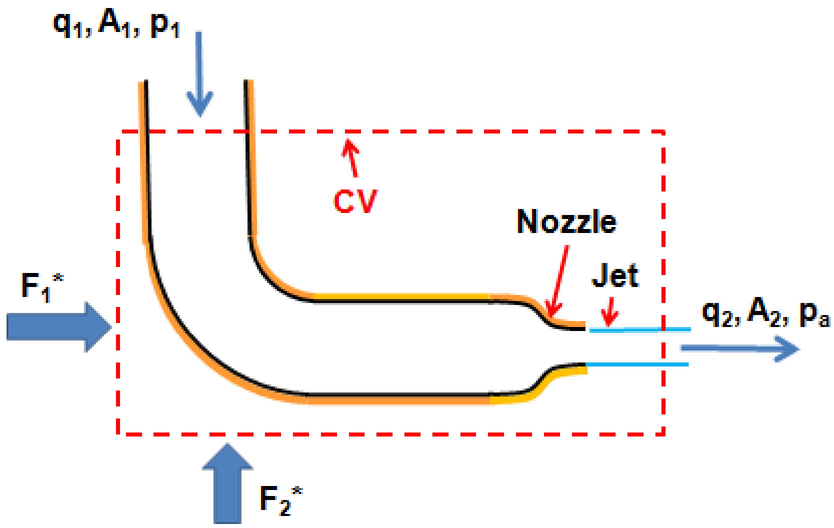


Figure 1: A fire hose with bend and nozzle.

It follows from the linear momentum theorem that the force, $F_1^*$, that must be applied to the structure to hold it in place is

$$F_1^* = mq_2 = \rho A_2 q_2^2 \tag{Bed1}$$

and the force, $F_2^*$, is

$$F_2^* = -m(-q_1) + A_1(p_1 - p_a) \tag{Bed2}$$

Making use of continuity and the Bernoulli equation for incompressible, inviscid flow these can be written as

$$F_1^* = \rho A_2 q_2^2 \quad \text{and} \quad F_2^* = \frac{\rho q_2^2 (A_1^2 + A_2^2)}{2A_1} \tag{Bed3}$$

or in terms of the pressure difference

$$F_1^* = \frac{2A_1^2 A_2 (p_1 - p_a)}{(A_1^2 - A_2^2)} \quad \text{and} \quad F_2^* = \frac{A_1(A_1^2 + A_2^2)(p_1 - p_a)}{(A_1^2 - A_2^2)} \tag{Bed4}$$

The force $F_1^*$ is intuitively obvious and will need to be supplied by a structural brace at the bend that is not shown; the force $F_2^*$ will be the force that could be transmitted through the structure of the inlet hose at the top of the sketch.