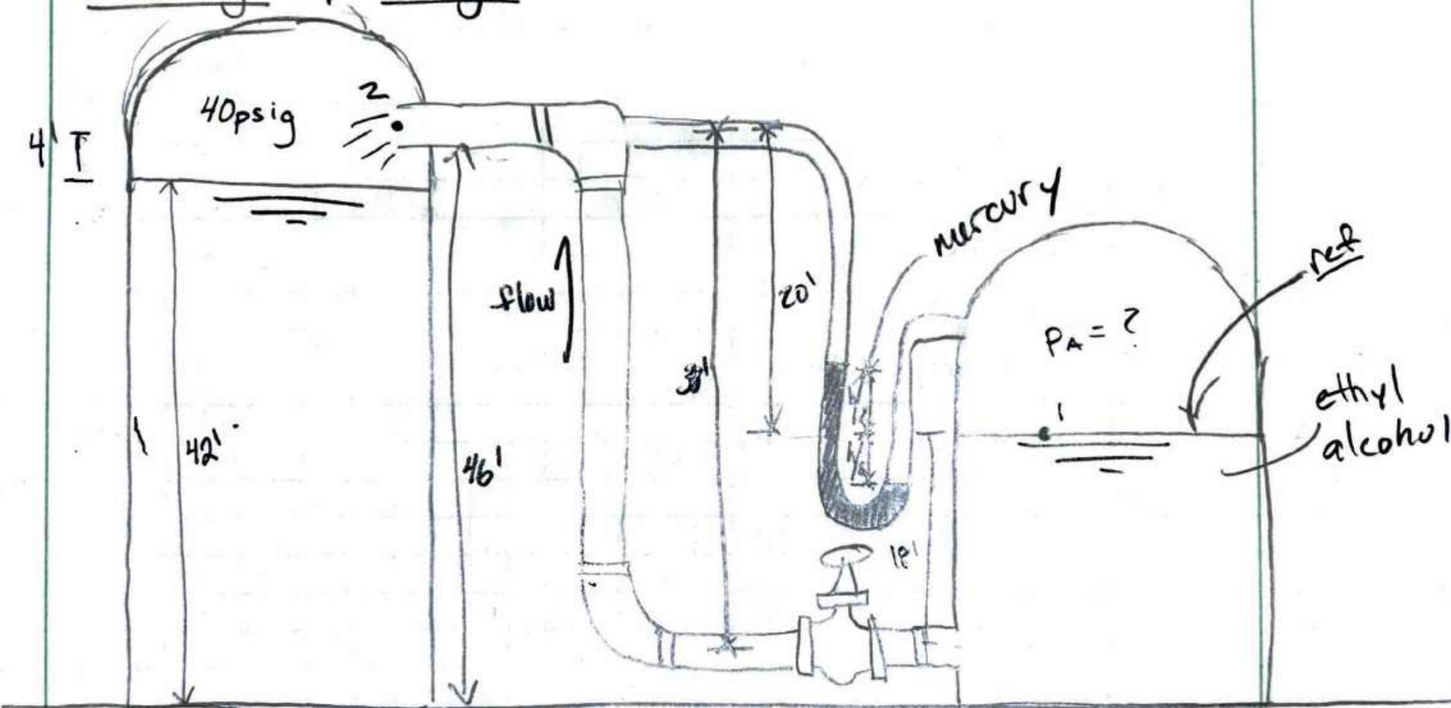
Problem 1 | Test 1 | Noel Tulensru

① Purpose:

Determine the pressure of the tank on the right and the manometer reading.

② Drawings & Design



③ Sources

- Mott, R., Untener, J.A., "Applied Fluid Mechanics", Eighth edition Pearson Education, Inc.
- Ayala, Orland, MET 330 Modules

④ Design Considerations

- T = 77 F
- Elbows ar standard
- Pressurized air

Problem 1 | Test 1 | Noel T

⑤ Data & Variables

$\gamma_{eth} = 49.01\ lb/ft^3$

$\gamma_{HG} = 844.9\ lb/ft^3$

$D = 0.1723\ ft$

$Q = 250\ gpm$

$A = 0.02333\ ft^2$

$P_2 = 40\ psig$

$\varepsilon = 1.5\times10^{-4}\ ft$

$\nu = 1.37\times10^{-5}\ ft^2/s$

⑥ Procedure

I will first use Reynolds equation to see if the stream is laminar or turbulent flow. Then I will find the friction factor for the pipe, elbow's, and valve. Using this I will solve for energy loss and plug that into Bernoulli's equation. I will then solve for P_1 using Bernoulli's. With the pressure I found using Bernoulli's, I will plug that into the manometer equation to solve for h.

