1. Problem 2-5

Blood pressure is usually given as a ratio of the maximum pressure (systolic pressure) to the minimum pressure (diastolic pressure). As shown in Video V2.3 such pressures are commonly measured with a mercury manometer. A typical value for this ratio for a human would be 120/70, where the pressures are in mm Hg. (a) What would these pressures be in pascals? (b) If your car tire was inflated to 120 mm Hg, would it be sufficient for normal driving?

\[ p = \gamma h \]

(a) For 120 mm Hg:
\[ p = (133 \times 10^3 \text{ N/m}^2)(0.120 \text{ m}) = 16.0 \text{ kPa} \]

For 70 mm Hg:
\[ p = (133 \times 10^3 \text{ N/m}^2)(0.070 \text{ m}) = 9.31 \text{ kPa} \]

(b) For 120 mm Hg:
\[ p = (16.0 \times 10^3 \text{ N/m}^2)(1.45 \times 10^{-4} \text{ lb/in}^2) \]
\[ = 2.32 \text{ psi} \]

Since a typical tire pressure is 30-35 psi, 120 mm Hg is not sufficient for normal driving.

2. Problem 2-16
2.16 Often young children drink milk \((\rho = 1030 \text{ kg/m}^3)\) through a straw. Determine the maximum length of a vertical straw that a child can use to empty a milk container, assuming that the child can develop 75 mm Hg of suction, and use this answer to determine if you think this is a reasonable estimate of the suction that a child can develop.

**Known:** \(\rho_{\text{milk}} = 1030 \text{ kg/m}^3\), suction = 75 mm Hg

**Determine:** maximum length of vertical straw, is this reasonable?

**Strategy:** compute height of equivalent milk column

**Solution:**

\[
\begin{align*}
    h_{\text{max}} &= \text{height of milk column lifted by suction} \\
    \Delta P_{\text{max}} &= \gamma_{\text{milk}} h_{\text{lift}} = 75 \text{ mm Hg} \\
    \Delta P_{\text{milk}} &= \gamma_{\text{milk}} h_{\text{milk}} \\
    h_{\text{max,milk}} &= \frac{\Delta P_{\text{max}}}{\gamma_{\text{milk}}} = \frac{\left(\gamma_{\text{milk}} h_{\text{lift}}\right)}{\gamma_{\text{milk}}} = \frac{13,600 \text{ kg/m}^3}{1,030 \text{ kg/m}^3} (75 \text{ mm}) \\
    h_{\text{max,milk}} &= 990.3 \text{ mm milk}
\end{align*}
\]

\[\text{max. length straw} \approx 1 \text{ m}\]

Although this may seem large, adults can routinely lift water much higher through a straw. Therefore, a 1 m draw seems large, but within reason for a child.

3. Problem 2-19

2.19 Denver, Colorado, is called the “mile-high city” because its state capitol stands on land 1 mi above sea level. Assuming that the Standard Atmosphere exists, what is the pressure and temperature of the air in Denver? The temperature follows the lapse rate \((T = T_0 - B z)\).

**GIVEN:** Denver altitude = 1 mile = 5280 ft and standard atmosphere. \(T=T_0-Bz\)

**FIND:** Temperature and pressure in Denver.

**SOLUTON:**

The Lapse rate gives

\[
T = T_0 - Bz = 518.67 \text{ °R} - \left(0.003566 \frac{\theta R}{\text{ft}}\right)(5280 \text{ ft}) = 500 \text{ °R} = 40 \text{ °F}
\]

Using Equation and Table:

\[
P = P_0 \left(1 - \frac{\theta z}{T_0}\right)
\]

\[
= \left(14.696 \text{ psia}\right) \left(1 - \frac{0.003566 \frac{\theta R}{\text{ft}}}{518.67 \text{ °R}} (5280 \text{ ft})\right)
\]

\[= 12.10 \text{ psia}\]

Which agrees reasonably well with the pressure given in Table from the Appendix.

4. Problem 2-20
Assume that a person skiing high in the mountains at an altitude of 15,000 ft takes in the same volume of air with each breath as she does while walking at sea level. Determine the ratio of the mass of oxygen inhaled for each breath at this high altitude compared to that at sea level.

