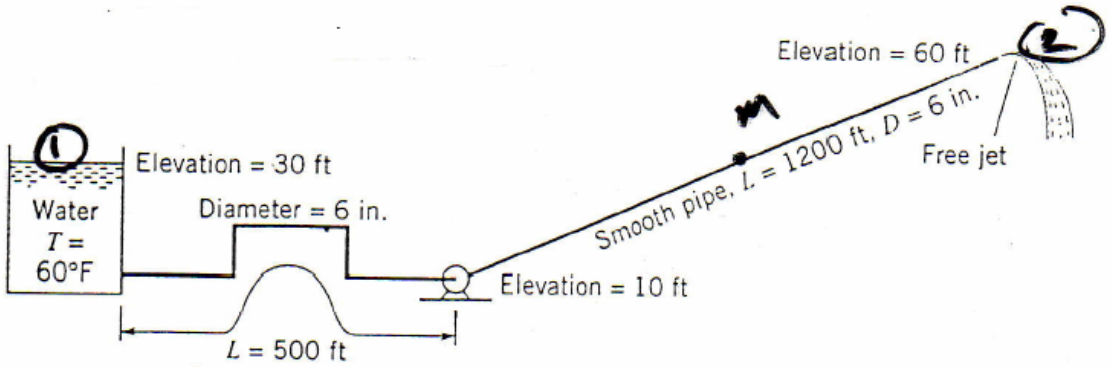
10.95 If the flowrate through the system shown is 2.0 cfs, what horsepower is the pump supplying to the water? Draw the HGL and the EGL for the system, and determine the water pressure at the midpoint of the long pipe. The four bends have a radius of 12 in., and the 6-in. pipe is smooth.



Solution:

Reservoir to exit ($z = 0$ exit)

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

$$z_1 + h_p = \frac{V_2^2}{2g} + z_2 + f\frac{L}{D}\frac{V_2^2}{2g} + h_e + 4h_b$$

$$z_1 + h_p = z_2 + \frac{V_2^2}{2g}\left(1 + K_e + 4K_b + f\frac{L}{D}\right)$$

$$V = \frac{Q}{A} = \frac{2}{\frac{\pi}{4}\times 0.5^2} = 10.18\ ft/s \Rightarrow \frac{V^2}{2g} = 1.611\ ft$$

$$K_e = 0.5, \quad K_b = K_b\left(r/D\right) = K_b\left(12/6 = 2\right) = 0.19$$

$$\text{Re} = \frac{4Q}{\pi D\nu} = \frac{4\times 2}{\pi \times 0.5 \times 1.22\times 10^{-5}} = 4.17\times 10^5$$

i.e., $f = 0.0135$, Moody Diagram, $f\left(\frac{k_s}{D} = 0, \mathrm{Re}\right)$

$$h_p = 30 + 1.611 \times \left(1 + 0.5 + 4 \times 0.19 + 0.0135 \frac{1700}{0.5}\right) = 107.6\, ft$$

$$p = Q\gamma h_p / 550 = 24.4 hp$$

$$\frac{p_m}{\gamma} + \frac{V_m^2}{2g} + z_m = \frac{V_2^2}{2g} + z_2 + f\frac{L}{D}\frac{V^2}{2g}$$

$$p_m = 62.4 \times \left(60 - 35 + 0.0135 \times \frac{600}{0.5} \times 1.61\right) = 3189\, psf = 22.1 psi$$