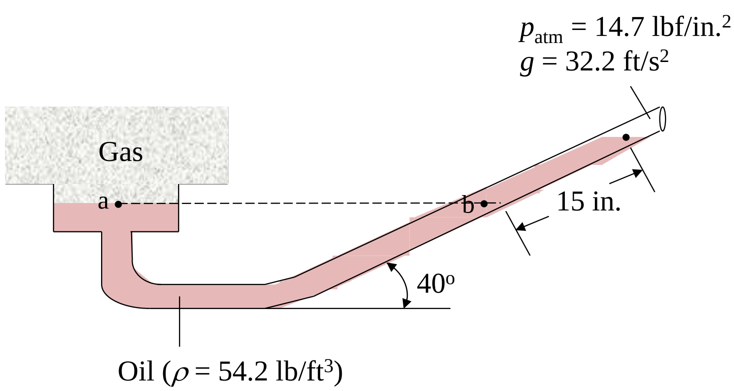
1.38 As shown in Figure P1.38, an inclined manometer is used to measure the pressure of the gas within the reservoir. (a) Using data on the figure, determine the gas pressure, in lbf/in.^{2} (b) Express the pressure as a gage or a vacuum pressure, as appropriate, in lbf/in.^{2} (c) What advantage does an inclined manometer have over the U-tube manometer shown in Figure 1.7?

KNOWN: A gas contained in a reservoir with inclined manometer attached.

FIND: (a) Pressure of gas within the reservoir, in lbf/in.^{2} (b) Pressure expressed as gage or vacuum pressure, as appropriate, in lbf/in.^{2} (c) Advantage of inclined manometer over the U-tube manometer.

SCHEMATIC AND GIVEN DATA:



ENGINEERING MODEL:
1. The gas is a closed system.
2. Atmospheric pressure is exerted at the open end of the manometer.
3. The manometer fluid is oil with a density of 54.2 lb/ft^3.

ANALYSIS:
(a) Applying Eq. 1.11

$$p_{gas} = p_{atm} + \rho g L$$

where p_{atm} is the local atmospheric pressure, ρ is the density of the manometer fluid (oil), g is the acceleration due to gravity, and L is the vertical difference in liquid levels. Since level a is the same as level b, applying trigonometry to determine the vertical difference in liquid levels between level b and the liquid level at the free surface with the atmosphere yields

$$p_{gas} = p_{atm} + \rho g L(\sin 40^{\circ})$$

Substituting values

$$p_{gas} = 14.7\,\frac{\text{lbf}}{\text{in.}^2} + \left(54.2\,\frac{\text{lb}}{\text{ft}}\right)\left(32.2\,\frac{\text{ft}}{\text{s}^2}\right)(15\,\text{in.})(\sin 40°)\left|\frac{1\,\text{lbf}}{32.2\,\frac{\text{lbm}\cdot\text{ft}}{\text{s}^2}}\right|\left|\frac{1\,\text{ft}^3}{1728\,\text{in.}^3}\right| = \underline{\mathbf{15.0\ lbf/in.^2}}$$

(b) Since the pressure of the gas is greater than atmospheric pressure, gage pressure is given by Eq. 1.14

$$p(\text{gage}) = p(\text{absolute}) - p_{\text{atm}}(\text{absolute}) = 15.0\text{ psia} - 14.7\text{ psia} = \underline{\mathbf{0.3\ psig}}$$

(c) The advantage of the inclined manometer is its easier readability since the surface of the liquid is wider than with a same diameter U-tube manometer. The scale on the inclined manometer is much more precise since more graduations are possible compared with the U-tube manometer.

Substituting values for pressures and specific volume yields

$$v_2 = \left(0.5\frac{\mathrm{m}^3}{\mathrm{kg}}\right)\left(\frac{250\,\mathrm{kPa}}{100\,\mathrm{kPa}}\right)^{\frac{1}{0.5}} = \underline{\mathbf{3.125\ m^3/kg}}$$

The volume of the system increased while pressure decreased during the process.

A plot of the process on a pressure versus specific volume graph is as follows: