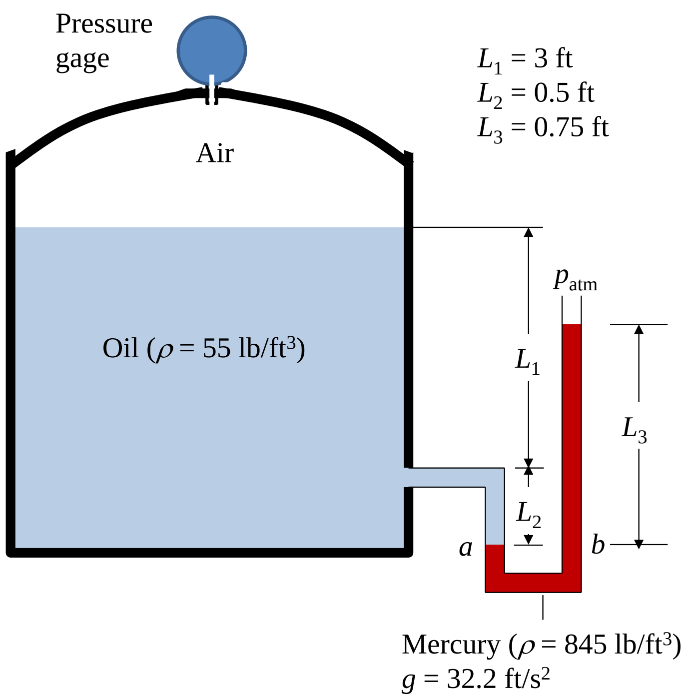
1.41 Figure P1.41 shows a closed tank holding air and oil to which is connected a U-tube mercury manometer and a pressure gage. Determine the reading of the pressure gage, in lbf/in.^{2} (gage). The densities of the oil and mercury are, 55 and 845, respectively, each in lb/ft^3. Let g = 32.2 ft/s^2.

KNOWN: Air and oil are in a closed tank to which a U-tube manometer and a pressure gage are connected. Densities of the oil and mercury are known.

FIND: the reading of the pressure gage.

SCHEMATIC AND GIVEN DATA:



ENGINEERING MODEL:
1. The acceleration of gravity is 32.2 ft/s^2.

ANALYSIS: Ignoring the vertical pressure variation of the air trapped above the oil, the gage reads

$$p_{\text{gage}} = p_{\text{air}} - p_{\text{atm}} \tag{1}$$

We also have

$$p_a = p_{\text{air}} + \rho_o g(L_1 + L_2) \tag{2}$$

and

$$p_b = p_{\text{atm}} + \rho_m g L_3 \tag{3}$$

Then, since $p_a = p_b$, Eqs. (2) and (3) give

$$p_{\text{air}} + \rho_o g(L_1 + L_2) = p_{\text{atm}} + \rho_m g L_3$$

$$p_{\text{air}} - p_{\text{atm}} = \rho_{\text{m}} g L_3 - \rho_{\text{o}} g (L_1 + L_2)$$

$$p_{\text{gage}} = [\rho_{\text{m}} L_3 - \rho_{\text{o}} (L_1 + L_2)] g$$

Calculating,

$$p_{\text{gage}} = \left[\left(845\,\frac{\text{lb}}{\text{ft}^3}\right)(0.75\,\text{ft}) - \left(55\,\frac{\text{lb}}{\text{ft}^3}\right)(3.5\,\text{ft})\right]\left(32.2\,\frac{\text{ft}}{\text{s}^2}\right)\left|\frac{1\,\text{lbf}}{32.2\,\frac{\text{lb}\cdot\text{ft}}{\text{s}^2}}\right|\left|\frac{1\,\text{ft}^2}{144\,\text{in}^2}\right| = \underline{\mathbf{3.06\ lbf/in^2\ (gage)}}$$