Let \( \rho_o \) denote sea level and \( \rho_{15} \) denote 15,000 ft altitude. Thus, since \( m = \rho V \), where \( V \) is volume,

\[
m_o = \rho_o V_o \quad \text{and} \quad m_{15} = \rho_{15} V_{15},
\]

where \( V_o = V_{15} \).

Hence,

\[
\frac{m_{15}}{m_o} = \frac{\rho_{15} V_{15}}{\rho_o V_o} = \frac{\rho_{15}}{\rho_o}
\]

If it is assumed that the air composition (e.g., \% of air that is oxygen) is the same at sea level as it is at 15,000 ft, then we can use the \( \rho \) values from Table C.1:

\[
\rho_o = 2.377 \times 10^{-3} \text{ slugs/ft}^3 \quad \text{and} \quad \rho_{15} = 1.496 \times 10^{-3} \text{ slugs/ft}^3
\]

so that

\[
\frac{m_{15}}{m_o} = \frac{1.496 \times 10^{-3} \text{ slugs/ft}^3}{2.377 \times 10^{-3} \text{ slugs/ft}^3} = 0.629 = 62.9\%
\]

5. Problem 2-27
6. Problem 2-31

2.31 A U-tube manometer is used to check the pressure of natural gas entering a furnace. One side of the manometer is connected to the gas inlet line, and the water level in the other side is open to atmospheric pressure rises 3 in. What is the gage pressure of the natural gas in the inlet line in in. H₂O and in lb/in² gage?

**SOLUTION:**

\[
P_{\text{gas}} + P_{H_2O} \Delta h = P_{\text{gas}}
\]

\[
P_{\text{gas}} = 0 + \left( 62.4 \text{ lbm/ft}^3 \right) \left( 32.174 \text{ ft/s}^2 \right) \left(\frac{6}{12} \text{ ft} \right) \left(\frac{1 \text{ lb-s}^2}{32.174 \text{ ft-lbm}} \right)
\]

\[
P_{\text{gas}} = 31.2 \text{ lb/ft}^2 \text{ gage} = 6 \text{ in. H}_2\text{O gauge}
\]

7. Problem 2-34
8. Problem 2-40

2.40 Two pipes are connected by a manometer as shown in Fig. P2.40. Determine the pressure difference, $p_A - p_B$, between the pipes.

\[
\begin{align*}
\gamma_{H_2O}(0.5m + 0.6m) - \gamma_{GF}(0.6m) + \gamma_{H_2O}(1.3m - 0.5m) &= p_B \\
\text{Thus,} \\
\gamma_{H_2O}(0.6m) - \gamma_{H_2O}(0.5m + 0.6m + 1.3m - 0.5m) &= \gamma_{GF}(0.6m) - \gamma_{GF}(0.6m) \\
&= -3.32 \text{ kPa}
\end{align*}
\]
2.42 A U-tube manometer is connected to a closed tank as shown in Fig. P2.42. The air pressure in the tank is 0.50 psi and the liquid in the tank is oil \( y = 54.0 \text{ lb/ft}^3 \). The pressure at point \( A \) is 2.00 psi. Determine (a) the depth of oil, \( z \), and (b) the differential reading, \( h \), on the manometer.

(a) \[ \frac{P_A}{\gamma_{oil}} = \frac{z}{\gamma_{oil}} + \frac{P_{atm}}{\gamma_{oil}} \]
Thus, \[ z = \frac{P_A - P_{atm}}{\gamma_{oil}} = \frac{(2 \frac{\text{lb}}{\text{in}^2} - 0.5 \frac{\text{lb}}{\text{in}^2})}{(144 \frac{\text{in}^2}{\text{ft}^2})} \frac{(54.0 \frac{\text{lb}}{\text{ft}^3})}{\frac{\text{lb}}{\text{ft}^3}} = 4.00 \text{ ft} \]

(b) \[ P_A + \gamma_{oil} (2 \text{ ft}) - (SG)(\gamma_{H_2O}) \frac{h}{\gamma_{H_2O}} = 0 \]
Thus, \[ h = \frac{P_A + \gamma_{oil} (2 \text{ ft})}{(SG)(\gamma_{H_2O})} = \frac{(2 \frac{\text{lb}}{\text{in}^2})(144 \frac{\text{in}^2}{\text{ft}^2}) + (54.0 \frac{\text{lb}}{\text{ft}^3})(2 \text{ ft})}{(3.05)(62.4 \frac{\text{lb}}{\text{ft}^3})} = 2.08 \text{ ft} \]

