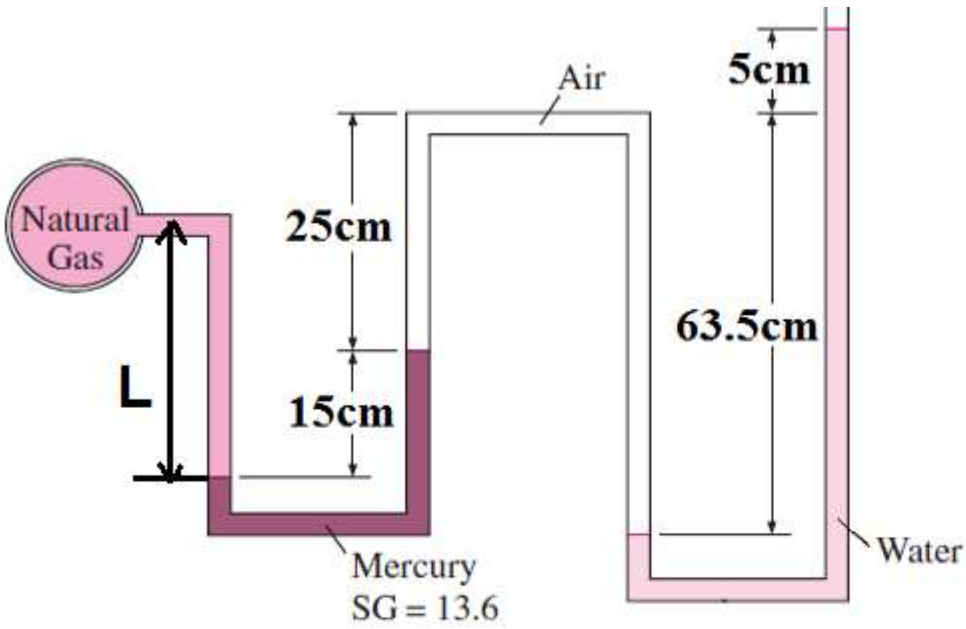
Q33/The pressure in a natural gas pipeline is measured by the manometer shown in Fig. with one of the arms open to the atmosphere where the local atmospheric pressure is 97.9 kPa. a) Determine the absolute pressure in the pipeline. b) Replacing air by oil with a specific gravity of 0.69.



Solution: (hint) the head of Natural Gas (NG) represented by L can be neglected.

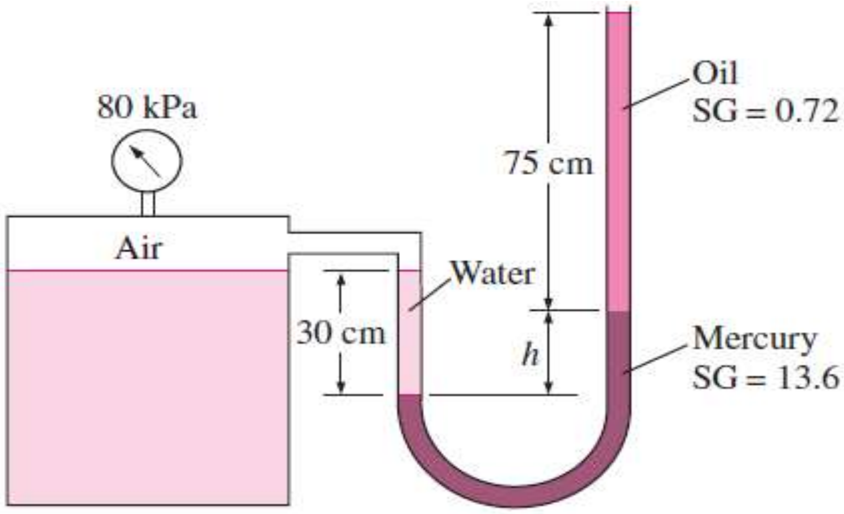
a) $p_{NG} - 13600 * 9.81 * 0.15 - 1.2 * 9.81 * 0.25 + 1.2 * 9.81 * 0.635 - 1000 * 9.81 * (0.635 + 0.05) = 97.9 * 10^{-3}$

(The head of air that represented by 25 cm and 63.5 cm can be neglected) so

$$p_{NG} - 13600 * 9.81 * 0.15 - 1000 * 9.81 * (0.635 + 0.05) = 97.9 * 10^{-3}$$

b) $p_{NG} - 13600 * 9.81 * 0.15 - 690 * 9.81 * 0.25 + 690 * 9.81 * 0.635 - 1000 * 9.81 * (0.635 + 0.05) = 97.9 * 10^{3}$

Q34/The gage pressure of the air in the tank shown in Fig. is measured to be 80 kPa. a) Determine the differential height *h* of the mercury column. b) Repeat for a gage pressure of 40 kPa.