⑦ Calculations

$$P_B + \gamma_{eth}(38 - 18 - h/2) + \gamma_{HG} h = P_A$$

$$\frac{P_1}{\gamma} + \cancel{\frac{V_1^2}{2g}}^{\,0} + \cancel{z_1}^{\,0} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$V = \frac{Q}{A} = \frac{250\ gpm}{0.0233\ ft^2}\left(\frac{1\ min}{60\ s}\right)\left(\frac{1\ ft^3}{7.48\ gal}\right)$$

$V = 23.9\ ft/s$

$$Re = \frac{VD}{\nu} = \frac{(23.9\ ft/s)(0.1723\ ft)}{(1.37\times10^{-5}\ ft^2/s)}$$

$Re = 300,204$

turbulent

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$$\frac{D}{\varepsilon} = \frac{0.1723\ ft}{(1.5 \times 10^{-4}\ ft)} = 1148.67$$

Pipe

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(1148.67)} + \frac{5.74}{(300{,}204)^{0.9}}\right)\right]^2}$$

$$f = 0.02$$

Elbow

$$f_T = \frac{1}{\left[\log\left(\frac{1}{3.7(1148.67)}\right)\right]^2}$$

$$f_T = 0.019$$

$$K_E = 30 f_T$$
$$K_E = 30(0.019)$$
$$K_E = 0.57$$

Valve

$$K_V = 8 f_T$$
$$K_V = 8(0.019)$$
$$K_V = 0.152$$

$$L = (36 + 38 + 36\ ft) = 110\ ft$$

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + 2\left(K_E \frac{V^2}{2g}\right) + K_V \frac{V^2}{2g}$$

$$h_L = 0.02\left(\frac{110\ ft}{0.1723\ ft}\right)\left(\frac{(23.9\ ft/s)^2}{2(32.2\ ft/s^2)}\right) + 2\left(0.57\frac{(23.9\ ft/s)^2}{2(32.2\ ft/s^2)}\right) + 0.152\left(\frac{(23.9)^2}{2(32.2)}\right)$$

$$h_L = 113 + 10.08 + 1.34$$

$$h_L = 124.42\ ft$$

$$P_1 = \left(\frac{40\ psig}{49.01\ lb/ft^3}\left(\frac{144\ lb/ft^2}{1\ lb/in^2}\right) + \frac{(23.9\ ft/s)^2}{2(32.2\ ft/s^2)} + 20\ ft + 124.42\ ft\right) 49.01\ lb/ft^3$$

$$\boxed{P_1 = 13{,}271.64\ lb/ft^2 \text{ or } 92.2\ psig}$$

Problem 1	Test 1	Noel T

$$P_B + \gamma_{eth}(20 - h/2) + \gamma_{Hg} h = P_A$$

$$\Rightarrow 5760\ lb/ft^2 + 49.01\ lb/ft^3 (20ft - h/2) + (844.9\ lb/ft^3)h = 13,271.64\ lb/ft^2$$

$$\Rightarrow 980.2\ lb/ft^2 - (24.505\ lb/ft^3)h + (844.9\ lb/ft^3)h = 7,511.64\ lb/ft^2$$

$$(820.4\ lb/ft^3)h = 6531.44\ lb/ft^2$$

$$h = 7.9\ ft$$

(8) Summary

The pressure in the tank on the right is 92.2 psig and the manometer reading is 7.9 ft.

