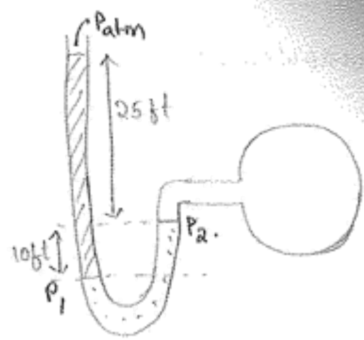
HW-2 solution:



1) Pressure in bulb = P_2

$$P_1 - P_{atm} = \rho_1 g h_1$$

$h_1 = 25 + 10 = 35ft$
$= 10.668$

$$P_1 = P_{atm} + \rho_1 g h_1.$$

$$P_2 - P_1 = -\rho_2 g h_2 \qquad h_2 = 10ft = 3.048$$

$$P_2 = P_1 - \rho_2 g h_2$$

$$= P_{atm} + \rho_1 g h_1 - \rho_2 g h_2.$$

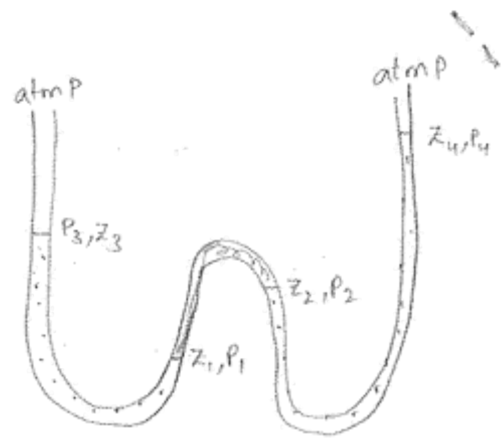
$$= 101325 + 1000(9.81)(10.668) - (2192.67)(9.81)(3.048)$$

$$= 140408 \ Pa$$

$$P_2 = P_0 = 140.408 \ kPa.$$

2) At higher altitudes and lower atmospheric pressures, liquid 1 will spill out of the manometer.

3.)



$$P_1 = P_{atm} + \rho_1 g (z_3 - z_1)$$

$$P_2 = P_{atm} + \rho_1 g (z_4 - z_2)$$

$$P_1 - P_2 = \rho_2 g (z_2 - z_1)$$

$$\rho_1 g (z_3 - z_1) - \rho_1 g (z_4 - z_2) = \rho_2 g (z_2 - z_1)$$

$$\rho_1 \left((z_3 - z_1) - (z_4 - z_2) \right) = \rho_2 (z_2 - z_1)$$

$$\frac{\rho_1}{\rho_2} = \frac{z_2 - z_1}{(z_3 - z_1) - (z_4 - z_2)}$$

Specific gravity of liquid

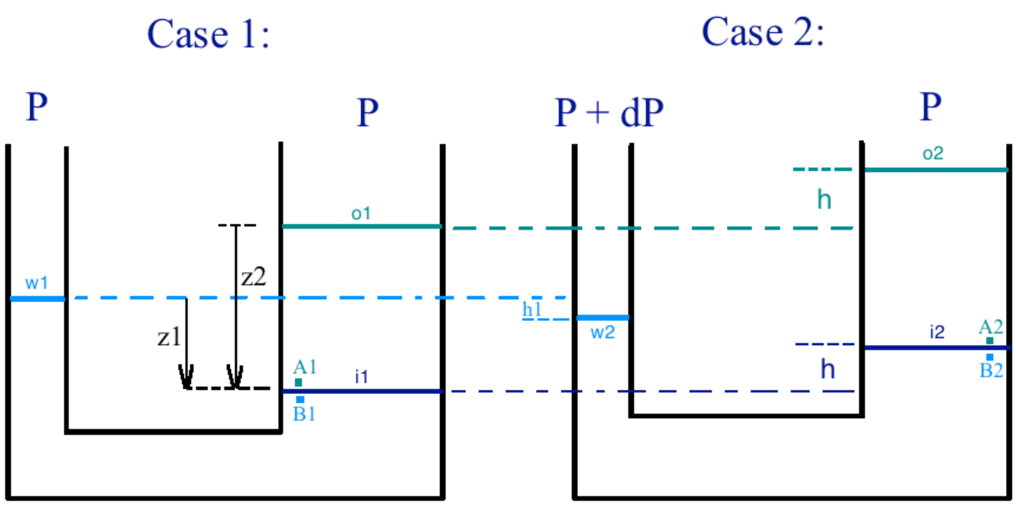
$$\frac{\rho_2}{\rho_1} = \frac{(z_4 - z_2) - (z_3 - z_1)}{z_1 - z_2}.$$

4)

Consider the two states of the system:

Case 1 – Both openings are exposed to the same pressure P.

