Problem (1-9)

1–9 At 45° latitude, the gravitational acceleration as a function of elevation z above sea level is given by $g = a - bz$, where $a = 9.807 \text{ m/s}^2$ and $b = 3.32 \times 10^{-6} \text{ s}^{-2}$. Determine the height above sea level where the weight of an object will decrease by 1 percent. *Answer:* 29,539 m

Problem (1-9)

1-9 The variation of gravitational acceleration above the sea level is given as a function of altitude. The height at which the weight of a body will decrease by 1% is to be determined.

Analysis The weight of a body at the elevation z can be expressed as

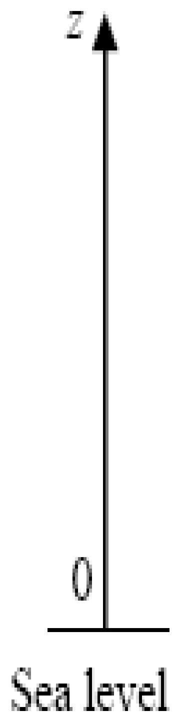
$$W = mg = m(9.807 - 3.32 \times 10^{-6} z)$$

In our case,

$$W = 0.99W_s = 0.99mg_s = 0.99(m)(9.807)$$

Substituting,

$$0.99(9.81) = (9.81 - 3.32 \times 10^{-6} z) \longrightarrow z = \mathbf{29{,}539\ m}$$



Problem (1-12)

1–12 A 5-kg rock is thrown upward with a force of 150 N at a location where the local gravitational acceleration is 9.79 m/s^2. Determine the acceleration of the rock, in m/s^2.

Problem (1-12)

1-12 A rock is thrown upward with a specified force. The acceleration of the rock is to be determined.

Analysis The weight of the rock is

$$W = mg = (5\ \text{kg})(9.79\ \text{m/s}^2)\left(\frac{1\ \text{N}}{1\ \text{kg}\cdot\text{m/s}^2}\right) = 48.95\ \text{N}$$

Then the net force that acts on the rock is

$$F_{\text{net}} = F_{\text{up}} - F_{\text{down}} = 150 - 48.95 = 101.05\ \text{N}$$

From the Newton's second law, the acceleration of the rock becomes

$$a = \frac{F}{m} = \frac{101.05\ \text{N}}{5\ \text{kg}}\left(\frac{1\ \text{kg}\cdot\text{m/s}^2}{1\ \text{N}}\right) = \mathbf{20.2\ m/s^2}$$

Problem (1-33)

$Given: T = 18\ ^{\circ}C$

1-33 A temperature is given in °C. It is to be expressed in °F, K, and R.

Analysis Using the conversion relations between the various temperature scales,

$$T(\text{K}] = T(^{\circ}\text{C}) + 273 = 18^{\circ}\text{C} + 273 = \mathbf{291\ K}$$

$$T(^{\circ}\text{F}] = 1.8T(^{\circ}\text{C}) + 32 = (1.8)(18) + 32 = \mathbf{64.4^{\circ}F}$$

$$T(\text{R}] = T(^{\circ}\text{F}) + 460 = 64.4 + 460 = \mathbf{524.4\ R}$$

Problem (1-53)

$Given: D_1 = 8\,cm^2,\ D_2 = 5\,cm^2$

$Given: p_1 = 1050\,kPa,\ p_2 = 1400\,kPa$

1-53 The pressure in chamber 3 of the two-piston cylinder shown in the figure is to be determined.

