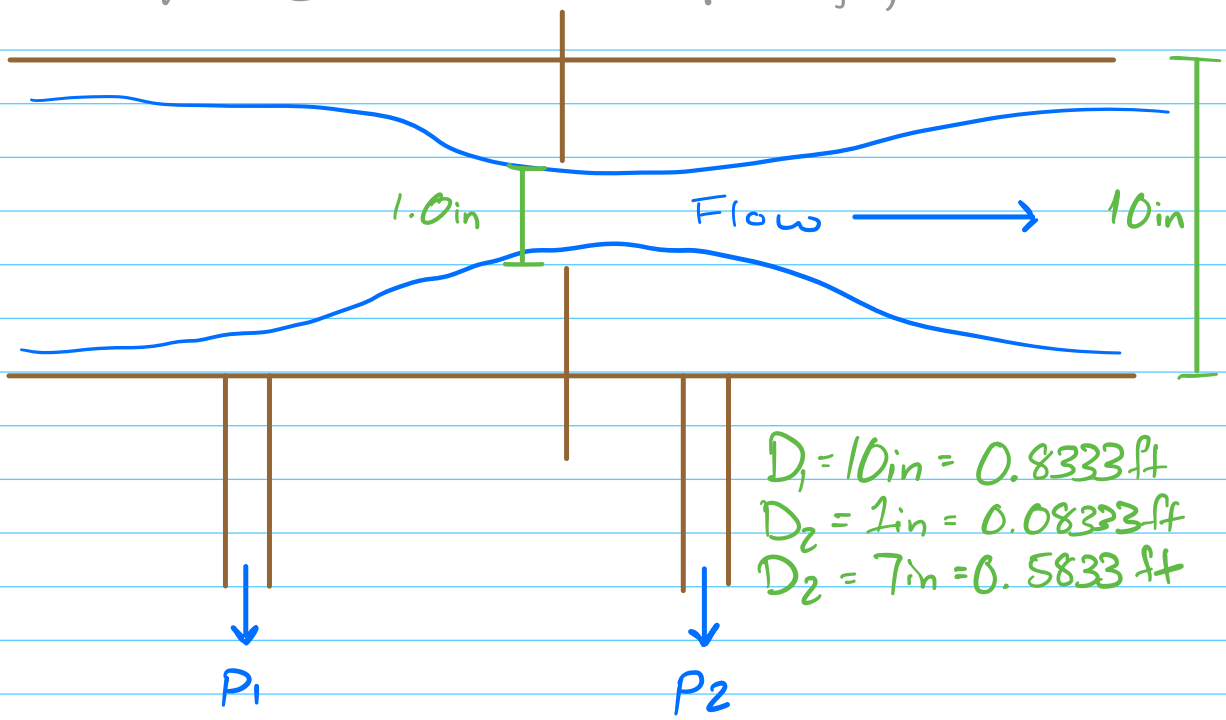
Tyler Crouse 10/22/24

Homework 2.4 [4,9,15]

Question 4



$D_1 = 10in = 0.8333ft$
$D_2 = 1in = 0.08333ft$
$D_2 = 7in = 0.5833ft$

$Q = 25gal/min = 0.0557002\ ft^3/s$

$\rho = 0.83 \quad \nu = 2.5 \times 10^{-6}\ lbs/ft^2$

$$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4}(0.8333ft)^2 = 0.5454153912ft^2$$

$$Q = A_2 \sqrt{\frac{2(P_1 - P_2)}{\rho\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}}$$

1in | $A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4}(0.08333ft)^2 = 0.005454158 9ft^2$

$A_2/A_1 = 0.005\ldots ft^2 / 0.5\ldots ft^2 = 0.01$

7in | $A_2 = \frac{\pi}{4}(0.5833ft)^2 = 0.2672535417ft^2$

$A_2/A_1 = 0.2\ldots ft^2 / 0.5\ldots ft^2 = 0.49$

$$\frac{P_1 - P_2}{\rho g} = h \Rightarrow \frac{P_1 - P_2}{\rho} = gh$$

$$Q = A_2 \sqrt{\frac{2(P_1 - P_2)}{\rho\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}} = A_2 \sqrt{\frac{2gh}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