10. Problem 2-43
For the inclined-tube manometer of Fig. P2.43 the pressure in pipe A is 0.6 psi. The fluid in both pipes A and B is water, and the gage fluid in the manometer has a specific gravity of 2.6. What is the pressure in pipe B corresponding to the differential reading shown?

\[ P_A + \gamma_{H_2O} \left( \frac{3}{12} \text{ ft} \right) - \gamma_{gf} \left( \frac{8}{12} \text{ ft} \right) \sin 30^\circ - \gamma_{H_2O} \left( \frac{3}{12} \text{ ft} \right) = P_B \]

(Where \( \gamma_{gf} \) is the specific weight of the gage fluid)

Thus,

\[ P_B = P_A - \gamma_{gf} \left( \frac{8}{12} \text{ ft} \right) \sin 30^\circ \]

\[ = 0.6 \left( \frac{144}{144} \right) - \left( 2.6 \left( \frac{62.4}{144} \right) \right) \left( \frac{8}{12} \right) \left( 0.5 \right) = 32.3 \left( \frac{144}{144} \right) \text{ psi} \]

\[ = 32.3 \frac{144}{144} \text{ psi} = 0.224 \text{ psi} \]
2.77 Determine the magnitude and direction of the force that must be applied to the bottom of the gate shown in Fig. P2.77 to keep the gate closed.

SOLUTION:
The hydrostatic force on the gate is
\[ F = \gamma v A \]
\[ = \left( 1000 \frac{kg}{m^3} \right) \left( 9.81 \frac{m}{s^2} \right) (1.3m + 0.4m)(2m \times 0.8m) \]
\[ = 26700 \text{ N} \]

The location of the force $F$ is
\[ y_p = y_c + \frac{I_w}{12 \gamma A} \]

Using Appendix,
\[ y_p = y_c + \frac{bh^3}{12 \gamma A} = y_c + \frac{h^3}{12 \gamma} \]
\[ = (1.3 + 0.4)m + \frac{(0.8m)^3}{12(1.3 + 0.4)m} = 1.73 \text{ m} \]

Summing moments about the hinge,
\[ \sum M_{hinge} = F_y h - F (y_p - H) = 0 \]
\[ F = \frac{F(y_p - H)}{h} = \frac{(26700 \text{ N})(1.73 - 1.3)m}{0.8m} \]
\[ \rightarrow F_y = 14,400 \text{ N} \]
A long, vertical wall separates seawater from freshwater. If the seawater stands at a depth of 7 m, what depth of freshwater is required to give a zero resultant force on the wall? When the resultant force is zero will the moment due to the fluid forces be zero? Explain.

For a zero resultant force

\[ F_{Rs} = F_{Rf} \]

or

\[ \gamma_s b_{Rs} A_s = \gamma_f b_{Rf} A_f \]

Thus, for a unit length of wall

\[ (10,1 \, \text{kN/m}^3)(7\text{m})(7\text{m} \times 1\text{m}) = (9.8 \, \text{kN/m}^3)(\frac{4}{2} \text{m})(7\text{m} \times 1\text{m}) \]

so that

\[ b_{Rs} = 7.11 \text{m} \]

In order for moment to be zero, \( F_{Rs} \) and \( F_{Rf} \) must be collinear.

For \( F_{Rs} \):

\[ Y_r = \frac{\text{I}_{zc} \gamma}{\gamma c A} + Y_c = \frac{1}{12} \text{m}(7\text{m})^3 + \frac{7}{2} \text{m} = 4.67\text{m} \]

Similarly for \( F_{Rf} \):

\[ Y_r = \frac{\frac{1}{12} \text{m}(7.11\text{m})^3}{\left(\frac{7.11}{2}\text{m}\right)(7.11\text{m} \times 1\text{m})} + \frac{7.11}{2} \text{m} = 4.74\text{m} \]

Thus, the distance to \( F_{Rs} \) from the bottom (point 0) is

\[ 7\text{m} - 4.67\text{m} = 2.33\text{m} \]. For \( F_{Rf} \) this distance is

\[ 7.11\text{m} - 4.74\text{m} = 2.37\text{m} \]. The forces are not collinear. No.