Solution:

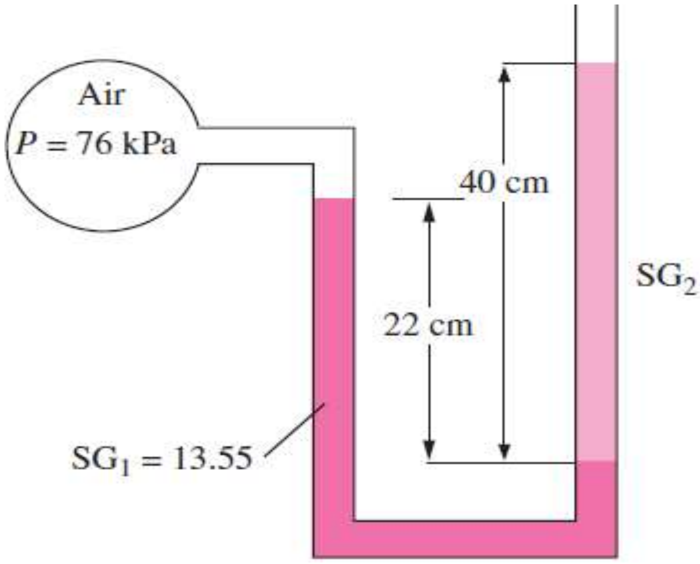
a) $80 * 10^{3} + 1000 * 9.81 * 0.3 - 13600 * 9.81 * h - 720 * 9.81 * 0.75 = 0$

Or

$$(80 * 10^{3} + p_{atm}) + 1000 * 9.81 * 0.3 - 13600 * 9.81 * h - 720 * 9.81 * 0.75 = 0 + p_{atm}$$

b) $40 * 10^{3} + 1000 * 9.81 * 0.3 - 13600 * 9.81 * h - 720 * 9.81 * 0.75 = 0$

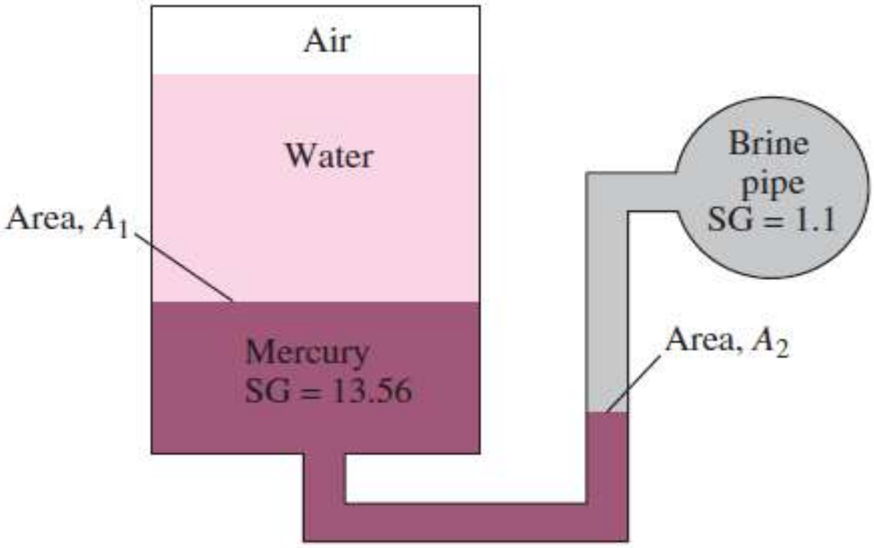
Q36/Consider a double-fluid manometer attached to an air pipe shown in Fig. If the specific gravity of one fluid is 13.55, determine the specific gravity of the other fluid for the indicated absolute pressure of air. Take the atmospheric pressure to be 100 kPa.