Analysis The area upon which pressure 1 acts is

$$A_1 = \pi \frac{D_1^2}{4} = \pi \frac{(8\text{ cm})^2}{4} = 50.27\text{ cm}^2$$

and the area upon which pressure 2 acts is

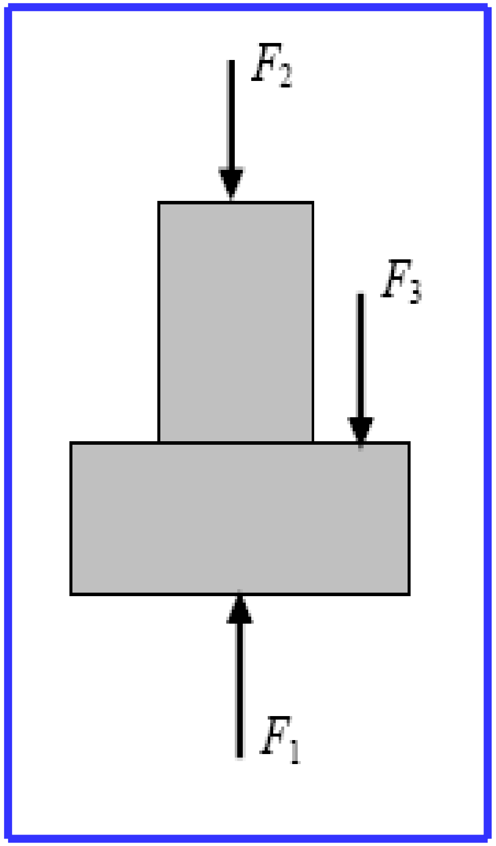
$$A_2 = \pi \frac{D_2^2}{4} = \pi \frac{(5\text{ cm})^2}{4} = 19.63\text{ cm}^2$$

The area upon which pressure 3 acts is given by

$$A_3 = A_1 - A_2 = 50.27 - 19.63 = 30.64\text{ cm}^2$$

The force produced by pressure 1 on the piston is then

$$F_1 = P_1 A_1 = (1050\text{ kN/m}^2)\left(\frac{1\text{ m}^2}{1000\text{ cm}^2}\right)(50.27\text{ cm}^2) = 52.78\text{ kN}$$



Problem (1-53)

while that produced by pressure 2 is

$$F_2 = P_2 A_2 = (1400\,\text{kN/m}^2)\left(\frac{1\,\text{m}^2}{1000\,\text{cm}^2}\right)(19.63\,\text{cm}^2) = 27.48\,\text{kN}$$

According to the vertical force balance on the piston free body diagram

$$F_3 = F_1 - F_2 = 52.78 - 27.48 = 25.3\,\text{kN}$$

Pressure 3 is then

$$P_3 = \frac{F_3}{A_3} = \frac{25.3\,\text{kN}}{30.64\,\text{cm}^2}\left(\frac{1000\,\text{cm}^2}{1\,\text{m}^2}\right)\left(\frac{1\,\text{kPa}}{1\,\text{kN/m}^2}\right) = \mathbf{825\,kPa}$$

Problem (1-62)

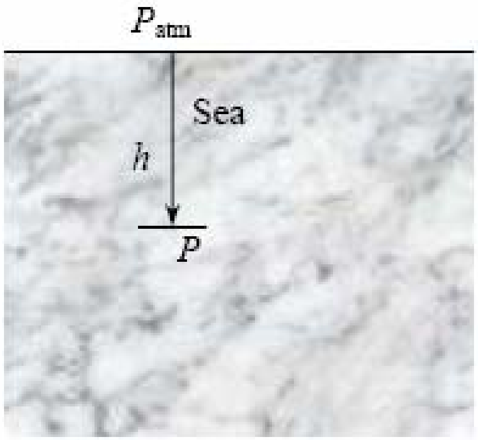
$Given: h = 30\,m,\ barometric\ \ pressure = 101\,kPa,\ S.G = 1.03$

1-62 A diver is moving at a specified depth from the water surface. The pressure exerted on the surface of the diver by water is to be determined.

Assumptions The variation of the density of water with depth is negligible.

Properties The specific gravity of seawater is given to be SG = 1.03. We take the density of water to be 1000 kg/m^3.

