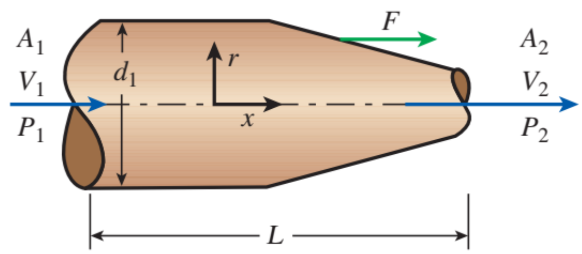
7–113 Experiments are being designed to measure the horizontal force F on a fireman's nozzle, as shown in Fig. P7–113. Force F is a function of velocity V_1, pressure drop $\Delta P = P_1 - P_2$, density ρ, viscosity μ, inlet area A_1, outlet area A_2, and length L. Perform a dimensional analysis for $F = f(V_1, \Delta P, \rho, \mu, A_1, A_2, L)$. For consistency, use V_1, A_1, and ρ as the repeating parameters and generate a dimensionless relationship. Identify any established nondimensional parameters that appear in your result.



114-

The pressure drop, Δp, for steady, incompressible viscous flow through a straight horizontal pipe depends on the pipe length, l, the average velocity, $\overline{V}$, the fluid viscosity, μ, the pipe diameter, D, the fluid density, ρ, and the average "roughness" height, e. Determine a set of dimensionless groups that can be used to correlate data.

Given: $\Delta p = f(\rho, \overline{V}, D, l, \mu, e)$ for flow in a circular pipe.

Find: A suitable set of dimensionless groups.

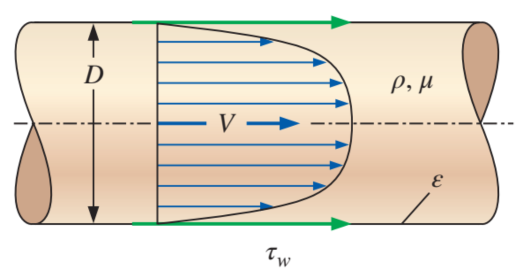
115-

When a small tube is dipped into a pool of liquid, surface tension causes a meniscus to form at the free surface, which is elevated or depressed depending on the contact angle at the liquid–solid–gas interface. Experiments indicate that the magnitude of this capillary effect, Δh, is a function of the tube diameter, D, liquid specific weight, γ, and surface tension, σ. Determine the number of independent Π parameters that can be formed and obtain a set.

Given: $\Delta h = f(D, \gamma, \sigma)$

116-

Consider flow of an incompressible fluid of density ρ and viscosity μ through a long, horizontal section of round pipe of diameter D. The velocity profile is sketched in Fig. 7–34; V is the average speed across the pipe cross section, which by conservation of mass remains constant down the pipe. For a very long pipe, the flow eventually becomes hydrodynamically **fully developed**, which means that the velocity profile also remains uniform down the pipe. Because of frictional forces between the fluid and the pipe wall, there exists a shear stress τ_w on the inside pipe wall as sketched. The shear stress is also constant down the pipe in the fully developed region. We assume some constant average roughness height ε along the inside wall of the pipe. In fact, the only parameter that is *not* constant down the length of pipe is the pressure, which must decrease (linearly) down the pipe in order to "push" the fluid through the pipe to overcome friction. Develop a nondimensional relationship between shear stress τ_w and the other parameters in the problem.



List of relevant parameters: $\tau_w = f(V, \varepsilon, \rho, \mu, D)$