6.75 You wish to water your garden with 100 ft of $\frac{5}{8}$-in-diameter hose whose roughness is 0.011 in. What will be the delivery, in ft^3/s, if the gage pressure at the faucet is 60 lbf/in^2? If there is no nozzle (just an open hose exit), what is the maximum horizontal distance the exit jet will carry?

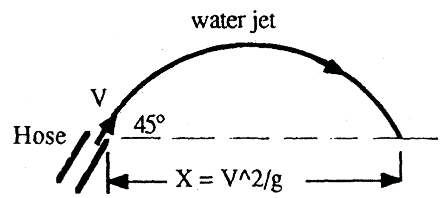

Fig. P6.75

Solution: For water, take $\rho = 1.94$ slug/ft^3 and $\mu = 2.09E{-}5$ slug/ft·s. We are given $\varepsilon/d = 0.011/(5/8) \approx 0.0176$. For constant area hose, $V_1 = V_2$ and energy yields

$$\frac{p_{faucet}}{\rho g} = h_f, \quad \text{or:} \quad \frac{60 \times 144 \text{ psf}}{1.94(32.2)} = 138 \text{ ft} = f\frac{L}{d}\frac{V^2}{2g} = f\frac{100}{(5/8)/12}\frac{V^2}{2(32.2)},$$

$$\text{or} \quad fV^2 \approx 4.64. \quad \text{Guess} \quad f \approx f_{\text{fully rough}} = 0.0463, \quad V \approx 10.0 \frac{ft}{s}, \quad Re \approx 48400$$

$$\text{then} \quad f_{better} \approx 0.0472, \quad V_{final} \approx \mathbf{9.91\ ft/s} \text{ (converged)}$$

The hose delivery then is $Q = (\pi/4)(5/8/12)^2(9.91) = \mathbf{0.0211\ ft^3/s}$. *Ans.* (a)

From elementary particle-trajectory theory, the maximum horizontal distance X travelled by the jet occurs at $\theta = 45°$ (see figure) and is $\mathbf{X} = V^2/g = (9.91)^2/(32.2) \approx \mathbf{3.05\ ft}$ *Ans.* (b), which is pitiful. You need a *nozzle* on the hose to increase the exit velocity.

6.76 The small turbine in Fig. P6.76 extracts 400 W of power from the water flow. Both pipes are wrought iron. Compute the flow rate Q m^3/h. Sketch the EGL and HGL accurately.

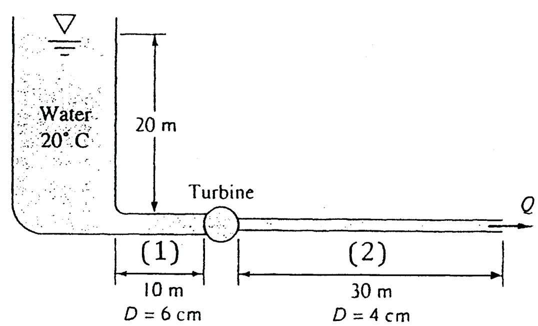

Fig. P6.76

Solution: For water, take $\rho = 998$ kg/m^3 and $\mu = 0.001$ kg/m·s. For wrought iron, take $\varepsilon \approx 0.046$ mm, hence $\varepsilon/d_1 = 0.046/60 \approx 0.000767$ and $\varepsilon/d_2 = 0.046/40 \approx 0.00115$. The energy equation, with $V_1 \approx 0$ and $p_1 = p_2$, gives

$$z_1 - z_2 = 20 \text{ m} = \frac{V_2^2}{2g} + h_{f2} + h_{f1} + h_{turbine}, \quad h_{f1} = f_1\frac{L_1}{d_1}\frac{V_1^2}{2g} \quad \text{and} \quad h_{f2} = f_2\frac{L_2}{d_2}\frac{V_2^2}{2g}$$

$$\text{Also,} \quad h_{turbine} = \frac{P}{\rho g Q} = \frac{400 \text{ W}}{998(9.81)Q} \quad \text{and} \quad Q = \frac{\pi}{4}d_1^2V_1 = \frac{\pi}{4}d_2^2V_2$$