Analysis The density of the seawater is obtained by multiplying its specific gravity by the density of water which is taken to be 1000 kg/m^3:



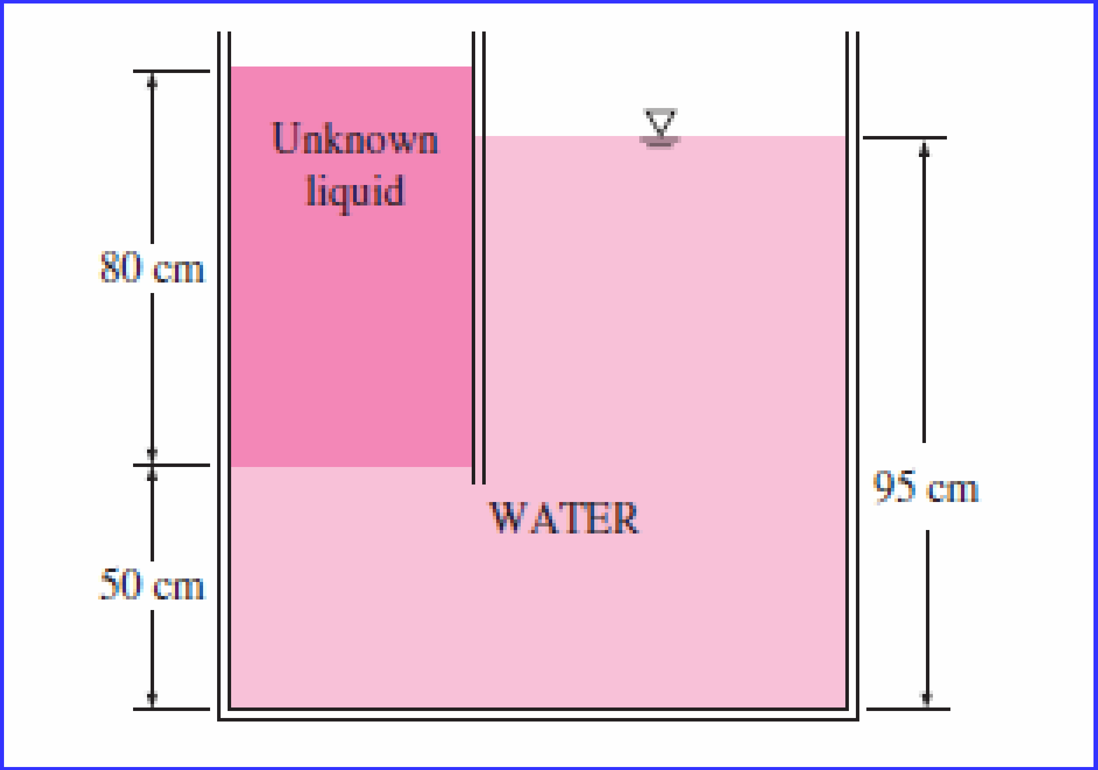
$$\rho = \mathrm{SG} \times \rho_{H_2O} = (1.03)(1000\ \mathrm{kg/m^3}) = 1030\ \mathrm{kg/m^3}$$

The pressure exerted on a diver at 30 m below the free surface of the sea is the absolute pressure at that location:

$$\begin{aligned} P &= P_{atm} + \rho g h \\ &= (101\ \mathrm{kPa}) + (1030\ \mathrm{kg/m^3})(9.807\ \mathrm{m/s^2})(30\ \mathrm{m})\left(\frac{1\ \mathrm{kPa}}{1000\ \mathrm{N/m^2}}\right) \\ &= \mathbf{404.0\ kPa} \end{aligned}$$

Problem (1-81)

1-81 The top part of a water tank is divided into two compartments, and a fluid with an unknown density is poured into one side. The levels of the water and the liquid are measured. The density of the fluid is to be determined.



