Problem 1-30
A vacuum gage connected to a tank reads 30 kPa at a location where the barometric pressure reading is 755 mm Hg. Determine the absolute pressure in the tank where the density of mercury $\rho_{\text{Hg}} = 13,590 \text{ kg/m}^3$.

\[
P_{\text{atm}} = \rho_g h = \left(13,590 \frac{\text{kg}}{\text{m}^3}\right) \left(9.81 \frac{\text{m}}{\text{s}^2}\right) \left(775 \frac{\text{m}}{\text{mm}}\right) \frac{1 \text{ kPa}}{1000 \text{ N/m}^2}
= 100.6 \text{ kPa}
\]

\[
P_{\text{abs}} = P_{\text{atm}} - P_{\text{vac}} = 100.6 - 30 = 70.6 \text{ kPa}
\]

Problem 1-30E
A vacuum gage connected to a tank reads 5.4 psig at a location where the barometric reading is 28.5 in Hg. Determine the absolute pressure in the tank where the density of mercury $\rho_{\text{Hg}} = 848.4 \text{ lb/ft}^3$.

\[
P_{\text{atm}} = \rho_g h
= \left(848.4 \frac{\text{lb}}{\text{ft}^3}\right) \left(32.17 \frac{\text{ft}}{\text{in}}\right) \left(28.5 \frac{\text{in}}{\text{ft}}\right) \frac{12 \text{ in}}{1 \text{ ft}}
= 64,829 \frac{\text{lb}}{\text{ft}^2} \left(\frac{\text{ft}^2}{144 \text{ in}^2}\right) \left(\frac{1 \text{ lb}}{32.17 \text{ ft-lb}}\right)
= 14.0 \text{ psig}
\]

\[
P_{\text{abs}} = P_{\text{atm}} - P_{\text{vac}} = 14 - 5.4 = 8.6 \text{ psig}
\]
Problem 1.32 A pressure gage connected to a tank reads 500 kPa at a location where the atmospheric pressure is 94 kPa. Determine the absolute pressure in the tank.

\[ P_{\text{abs}} = P_{\text{gage}} + P_{\text{atm}} = 500 + 94 = 594 \text{ kPa} \]

Problem 1.36 Determine the pressure exerted on the surface of a submarine cruising 100 meters below the surface of the sea. Assume that the barometric pressure is 14.7 psia and that the specific gravity of the seawater is 1.03.

\[ \rho = \rho_s (\rho_{\text{H}_2\text{O}}) = 1.03 (1000) \frac{\text{kg}}{\text{m}^3} = 1030 \frac{\text{kg}}{\text{m}^3} \]

\[ P = P_{\text{atm}} + \rho g h = 101 \text{ kPa} + 1030 \frac{\text{kg}}{\text{m}^3} (9.81) \frac{\text{m}}{\text{s}^2} (100) \text{ m} \\
\quad = 1111 \text{ kPa} \]
Problem 1-33
A barometer of a mountain hiker reads 930 mbars at the beginning of a trip and 780 mbars at the end. Neglecting the effect of gravity change on the climb, determine the vertical distance climbed. Assume an average air density $\rho = 1.20 \text{ kg/m}^3$, and an average local acceleration of gravity of $g = 9.70 \text{ m/s}^2$.

$$1 \text{ bar} = 100,000 \text{ Pa} = 100,000 \text{ N/m}^2$$

$$\Delta P_{\text{air}} = P_{\text{bottom}} - P_{\text{top}} = (\rho gh)_{\text{air}} = (930 - 780) \text{ bar}$$

$$1.2 \text{ Kg/m}^3 \times (9.7) \frac{m}{\text{sec}^2} \times h = 0.15 \text{ bar}$$

$$h = 1288.66 \text{ m}$$

Problem 1-33E
The barometer of a mountain hiker reads 13.8 psia at the beginning of a trip and 12.6 psia at the end. Neglecting the effects of gravity change on the climb, determine the vertical distance climbed. Assume an average air density $\rho = 0.074 \text{ lb}_m/\text{ft}^3$ and the local acceleration due to gravity to be $g = 31.8 \text{ ft/s}^2$.

$$\left(0.074 \frac{\text{lb}_m}{\text{ft}^3}\right) \times (31.8) \frac{\text{ft}}{\text{sec}^2} \times h = (13.8 - 12.6) \frac{\text{lb}_f}{\text{ft}^2} \times \frac{144}{\text{in}^2}$$

$$2.3532 \frac{\text{lb}_m}{\text{ft}^2 \text{sec}^2} \times h = 172.8 \frac{\text{lb}_f}{\text{ft}^2} \times 
(32.172) \frac{\text{ft}}{\text{sec}^2} \frac{1}{\text{lb}_f}$$

$$h = 2363 \text{ ft}$$
Problem 1-36
Determine the pressure exerted on the surface of a submarine cruising 100 m below the surface of the sea. Assume that the barometric pressure is 101 kPa and the specific gravity of sea water is 1.03.

\[ \rho = (1.03) (1000) \frac{kg}{m^3} = 1030 \frac{kg}{m^3}. \]

\[ P = P_{atm} + \rho g h = 101 \text{kPa} + \left(1030 \frac{kg}{m^3} \right) \left(9.8 \frac{m}{s^2} \right) (100) \text{m} \]

\[ = 1111.1 \text{kPa} \]

Problem 1-36E
Determine the pressure exerted in the surface of a submarine cruising 300 ft below the surface of the sea. Assume that the barometric pressure is 14.7 psia and that the specific gravity of the sea water is 1.03.

\[ \rho = (1.03) (62.4) \frac{lbm}{ft^3} = 64.27 \frac{lbm}{ft^3}. \]

\[ P = P_{atm} + \rho g h = 14.7 + \left(64.27 \frac{lbm}{ft^3} \right) \left(32.17 \frac{lbm}{ft^3} \right) \left(300 \frac{ft}{sec^2} \right) \frac{ft^3}{in^2} \]

\[ = 14.7 \frac{lbm}{in^2} + 620,347 \frac{lbm}{in^2} \left( \frac{1}{444} \right) \frac{ft^2}{sec^2} \frac{lbm}{in^2} \]

\[ = 14.7 + 133.89 = 148.6 \text{ psia} \]
Problem 1.38  Both the gage and a manometer are attached to a gas tank to measure its pressure. If the reading on the pressure gage is 80 kPa, determine the distance (height) between the two fluid levels of the manometer if the fluid is a) mercury (ρ = 13,600 kg/m³) and b) water (ρ = 1000 kg/m³).

\[ P = P_{\text{atm}} + \frac{pgh}{\rho g} \]

\[ h = \frac{p_{\text{gage}}}{\rho g} = \frac{80 \text{ kPa} \times (1000) \text{ Pa}}{(13,600) \text{ kg/m}^3 \times (9.81) \text{ m/sec}^2 \times \text{kPa}} \]

\[ = \frac{0.60 \text{ m}^3}{N} = 0.6 \text{ N/m}^2 \text{ N/m}^2 \]

\[ = 0.6 \text{ m} \]

For Water

\[ h = \frac{80 \text{ kPa} \times (1000) \text{ Pa}}{(1000) \text{ kg/m}^3 \times (9.81) \text{ m/sec}^2 \times \text{kPa}} = 8.16 \text{ m} \]