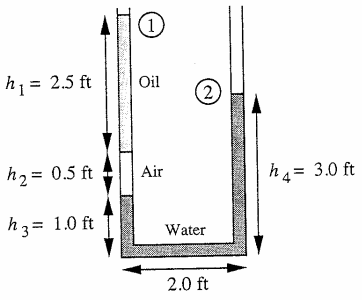
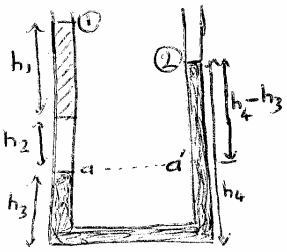
4. **(25 pts)**

a) **(15 pts)** The U-tube shown in the following figure contains oil and water columns open to atmosphere. As seen, there is a long trapped air bubble between the two columns. For the indicated heights of the columns, find the specific gravity of the oil. (Show your work clearly!) $(SG_{H_2O} = 1.0)$





Method 1

$$P_{bottom\ left} = P_1 + \frac{\rho_{oil} g h_1}{g_c} + \frac{\rho_{air} g h_2}{g_c} + \frac{\rho_{H_2O} g h_3}{g_c}$$

(0 (negligible))

$$P_{bottom\ right} = P_2 + \frac{\rho_{H_2O} g h_4}{g_c}$$

$$P_{bottom\ left} = P_{bottom\ right}$$

$$P_1 + \frac{\rho_{oil} g h_1}{g_c} + \frac{\rho_{H_2O} g h_3}{g_c} = P_2 + \frac{\rho_{H_2O} g h_4}{g_c} \quad \& \quad P_1 = P_2 = P_{atm}$$

$$\Rightarrow \rho_{oil} = \frac{\rho_{H_2O}(h_4 - h_3)}{h_1} = 1\ g/cm^3 \cdot \frac{(3\ ft - 1\ ft)}{2.5\ ft} = 0.8\ g/cm^3$$

$$SG_{oil} = \frac{\rho_{oil}}{\rho_{ref}} = \frac{0.8\ g/cm^3}{1\ g/cm^3} = 0.8$$

—or—

Method 2

$$P_a = P_1 + \frac{\rho_{oil} g h_1}{g_c} + \frac{\rho_{air} g h_2}{g_c}$$

(0 (negligible))

$$P_{a'} = P_2 + \frac{\rho_{H_2O} g (h_4 - h_3)}{g_c}$$

$$P_a = P_{a'}$$

$$P_1 + \frac{\rho_{oil} g h_1}{g_c} = P_2 + \frac{\rho_{H_2O} g (h_4 - h_3)}{g_c} \quad \& \quad P_1 = P_2 = P_{atm}$$

$$\Rightarrow \rho_{oil} = \rho_{H_2O} \frac{(h_4 - h_3)}{h_1} = 1\ g/cm^3 \frac{(3\ ft - 1\ ft)}{2.5\ ft} = 0.8\ g/cm^3$$

$$SG_{oil} = \frac{\rho_{oil}}{\rho_{ref}} = \frac{0.8\ g/cm^3}{1\ g/cm^3} = 0.8$$