1 in

$$h = \frac{\left(\frac{Q}{A_2}\right)^2\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}{2g} = \frac{\left(\frac{0.05\ldots\ ft^3/s}{0.005 ft^2}\right)^2\left(1 - (0.01)^2\right)}{2(32.2\ ft/s^2)}$$

$$h_{NH_3} = 1.619307896\ ft$$

7 in

$$h = \frac{\left(\frac{Q}{A_2}\right)^2\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}{2g} = \frac{\left(\frac{0.05\ldots\ ft^3/s}{0.2\ldots\ ft^2}\right)^2\left(1 - (0.49)^2\right)}{2(32.2\ ft/s^2)}$$

$$h_{NH_3} = 5.125510738 \times 10^{-4}\ ft$$

$$h_{H_2O}\rho_{H_2O} = h_{NH_3}\rho_{NH_3}$$

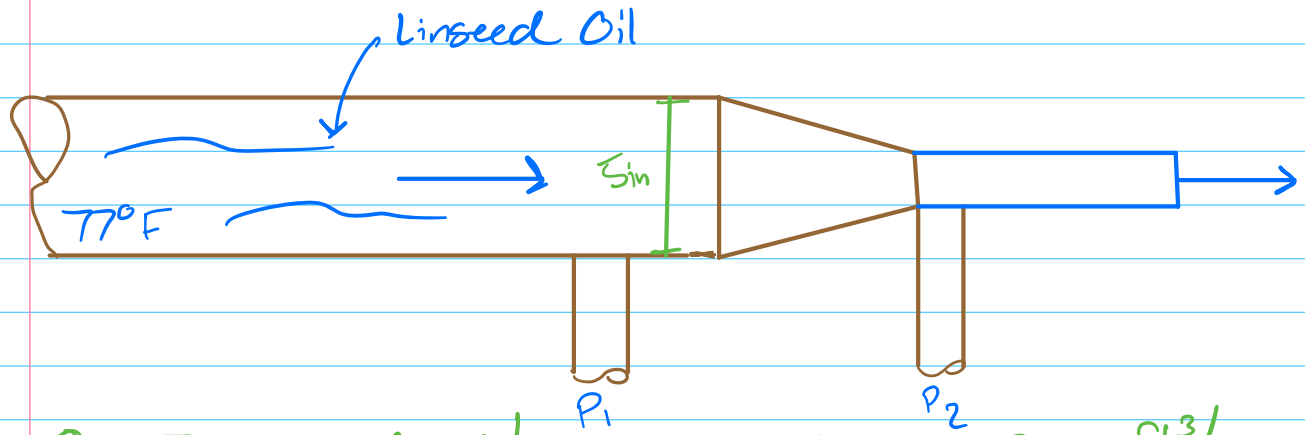
1 in

$$h_{NH_3} = \frac{h_{H_2O}\rho_{H_2O}}{\rho_{NH_3}} = \frac{(1.6\ldots\ ft)(1)}{0.83} = \boxed{1.95\ ft}$$

7 in

$$h_{NH_3} = \frac{(5.1\ldots\ ft)(1)}{0.83} = \boxed{6.18 \times 10^{-4}\ ft}$$

Question 9



$Q = 700 - 1000\ gal/min = 1.55961 - 2.22801\ ft^3/s$

Manometer: 0 - 8 in Hg

Determine diameter of nozzle.