(9) Materials

- Ethyl alcohol
- Mercury
- Schedule 40 2-in steel

(10) Analysis

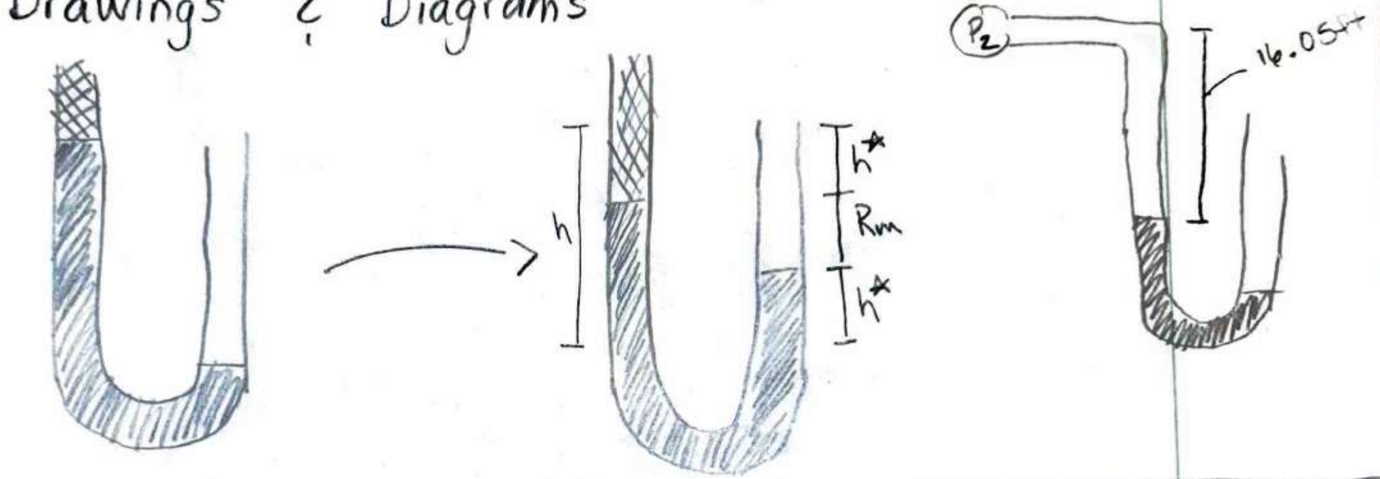
The pressurized air in the tank on the right allows the liquid to flow in the other tank and gives us a high manomatur reading.

Problem 2 | Test 1 | Noel T

① Purpose:

Determine the pressure of the tank and the manometer reading when the flow of ethyl alcohol stops.

② Drawings & Diagrams



③ Sources:

- Mott, R., Untener, J.A., "Applied Fluid Mechanics", Eighth edition Pearson Education, Inc.
- Ayala, Orlando, MET 330 Modules

④ Design Considerations:

- T = 77°F
- No flow
- Pressurized air

Problem 2	Test 1	Noel T

(5) <u>Data & Variables</u>:

$\gamma_{eth} = 49.01 \ lb/ft^3$ $\gamma_{HG} = 844.9 \ lb/ft^3$

$h = 7.9 \ ft$ $P_2 = 40 \ psig = 5760 \ lb/ft^2$

(6) <u>Procedure</u>:

I will first use Bernoulli's equation to find pressure of the tank on the right. Then I will use that found pressure to solve for the new manometer reading using the manometer equation.

(7) <u>Calculations</u>:

$$\frac{P_1}{\gamma_{eth}} + \cancel{\frac{V_1^2}{2g}}^{\,0} + \cancel{z_1}^{\,0} = \frac{P_2}{\gamma_{eth}} + \cancel{\frac{V_2^2}{2g}}^{\,0} + z_2 + \cancel{h_L}^{\,0}$$

$$P_1 = \left(\frac{P_2}{\gamma_{eth}} + z_2\right)\gamma_{eth}$$

$$P_1 = \left[\left(\frac{5760 \ lb/ft^2}{49.01 \ lb/ft^3}\right) + 20 ft\right] 49.01 \ lb/ft^3$$

$$P_1 = 6740.2 \ lb/ft^2$$

or

$47.8 \ psi$

$$P_B + \gamma_{eth}(16.05ft + h^*) + \gamma_{Hg}(h - 2h^*) = P_A$$

$$R_m = h - 2h^*$$

$$5760\,lb/ft^2 + 49.01\,lb/ft^3(16.05ft + h^*) + 844.9\,lb/ft^3(7.9ft - 2h^*) = 6740.2\,lb/ft^2$$

$$786.61\,lb/ft^2 + (49.01\,lb/ft^3)h^* + 6674.71\,lb/ft^2 - (1689.8\,lb/ft^3)h^* = 980.2\,lb/ft^2$$

$$-(1640.79\,lb/ft^3)h^* = -6481.12\,lb/ft^2$$

$$h^* = 3.95\,ft$$

$$R_m = 7.9 - 2(3.95)$$

$$R_m = 0$$

8 Summary:

The new pressure in the tank is 47.8 psig and with this new pressure the new manometer reading is 0.