Solution:

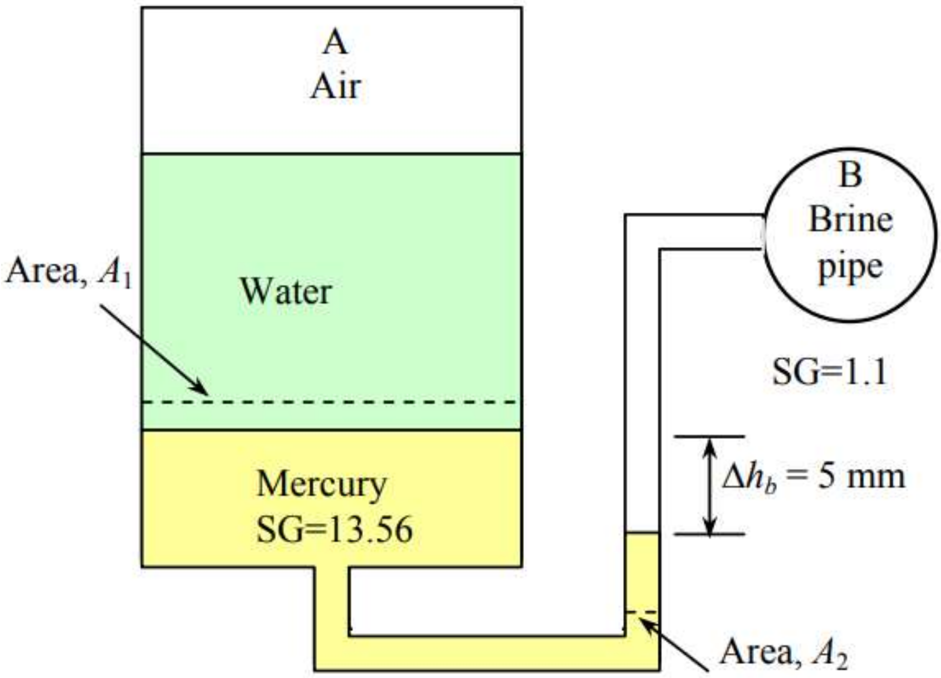
$$76 * 10^3 + 13.55 * 1000 * 9.81 * 0.22 - SG_2 * 1000 * 9.81 * 0.4 = 100 * 10^3$$

Q37/Consider the system shown in Fig. If a change of 0.7 kPa in the pressure of air causes the brine–mercury interface in the right column to drop by 5 mm in the brine level in the right column while the pressure in the brine pipe remains constant, determine the ratio of $A2/A1$



Solution:

It is clear from the problem statement and the figure that the brine pressure is much higher than the air pressure, and when the air pressure drops by 0.7 kPa, the pressure difference between the brine and the air space increases also by the same amount.



Starting with the air pressure (point A) and moving along the tube by adding (as we go down) or subtracting (as we go up) the ρgh terms until we reach the brine pipe (point B), and setting the result equal to P_B before and after the pressure change of air give

Before: $P_{A1} + \rho_w g h_w + \rho_{Hg} g h_{Hg,1} - \rho_{br} g h_{br,1} = P_B$

After: $P_{A2} + \rho_w g h_w + \rho_{Hg} g h_{Hg,2} - \rho_{br} g h_{br,2} = P_B$

Subtracting,

$$P_{A2} - P_{A1} + \rho_{Hg} g \Delta h_{Hg} - \rho_{br} g \Delta h_{br} = 0 \quad \rightarrow \quad \frac{P_{A1} - P_{A2}}{\rho_w g} = SG_{Hg} \Delta h_{Hg} - SG_{br} \Delta h_{br} \qquad (1)$$

where Δh_{HG} and Δh_b are the changes in the differential mercury and brine column heights, respectively, due to the drop in air pressure. Both of these are positive quantities since as the mercury-brine interface drops, the differential fluid heights for both mercury and brine increase. Noting also that the volume of mercury is constant, we have

$$A_1 \Delta h_{HG\,left} = A_2 \Delta h_{HG\,right}$$

And

$$P_{A2} - P_{A1} = -0.7 \text{ kPa} = -700 \text{ N/m}^2 = -700 \text{ kg/m} \cdot \text{s}^2$$

$$\Delta h_{br} = 0.005 \text{ m}$$

$$\Delta h_{Hg} = \Delta h_{Hg,right} + \Delta h_{Hg,left} = \Delta h_b + \Delta h_b A_2/A_1 = \Delta h_b (1 + A_2/A_1)$$

Substituting,

$$\frac{700 \text{ kg/m} \cdot \text{s}^2}{(1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} = [13.56 \times 0.005(1 + A_2/A_1) - (1.1 \times 0.005)] \text{ m}$$

It gives

$A_2/A_1 = \mathbf{0.134}$