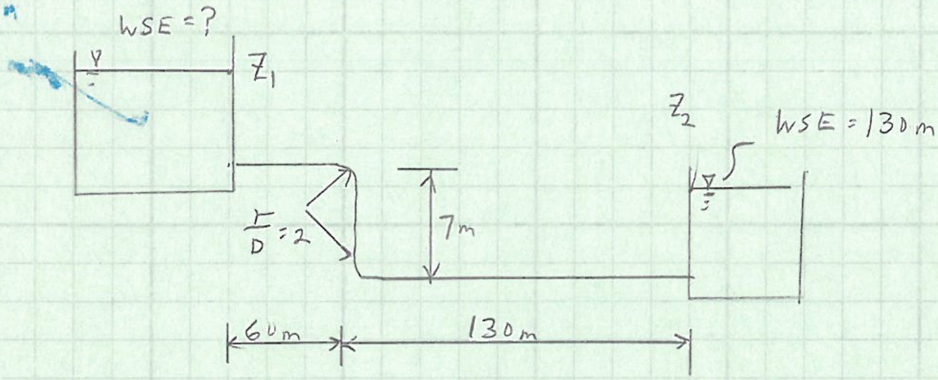
If oil ($\nu = 4 \times 10^{-5}$ m²/sec, S = 0.9) flows from the upper to the lower reservoir @ a rate of Q = 0.028 m³/sec in the 15-cm smooth pipe, what is the elevation of the oil surface in the upper reservoir



Bernoulli's Equ.

$$\frac{V_1^2}{2g} + \frac{p_1}{\gamma} + z_1 = \frac{V_2^2}{2g} + \frac{p_2}{\gamma} + z_2 + h_L$$

0 0 0 0

$$z_1 = z_2 + h_L$$

$$h_L = \underbrace{h_f}_{\text{friction}} + \underbrace{h_{b1} + h_{b2}}_{\text{bends}} + \underbrace{h_e}_{\text{entrance}} + \underbrace{h_E}_{\text{outlet}}$$

$$h_f = f\left(\frac{L}{D}\right)\frac{V^2}{2g} \qquad Vel = \frac{Q}{A} = \frac{0.028\ m^3/sec}{\pi (0.075m)^2} = 1.58\ m/sec$$

$$R_e = \frac{VD}{\nu} = \frac{(1.58)(0.15)}{4 \times 10^{-5}} = 5925$$

From Fig. 10.8 $f = 0.035$

$$h_f = (0.035)\left(\frac{197m}{0.15m}\right)\left(\frac{1.58^2}{(2)(9.81)}\right) = 5.85\ m$$ ⟸ loss due to friction

2 bends

$$h_b = 2K\frac{V^2}{2g}$$

$$h_b = (2)(0.19)\frac{(1.58)^2}{(2)(9.81)}$$

$h_b = 0.05\,m$ loss due to bends

$$h_e = 0.5\frac{V^2}{2g} = \frac{(0.5)(1.58)^2}{(2)(9.81)}$$

$h_e = 0.06\,m$ loss due to abrupt entrance

$h_E = 1\frac{V^2}{2g} = 0.12\,m$ loss due to abrupt outlet

Total $h_L = 5.85 + 0.05 + 0.06 + 0.12 = 6.08$

$$z_1 = z_2 + h_L$$

$$= 130\,m + 6.08$$

$$\boxed{z_1 = 136.1\,m}$$

If h_L other than h_f were neglected answer would be 135.9 m

$\frac{5.85}{6.08} = 96\%$ ⇐ friction accounted for 96% of head loss