Case 2 – Opening on the left is subjected to pressure P + dP, one on the right is at P.



Initial levels of water, interface and oil are w1, o1, and i1 respectively.

When the pressure on the left side is increased to P + dP, we see that the water level dips to w2. The interface between oil and water (Purple) rises by h to i2, and the oil surface rises by a margin h to o2.

We have:

Case 1: $P_{A1} = P_{B1}$.

⇨ $P + \rho_w g(w1 - i1) = P + \rho_o g(o1 - i1)$ 1*

Case 2: $P_{A2} = P_{B2}$.

⇨ $P + dP + \rho_w g(w2 - i2) = P + \rho_o g(o2 - i2)$......................... 2*

From the figure below we observe that

$w2 = w1 - h1$ 3
$i2 = i1 + h$ 4
$o2 = o1 + h$ 5

From 3, 4, and 5, we have:
$w2 - i2 = w1 - i1 - h1 - h$ 6

$o2 - i2 = o1 - i1$.......................................7

Plugging 6 and 7 into 2*, we have:

$P + dP + \rho_w g(w1 - i1 - h1 - h) = P + \rho_o g(o1 - i1)$.......................3*

Subtracting 1* from 3*, we have:

$dP = \rho_w g(h1 + h)$……………………………4*

Since the mass of water is conserved, if the diameter of the left column is d1 and that of the right column is d2,

$\pi d1^2 . h1 = \pi d2^2 . h$…………………………5*

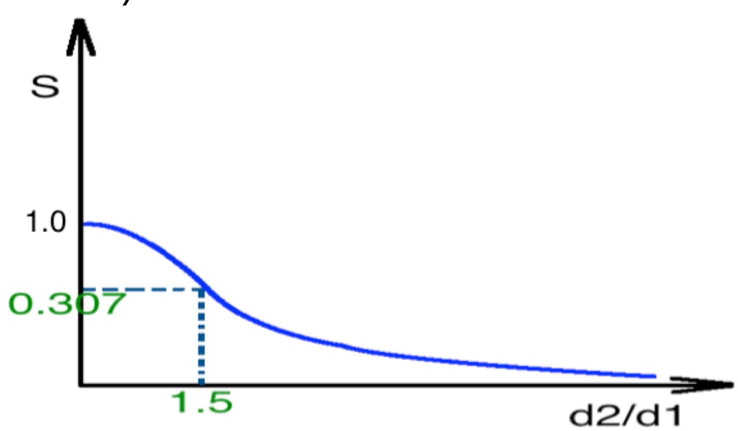
Solving equations 4* and 5* together, we have:

$$h = \frac{dP}{\rho_w g\left(1 + \frac{d2^2}{d1^2}\right)},$$

And sensitivity, $S = \frac{1}{\left(1 + \frac{d2^2}{d1^2}\right)}$.

Plugging in the values: h = 7.849mm and s = 0.307.

S vs d1/d2 :



5)

Volume under water $= V_w$

$$\cancel{\rho_g} V \cancel{g} = \gamma \cancel{\rho_w} V_{cylinder}$$

$V_{cylinder} = \pi r^2 h$ $\quad h = 40cm$

$\quad r = 7cm.$

$$V_w = \pi r^2 l + \frac{\pi r^2 x}{2} \qquad \tan 60 = \frac{x}{14}$$

$$x = 14\sqrt{3}.$$

$$V_w = \gamma \pi r^2 h.$$

$$\cancel{\pi r^2} l + \frac{\cancel{\pi r^2} 14\sqrt{3}}{2} = \gamma \cancel{\pi r^2} h$$

$$l + 7\sqrt{3} = 0.38 \times 40 \text{ cm}$$

$$l = 3.075 \text{ cm}$$

$$l + x = 27.325 \text{ cm}$$