Given: Pipe diameter: $D = 3.175 \cdot 10^{-3}$ m

fluid flow rate $= 8.4 \cdot 10^{-6}$ L/s

$L = 12.19$ m

$\rho = 1000$ kg/m^3

$z = 1.83$ m

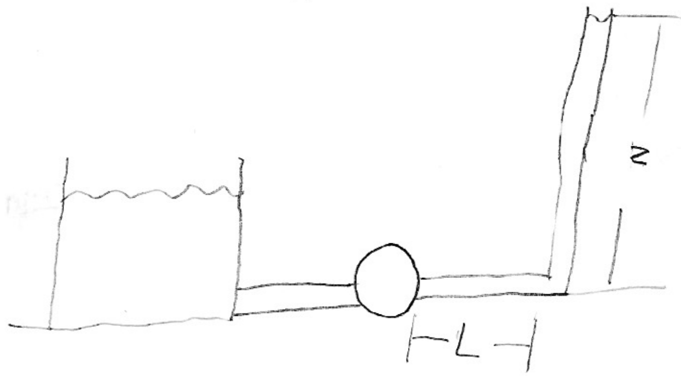
$\mu = 1 \cdot 10^{-3}$ kg/m·s

$\nu = 1 \cdot 10^{-6}$ m^2/s

$g = 9.81$ m/s^2

Find: Required pump head (h_p)

Schematic:



Assumptions:

Incompressible fluids

Uniform, fully developed, and steady flow

Pipe is a straight line with no joints or fittings

To function, hp must be greater than or equal to the total head losses of the system

$$h_p = \cancel{h_{L_{minor}}}^{0} + h_{L_{major}} + z$$

$$h_p = 4.185 \cdot 10^{-7} m + 1.83 m$$

$$h_p = 1.830000419$$

$$h_{major} = f \frac{L}{D} \frac{\bar{V}^2}{2g}$$

$$= .19 \frac{12.19}{3.175 \cdot 10^{-3}} \cdot \frac{(1.06 \cdot 10^{-4})^2}{2 \cdot 9.81}$$

$$h_{major} = 4.185 \cdot 10^{-7} m$$

$$Re = \frac{\rho Q D}{\mu A}$$

$$= \frac{1000(8.4 \cdot 10^{-7})(3}{(1 \cdot 10^{-3})(\pi \cdot 1.58}$$

$$Re = 336.85$$

Flow is Laminar

Poiseuille's Law

$$f = \frac{64}{Re} = \frac{64}{336.85} = 0.1$$

$$\bar{V} = \frac{\forall}{A} = \frac{4\forall}{\pi D^2}$$

$$= \frac{4(8.4 \cdot 10^{-7})(\frac{1 m^3}{1000 L})}{\pi (3.175 \cdot 10^{-3})^2}$$

$$\bar{V} = 1.06 \cdot 10^{-4} m/s$$