CHAPTER (1)

INTRODUCTION AND BASIC CONCEPTS

HOMEWORK (1)

1.44, 1.71, 1.73, 1.76

Problem (1-44)

$$1bar = 14.7\ psi = 10^5\ Pa = 10^3\ kPa$$

1-44 The maximum pressure of a tire is given in English units. It is to be converted to SI units.

Assumptions The listed pressure is gage pressure.

Analysis Noting that 1 atm = 101.3 kPa = 14.7 psi, the listed maximum pressure can be expressed in SI units as

$$P_{max} = 35\text{ psi} = (35\text{ psi})\left(\frac{101.3\text{ kPa}}{14.7\text{ psi}}\right) = \mathbf{241\ kPa}$$

Discussion We could also solve this problem by using the conversion factor 1 psi = 6.895 kPa.

Problem (1-71)

1-71 A vertical tube open to the atmosphere is connected to the vein in the arm of a person. The height that the blood will rise in the tube is to be determined.

Assumptions **1** The density of blood is constant. **2** The gage pressure of blood is 120 mmHg.

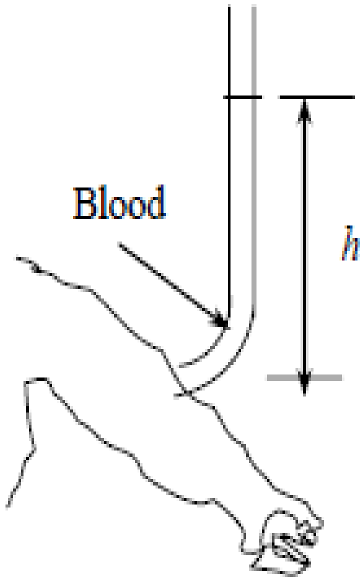
Properties The density of blood is given to be ρ = 1050 kg/m³.

Analysis For a given gage pressure, the relation $P = \rho g h$ can be expressed for mercury and blood as $P = \rho_{blood} g h_{blood}$ and $P = \rho_{mercury} g h_{mercury}$. Setting these two relations equal to each other we get

$$P = \rho_{blood} g h_{blood} = \rho_{mercury} g h_{mercury}$$

Solving for blood height and substituting gives

$$h_{blood} = \frac{\rho_{mercury}}{\rho_{blood}} h_{mercury} = \frac{13{,}600 \text{ kg/m}^3}{1050 \text{ kg/m}^3}(0.12 \text{ m}) = \mathbf{1.55 \text{ m}}$$

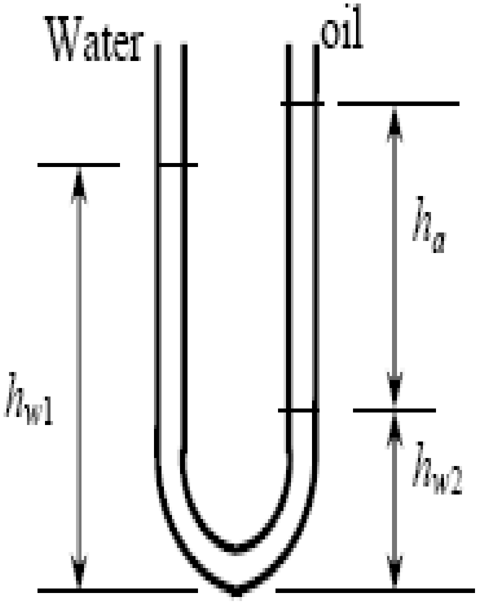


Discussion Note that the blood can rise about one and a half meters in a tube connected to the vein. This explains why IV tubes must be placed high to force a fluid into the vein of a patient.

Problem (1-73)

1-73 Water is poured into the U-tube from one arm and oil from the other arm. The water column height in one arm and the ratio of the heights of the two fluids in the other arm are given. The height of each fluid in that arm is to be determined.

$$h_{w1} = 70\,cm, \frac{h_a}{h_{w2}} = 4$$



Assumptions Both water and oil are incompressible substances.

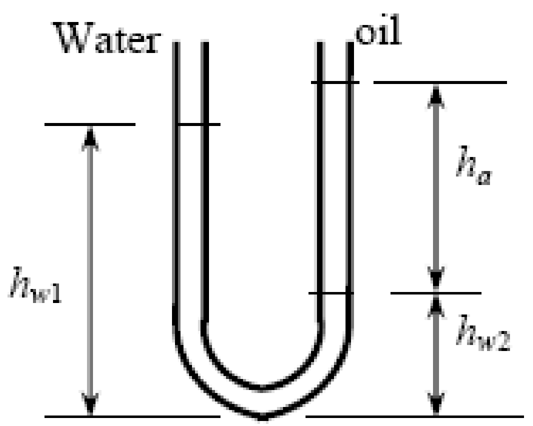
Properties The density of oil is given to be $\rho = 790\ kg/m^3$. We take the density of water to be $\rho = 1000\ kg/m^3$.