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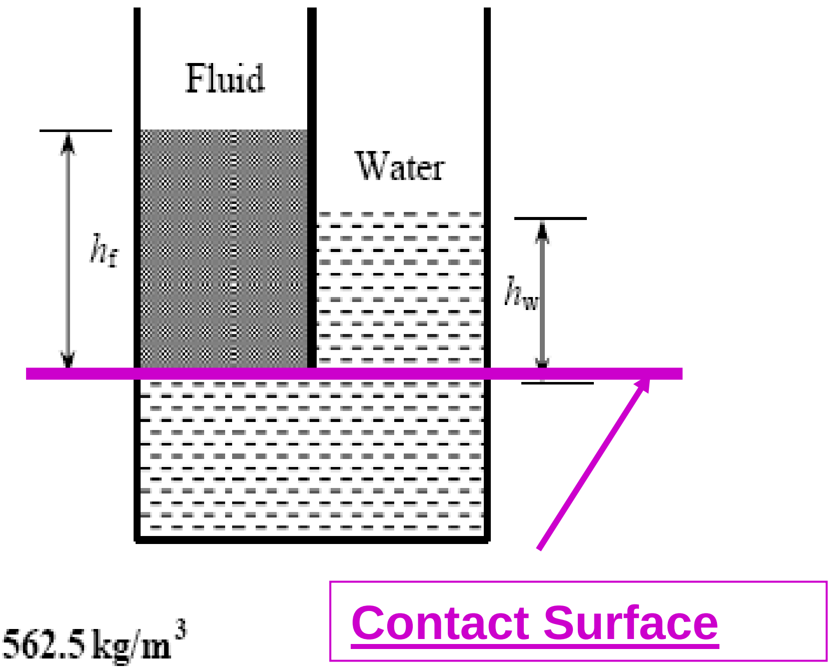


Assumptions **1** Both water and the added liquid are incompressible substances. **2** The added liquid does not mix with water.

Properties We take the density of water to be ρ =1000 kg/m³.

Analysis Both fluids are open to the atmosphere. Noting that the pressure of both water and the added fluid is the same at the contact surface, the pressure at this surface can be expressed as

$$P_{contact} = P_{atm} + \rho_f g h_f = P_{atm} + \rho_w g h_w$$

Simplifying and solving for ρ_f gives

$$\rho_f g h_f = \rho_w g h_w \quad \rightarrow \quad \rho_f = \frac{h_w}{h_f}\rho_w = \frac{45\text{ cm}}{80\text{ cm}}(1000\text{ kg/m}^3) = \mathbf{562.5\ kg/m^3}$$

Discussion Note that the added fluid is lighter than water as expected (a heavier fluid would sink in water).

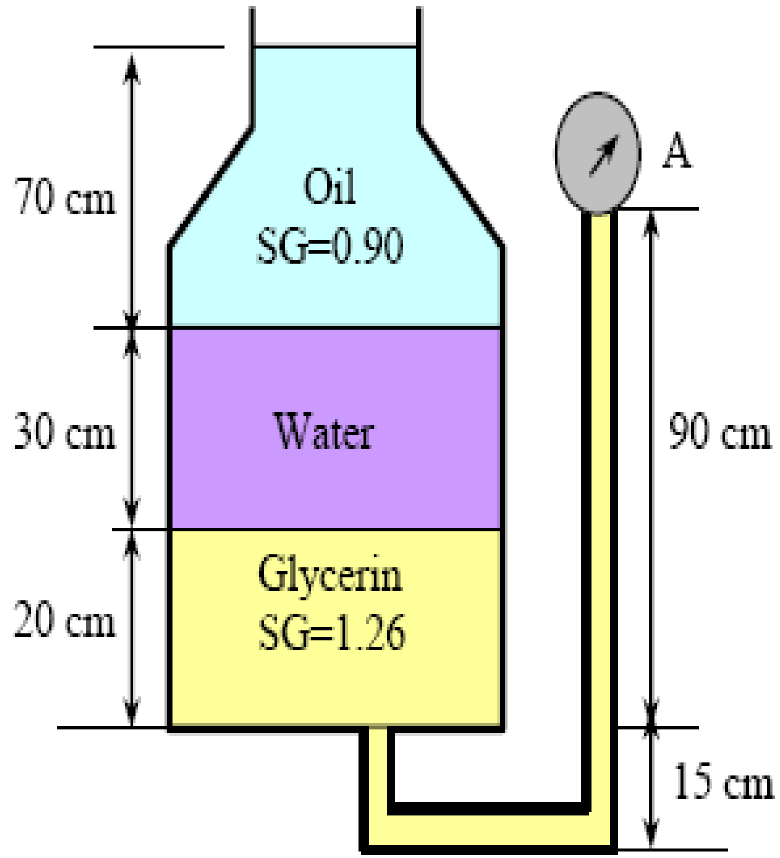
Problem (1-83)

