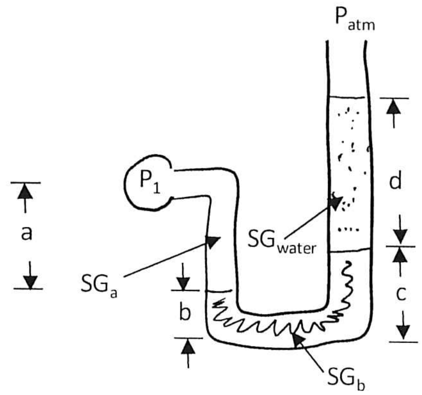
2. (25 pts) A gauge and manometer are attached to a column of water, as shown.



(a) (10 pts) Derive an equation that can be solved to find pressure P_1 if P_{atm}, a, b, c, d, SG_a, and SG_b are known. *Use the head form of the pressure balance equation.*

(b) (15 pts) Find P_1 (in psig) when a = 6 inches, b = 3 inches, c = 7 inches, d = 50 inches, SG_a = 0.001 (a gas), and SG_b is that of mercury (SG_{Hg} = 13.546), SG_w = specific gravity of water.

- Remember that $\rho_{water} = 62.43\ lb_m/ft^3$, and that 14.7 psi = 1 atm = 33.9 ft H_2O.
- If you can justify that one term in the pressure balance equation is very small, please neglect that term.

(a) $P_1 + SG_a \rho_w g a + SG_b \rho_w g b = SG_b \rho_w g c + \rho_w g d + P_{atm}$

(b) Since we want gauge pressure (in psig), we want $P_1 - P_{atm}$

also, since SG_a is so small, neglect that term

So $P_1 - P_{atm} = SG_b \rho_w g (c-b) + \rho_w g d$

Now divide by $\rho_w g$

$$\frac{P_1 - P_{atm}}{\rho_w G} = SG_b (c-b) + d = (13.546)(7-3 \text{ inches}) + 50 \text{ inches}$$

$= 104.18$ inches of water

now use conversion table

$$(104.18 \text{ in. } H_2O)\left(\frac{14.696 \text{ psi}}{33.9 \text{ ft } H_2O}\right)\left(\frac{\text{ft } H_2O}{\text{in. } H_2O}\right) = \boxed{3.76 \text{ psig}}$$

or

$$\underset{h}{(104.18 \text{ in } H_2O)}\underset{\rho_w}{\left(62.43 \frac{lbm\ H_2O}{ft^3}\right)}\underset{g}{\left(32.17 \frac{ft}{s^2}\right)}\left(\frac{ft}{12 \text{ in}}\right)^3\left(\frac{lb_f\ s^2}{32.17\ lbm\text{-}ft}\right)$$

$$\boxed{= 3.76 \frac{lb_f}{in^2}}$$