$D_p = 5in = 0.4167ft$

$V_{min} = \frac{Q_{min}}{A}$ $\quad A = \frac{\pi}{4}(0.4167ft)^2 = 0.136353847 8 ft^2$

$V_{min} = \frac{(1.55961\ ft^3/s)}{(0.13...\ ft^2)} = 11.43796105\ ft/s$

Diameter of nozzle D is $4.805in = 0.4004166667ft$

$N_{Rmin} = \frac{V_{min}\ D}{\nu}$ $\quad \nu = 3.84 \times 10^{-4}\ ft^2/s$

$N_{Rmin} = \frac{(11...\ ft/s)(0.4...ft)}{3.841 \times 10^{-4} ft^2/s} = 11926.95374$

$$\frac{d}{D} = \frac{(0.4\ldots ft)}{(6.4\ ft)} = 0.960923126 2$$

$$C_{min} = 0.955$$

$$V_{max} = \frac{Q_{max}}{A} = \frac{(2.2\ldots\ ft^3/s)}{(0.13\ldots ft^2)} = 16.33991292\ ft/s$$

$$N_{Rmax} = \frac{V_{max} D}{\nu} = \frac{(16\ldots\ ft/s)(0.4\ldots\ ft)}{(3.84\times10^{-4}\ ft^2/s)}$$

$$N_{Rmax} = 17020.74263$$

$$C_{max} = 0.961$$

$$V_{max} = C_{max}\sqrt{\frac{2gh\left(\frac{\gamma_m}{\gamma_w} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$A_1 = \frac{A_2}{\sqrt{\frac{2gh\left(\frac{\gamma_w}{\gamma_w}\right)(C_{max})^2}{V_{max}^2} + 1}}$$

$$A_1 = \frac{0.13\ldots ft^2}{\sqrt{\frac{2(32.2)(0.667)\left(\frac{844.9}{58}\right)(0.96[)^2}{16\ldots\ ft/s}} =}$$

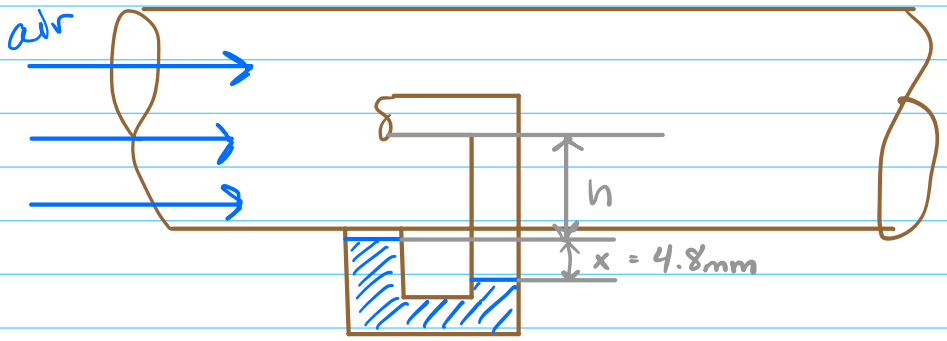
$$A_1 = 0.022928434 4 ft^2$$

$$A_1 = \frac{\pi}{4} D^2$$

$$D = \sqrt{A_1 \left(\frac{4}{\pi}\right)}$$

$$D = 0.170860730\,\text{ft} = \boxed{2.05\,\text{in}}$$

Question 15



$T = 50°C = 323K$

$P = P_{atm} = 101.325kPa$

$$V = \sqrt{2gh} \qquad h = x\left(\frac{\rho_m}{\rho} - 1\right)$$

$$\rho_m = \frac{\rho_{H_2O}}{\rho_{H_2O}} = 1 \qquad \rho = \frac{\rho_{air}}{\rho_{H_2O}} = \qquad R = 287.05\ J/kgK$$

$$P = \rho RT \Rightarrow \rho_{air} = \frac{P}{RT} = \frac{(101.325\times10^3)}{(287.05)(323)}$$

$$\rho_{air} = 1.092\ kg/m^3$$

$$h = 4.8\left(\frac{1000}{1.092} - 1\right) = 4390.804396mm$$

$$h = 4.390804396m$$

$$V = \sqrt{2(9.81)(4.390804396)} = 9.28\ m/s$$