1-83 A multi-fluid container is connected to a U-tube. For the given specific gravities and fluid column heights, the gage pressure at A and the height of a mercury column that would create the same pressure at A are to be determined.

Assumptions **1** All the liquids are incompressible. **2** The multi-fluid container is open to the atmosphere.

Properties The specific gravities are given to be 1.26 for glycerin and 0.90 for oil. We take the standard density of water to be ρ_w =1000 kg/m^3, and the specific gravity of mercury to be 13.6.

Analysis Starting with the atmospheric pressure on the top surface of the container and moving along the tube by adding (as we go down) or subtracting (as we go up) the ρgh terms until we reach point *A*, and setting the result equal to P_A give



$$P_{atm} + \rho_{oil} g h_{oil} + \rho_w g h_w - \rho_{gly} g h_{gly} = P_A$$

Problem (1-83)

Rearranging and using the definition of specific gravity,

$$P_A - P_{atm} = SG_{oil}\rho_w g h_{oil} + SG_w \rho_w g h_w - SG_{gly}\rho_w g h_{gly}$$

or

$$P_{A,gage} = g\rho_w (SG_{oil} h_{oil} + SG_w h_w - SG_{gly} h_{gly})$$

Substituting,

$$P_{A,gage} = (9.81\,\text{m/s}^2)(1000\,\text{kg/m}^3)[0.90(0.70\,\text{m}) + 1(0.3\,\text{m}) - 1.26(0.70\,\text{m})]\left(\frac{1\,\text{kN}}{1000\,\text{kg}\cdot\text{m/s}^2}\right)$$

$$= 0.471\,\text{kN/m}^2 = \mathbf{0.471\,kPa}$$

The equivalent mercury column height is

$$h_{Hg} = \frac{P_{A,gage}}{\rho_{Hg}g} = \frac{0.471\,\text{kN/m}^2}{(13{,}600\,\text{kg/m}^3)(1000\,\text{kg/m}^3)(9.81\,\text{m/s}^2)}\left(\frac{1000\,\text{kg}\cdot\text{m/s}^2}{1\,\text{kN}}\right) = 0.00353\,\text{m} = \mathbf{0.353\,cm}$$

Discussion Note that the high density of mercury makes it a very suitable fluid for measuring high pressures in manometers.

Problem (1-97)

1-97 The thrust developed by the jet engine of a Boeing 777 is given to be 85,000 pounds. This thrust is to be expressed in N and kgf.

Analysis Noting that 1 lbf = 4.448 N and 1 kgf = 9.81 N, the thrust developed can be expressed in two other units as

Thrust in N: $\text{Thrust} = (85{,}000\ \text{lbf})\left(\dfrac{4.448\ \text{N}}{1\ \text{lbf}}\right) = \mathbf{3.78 \times 10^5\ N}$

Thrust in kgf: $\text{Thrust} = (37.8 \times 10^5\ \text{N})\left(\dfrac{1\ \text{kgf}}{9.81\ \text{N}}\right) = \mathbf{3.85 \times 10^4\ kgf}$

Problem (1-111)

1-111 A glass tube open to the atmosphere is attached to a water pipe, and the pressure at the bottom of the tube is measured. It is to be determined how high the water will rise in the tube.

Properties The density of water is given to be ρ = 1000 kg/m³.