9 Materials:

- Ethyl alcohol
- mercury

10 Analysis:

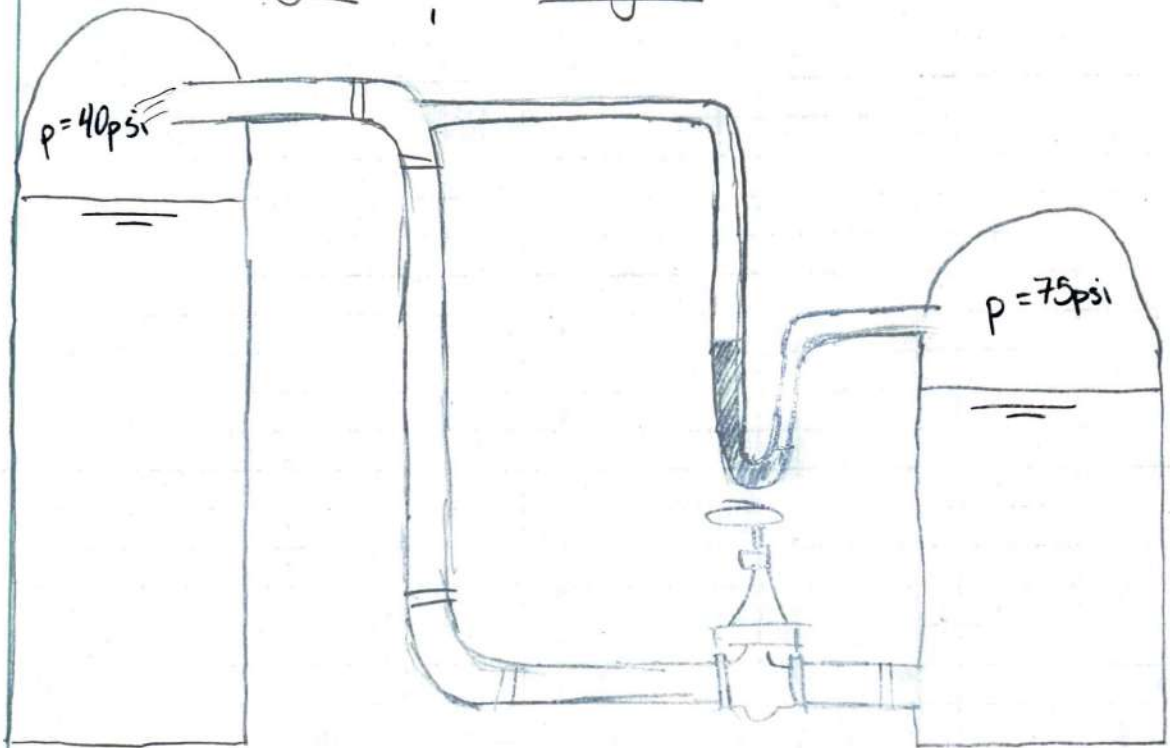
As the pressure in the tank starts to drop so will the manometer reading. And if it gets low enough, as we see it will be 0.

Problem 3	Test 1	Noel T

① Purpose:

Determine the flow rate when the air pressure is 75psi.

② Drawings & Designs



③ Sources:

- Mott, R., Untener, J. A, "Applied Fluid Mechanics", Eighth Edition Pearson Education, Inc.
- Ayala, Orlando, MET 330 Modules

④ Design considerations

- h_L changes
- $T = 77°F$
- $P = 75psi$

Problem 3 | Test 1 | Noel T

⑤ **Data & Variables**

• $\gamma_{eth} = 49.01\ lb/ft^3$ $\gamma_{HG} = 844.9\ lb/ft^3$

$P_2 = 40psi = 5760\ lb/ft^2$ $P_1 = 75psi = 10800\ lb/ft^2$

⑥ **Procedure:**

Using the spreadsheet I created on the first problem I will determine the flow rate at 75 psi by calculating several different flow rates and then plot them versus the different pressures. I will then get a trendline equation from the graph at with that I will be able to solve for flow rate.

⑦ **Calculations**

* calculations done through excel.

↳ $Q = 0.00005P_1 - 0.1039$

$Q = 0.00005(10800) - 0.1039$

$Q = 0.4361\ ft^3/s \left(\frac{60s}{1min}\right)\left(\frac{7.48gal}{1ft^3}\right)$

$Q = 195.72\ gpm$

Problem 3 | Test 1 | Noel T

(8) Summary:

The flow rate when air pressure equals 75psi is 195.72 gpm.

(9) Materials:

- Ethyl Alcohol
- Mecury
- Schedule 40 2- steel

(10) Analysis

As the pressure pushing the ethyl through the pipe decreases, so will the flow rate, and vice versa.