Solution to Problem 274A

The pipe has an internal diameter $d = 5\ cm$, flow rate $Q = 0.05\ m^3/s$ and roughness ranging from $\epsilon = 0.05\ mm$ to $\epsilon = 1.0\ mm$. Water has a kinematic viscosity of $\nu = 10^{-6}\ m^s/s$ The average velocity of flow through the pipe,

$$U = \frac{Q}{\pi(d/2)^2} = \frac{0.05\ m^3/s}{\pi(0.025\ m)^2} = 25.5\ m/s \tag{1}$$

The Reynolds number of the flow is

$$\text{Re} = \frac{dU}{\nu} = \frac{(0.05\ m)(25.5\ m/s)}{10^{-6}\ m^s/s} = 1.27 \times 10^6 \tag{2}$$

The relative roughness of the new pipe

$$\frac{\epsilon}{d} = \frac{5 \times 10^{-5}\ m}{0.05\ m} = 0.001 \tag{3}$$

From the Moody friction factor chart at $\frac{\epsilon}{d} = 0.001$ and $\text{Re} = 1.27 \times 10^6$, the friction factor $f = 0.02$
The relative roughness of the old pipe

$$\frac{\epsilon}{d} = \frac{0.001\ m}{0.05\ m} = 0.02 \tag{4}$$

From the Moody friction factor chart at $\frac{\epsilon}{d} = 0.02$ and $\text{Re} = 1.27 \times 10^6$, the friction factor $f \approx 0.048$
Since the pressure difference is linearly related to the friction factor,

$$\frac{p_{\text{old}}}{p_{\text{new}}} = \frac{0.048}{0.02} = 2.4 \tag{5}$$