Analysis The pressure at the bottom of the tube can be expressed as

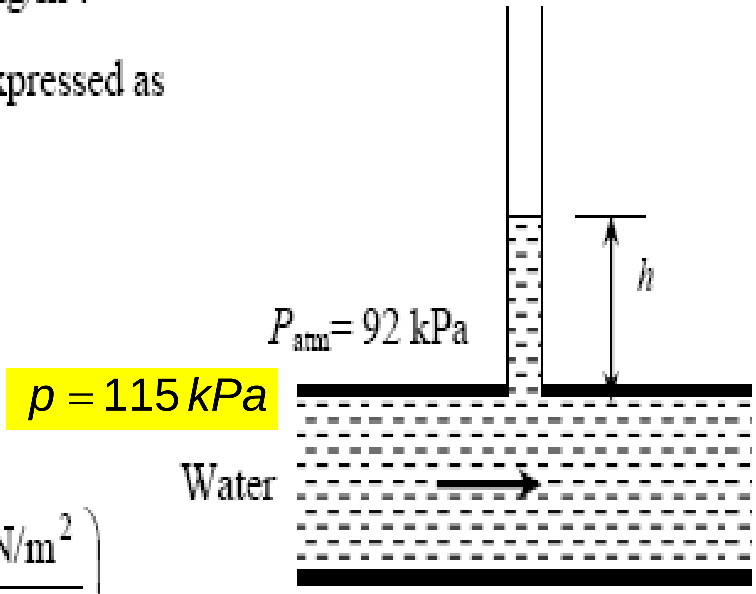
$$P = P_{atm} + (\rho g h)_{tube}$$

Solving for *h*,

$$h = \frac{P - P_{atm}}{\rho g}$$

$$= \frac{(115 - 92)\ \text{kPa}}{(1000\ \text{kg/m}^3)(9.81\ \text{m/s}^2)}\left(\frac{1\ \text{kg}\cdot\text{m/s}^2}{1\ \text{N}}\right)\left(\frac{1000\ \text{N/m}^2}{1\ \text{kPa}}\right)$$

$$= \mathbf{2.34\ m}$$



Problem (1-116)

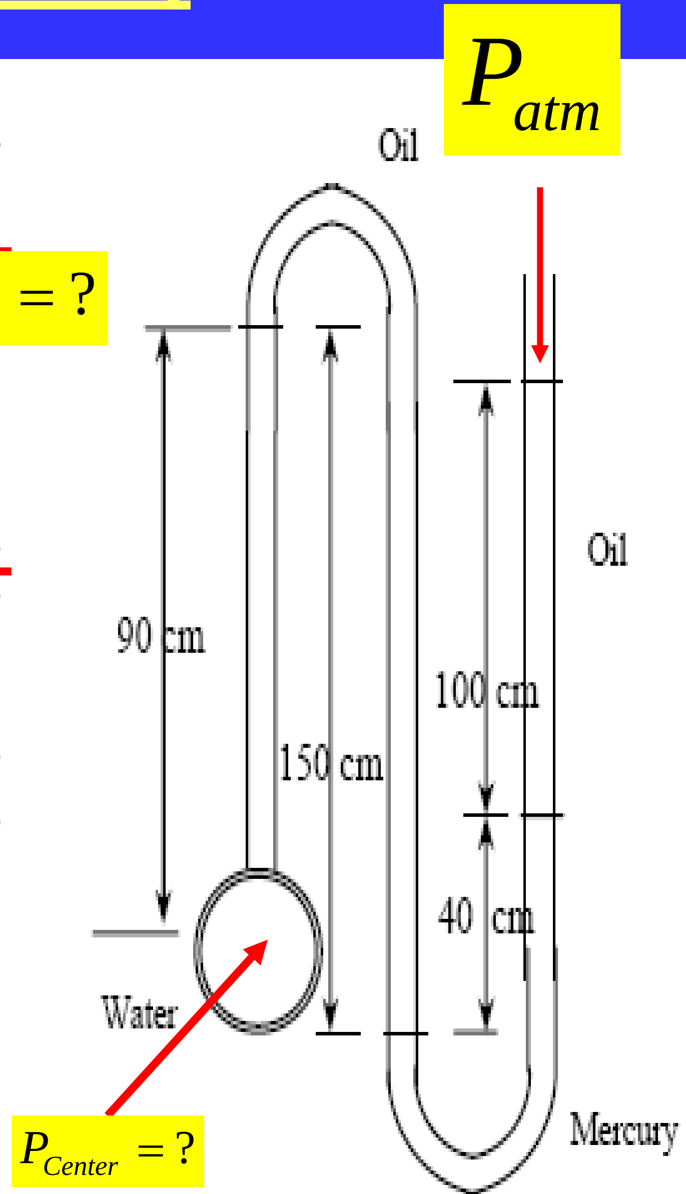
1-116 A water pipe is connected to a double-U manometer whose free arm is open to the atmosphere. The absolute pressure at the center of the pipe is to be determined.