Analysis The height of water column in the left arm of the monometer is given to be $h_{w1} = 0.70$ m. We let the height of water and oil in the right arm to be h_{w2} and h_a, respectively. Then, $h_a = 4h_{w2}$. Noting that both arms are open to the atmosphere, the pressure at the bottom of the U-tube can be expressed as

$$P_{bottom} = P_{atm} + \rho_w g h_{w1} \quad \text{and} \quad P_{bottom} = P_{atm} + \rho_w g h_{w2} + \rho_a g h_a$$

Problem (1-73)

$$h_{w1} = 70\,cm, \frac{h_a}{h_{w2}} = 4$$



$$P_{bottom} = P_{atm} + \rho_w g h_{w1} \quad \text{and} \quad P_{bottom} = P_{atm} + \rho_w g h_{w2} + \rho_a g h_a$$

Setting them equal to each other and simplifying,

$$\rho_w g h_{w1} = \rho_w g h_{w2} + \rho_a g h_a \quad \rightarrow \quad \rho_w h_{w1} = \rho_w h_{w2} + \rho_a h_a \quad \rightarrow \quad h_{w1} = h_{w2} + (\rho_a / \rho_w) h_a$$

Noting that $h_a = 4h_{w2}$, the water and oil column heights in the second arm are determined to be

$$0.7\text{ m} = h_{w2} + (790/1000)\,4h_{w2} \quad \rightarrow \quad h_{w2} = \mathbf{0.168\text{ m}}$$

$$0.7\text{ m} = 0.168\text{ m} + (790/1000)h_a \quad \rightarrow \quad h_a = \mathbf{0.673\text{ m}}$$

Discussion Note that the fluid height in the arm that contains oil is higher. This is expected since oil is lighter than water.

Problem (1-76)

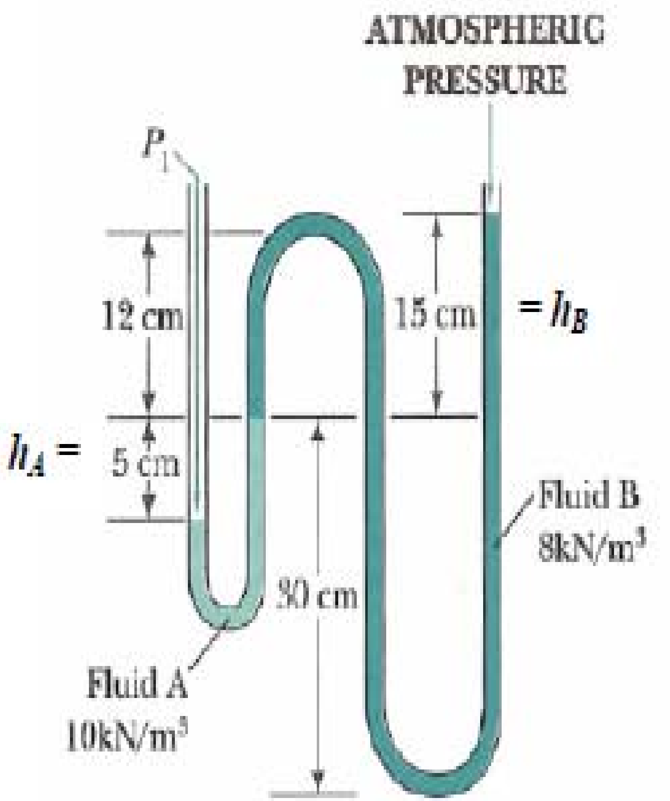
1-76 The pressure indicated by a manometer is to be determined.

Properties The specific weights of fluid A and fluid B are given to be 10 kN/m³ and 8 kN/m³, respectively.

Analysis The absolute pressure P_1 is determined from

$$P_1 = P_{atm} + (\rho g h)_A + (\rho g h)_B$$
$$= P_{atm} + \gamma_A h_A + \gamma_B h_B$$
$$= (758 \text{ mm Hg})\left(\frac{0.1333 \text{ kPa}}{1 \text{ mm Hg}}\right)$$
$$+ (10 \text{ kN/m}^3)(0.05 \text{ m}) + (8 \text{ kN/m}^3)(0.15 \text{ m})$$
$$= \mathbf{102.7 \text{ kPa}}$$

Note that 1 kPa = 1 kN/m².



THE END