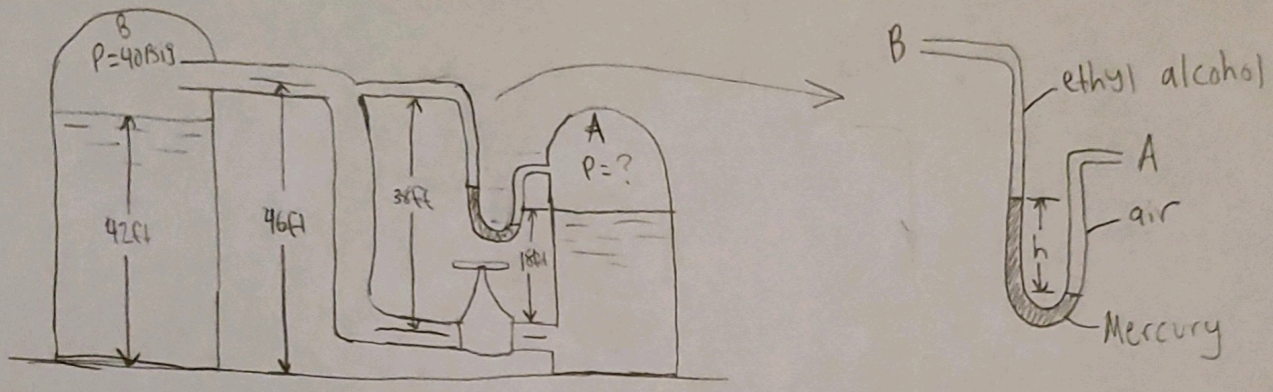
Purpose:

The purpose of this test is to find air pressure with different flow rates, as well as finding the manometer readings.

Drawings & diagrams:



Sources:

Applied Fluid Mechanics, 7th edition, Robert L Mott & Joseph Untener
Pearson Education

Design considerations:

- $T = 77°F$
- Incompressible fluids

Datal & Variables:

- $\gamma_{ethyl\ alcohol} = 49.01\ lb/ft^3$
- $\gamma_{mercury} = 844.9\ lb/ft^3$
- $Q = 250\ gpm \rightarrow Q = 0.557\ ft^3/s$
- $A_{Pipe} = 0.02333\ ft$
- $P_B = 40\ Psi \rightarrow P_B = 5760\ lb/ft^2$
- $h_1 = 38ft$
- $h_2 = 18ft$

Procedure:

I start with Bernoulli's equation and manipulate it to work for this problem. I plugged in Q/A into both v^2's. I then rearrange the equation to solve for P_A and plug in all the numbers. I ended up getting 52.83 psi for P_A. I then solve for manometer reading (h). I start with the $P=\gamma h$ equation and manipulate it to work for this problem. I plug in the numbers and solve for h. I ended up getting 2.32 ft. onto the next problem, I started with Bernoulli's equation and canceled out the velocities due to flow. I plugged in the numbers and solved for P_A and got 46.81 psi. For the last problem, I used the same equation from the first problem and put it in excel. I then plugged in multiple different flow rates and created a plot from that. Using the plot, I found the flow rate when the air pressure is 75 psi. I got 538 gpm.

Calculations:

1. $\frac{P_A}{\gamma_{ea}} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma_{ea}} + \frac{V_B^2}{2g} + Z_B \rightarrow \frac{P_A}{\gamma_{ea}} + \frac{1}{2g}\left(\frac{Q_A}{A_A}\right)^2 + Z_A = \frac{P_B}{\gamma_{ea}} + \frac{1}{2g}\left(\frac{Q_B}{A_B}\right)^2 + Z_B$

↳ $\frac{P_A - P_B}{\gamma_{ea}} + (Z_A - Z_B) = \frac{1}{2g}\left(\frac{1}{A_B^2} + \frac{1}{A_A^2}\right)Q^2$

↳ $\frac{P_A}{49.01\ lb/ft^3} - \frac{5760\ lb/ft^2}{49.01\ lb/ft^3} + (18-38\ ft) = \frac{1}{2(32.2\ ft/s^2)}\left(\frac{1}{(0.02333\ ft^2)^2} + \frac{1}{(0.02333\ ft^2)^2}\right)(0.557\ ft^3/s)^2$

↳ $P_A = \left[\left(\frac{(0.557\ ft^3/s)^2}{2(32.2\ ft/s^2)}\right)\left(\frac{1}{(0.02333\ ft^2)^2} + \frac{1}{(0.02333\ ft^2)^2}\right) - (18-38) + \left(\frac{5760\ lb/ft^2}{49.01\ lb/ft^3}\right)\right] \times 49.01\ lb/ft^3$

$P_A = 7607.78\ lb/ft^2$ or $52.83\ psi$

$P = \gamma h \rightarrow P_A + \gamma_m h = P_B + \gamma_{ea} h \rightarrow P_A - P_B = \gamma_m h - \gamma_{ea} h$

↳ $P_A - P_B = h(\gamma_m - \gamma_{ea}) \rightarrow 7607.78\ lb/ft^2 - 5760\ lb/ft^2 = h(844.9 - 49.01\ lb/ft^3)$

$h = 1847.78/795.89 \rightarrow h = 2.32\ ft$

2. $\frac{P_A}{\gamma_{ea}} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma_{ea}} + \frac{V_B^2}{2g} + Z_B$

↳ $\frac{P_A}{\gamma_{ea}} + Z_A = \frac{P_B}{\gamma_{ea}} + Z_B \rightarrow \frac{P_A}{\gamma_{ea}} = \frac{P_B}{\gamma_{ea}} + Z_B - Z_A$

↳ $\frac{P_A}{49.01\ lb/ft^3} = \frac{5760\ lb/ft^2}{49.01\ lb/ft^3} + 38 - 18 \rightarrow \frac{P_A}{49.01\ lb/ft^3} = 137.53$

↳ $P_A = 6740.2\ lb/ft^2$ or $46.81\ PSi$

$P_A - P_B = h(\gamma_m - \gamma_{ea})$

$6740.2 - 5760 = h(844.9 - 49.01)$

$h = 1.23\ ft$

3. After Plugging in several flow rates and plotting them and their Pressure's, I found the flow rate is about $1.2\ ft^3/s$ or $538\ gpm$ at 75 Psi.

Summary:

- The Pressure at the right tank must be 52.83 Psi in order to deliver 250 gpm. The manometer reading is 2.32 ft.
- The Pressure at the right tank is 46.81 Psi when there is no flow. The manometer reading is 1.23 ft.
- The flow rate at 75 Psi is about 538 gpm

Materials:

- Mercury
- ethyl alcohol

Analysis:

There are multiple ways to calculate Pressure, but in order to find pressure, it is important to know h & γ.