$P_{Center} = ?$

Assumptions 1 All the liquids are incompressible. 2 The solubility of the liquids in each other is negligible.

Properties The specific gravities of mercury and oil are given to be 13.6 and 0.80, respectively. We take the density of water to be $\rho_w = 1000\ \text{kg/m}^3$.

Analysis Starting with the pressure at the center of the water pipe, and moving along the tube by adding (as we go down) or subtracting (as we go up) the ρgh terms until we reach the free surface of oil where the oil tube is exposed to the atmosphere, and setting the result equal to P_{atm} gives



Problem (1-116)

$$P_{\text{water pipe}} - \rho_{\text{water}} g h_{\text{water}} + \rho_{\text{oil}} g h_{\text{oil}} - \rho_{\text{Hg}} g h_{\text{Hg}} - \rho_{\text{oil}} g h_{\text{oil}} = P_{atm}$$

Solving for $P_{\text{water pipe}}$,

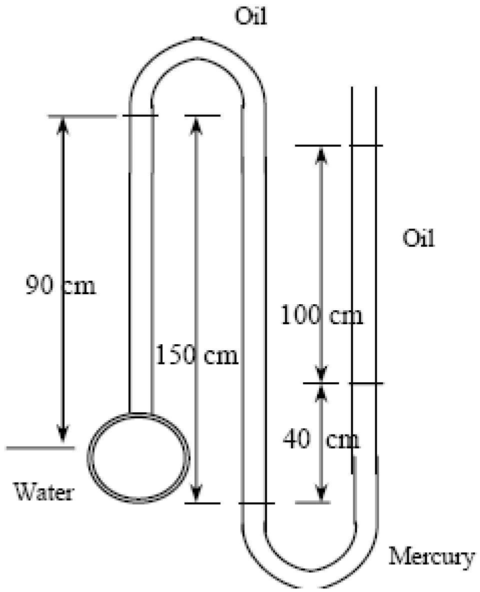
$$P_{\text{water pipe}} = P_{atm} + \rho_{\text{water}} g (h_{\text{water}} - SG_{\text{oil}} h_{\text{oil}} + SG_{\text{Hg}} h_{\text{Hg}} + SG_{\text{oil}} h_{\text{oil}})$$

Substituting,

$$P_{\text{water pipe}} = 98\,\text{kPa} + (1000\,\text{kg/m}^3)(9.81\,\text{m/s}^2)[0.90\,\text{m} - 0.8(1.5\,\text{m})$$

$$+13.6(0.4\,\text{m}) + 0.8(1\,\text{m})] \times \left(\frac{1\,\text{N}}{1\,\text{kg}\cdot\text{m/s}^2}\right)\left(\frac{1\,\text{kPa}}{1000\,\text{N/m}^2}\right)$$

$$= \mathbf{156\ kPa}$$



Therefore, the absolute pressure in the water pipe is 156 kPa.

Discussion Note that jumping horizontally from one tube to the next and realizing that pressure remains the same in the same fluid simplifies the analysis greatly.

THE END