PROBLEM 2.16

Situation: Air and water at 20°C.

Find: (a) Ratio of dynamic viscosity of air to that of water.
     (b) Ratio of kinematic viscosity of air to that of water.

Properties: From Table A.3, $\mu_{\text{air,20}^\circ\text{C}} = 1.81 \times 10^{-5}$ N·s/m²; $\nu = 1.51 \times 10^{-5}$ m²/s
From Table A.5, $\mu_{\text{water,20}^\circ\text{C}} = 1.00 \times 10^{-3}$ N·s/m²; $\nu = 1.00 \times 10^{-6}$ m²/s

ANALYSIS

\[
\frac{\mu_{\text{air}}}{\mu_{\text{water}}} = \frac{1.81 \times 10^{-5} \text{ N} \cdot \text{s/m}^2}{1.00 \times 10^{-3} \text{ N} \cdot \text{s/m}^2} = 1.81 \times 10^{-2}
\]

\[
\frac{\nu_{\text{air}}}{\nu_{\text{water}}} = \frac{1.51 \times 10^{-5} \text{ m}^2/\text{s}}{1.00 \times 10^{-6} \text{ m}^2/\text{s}} = 15.1
\]
PROBLEM 2.49

Situation: A water bug with 6 legs, each with a contact length of 5 mm, is balanced on the surface of a water pond.

Find: Maximum mass of bug to avoid sinking.

Properties: Surface tension of water, from Table A.5, $\sigma = 0.073 \text{ N/m}$.

APPROACH

Apply equilibrium, then the surface tension force equation.

ANALYSIS

Force equilibrium

\[
\text{Upward force due to surface tension} = \text{Weight of Bug}
\]

\[
F_T = mg
\]

To find the force of surface tension ($F_T$), consider the cross section of one leg of the bug:

\[
F_T = (2/\text{leg})(6 \text{ legs})\sigma \ell
\]

\[
= 12\sigma \ell
\]

\[
= 12(0.073 \text{ N/m})(0.005 \text{ m})
\]

\[
= 0.00438 \text{ N}
\]

Apply equilibrium

\[
F_T - mg = 0
\]

\[
m = \frac{F_T}{g} = \frac{0.00438 \text{ N}}{9.81 \text{ m/s}^2}
\]

\[
= 0.4465 \times 10^{-3} \text{ kg}
\]

\[
m = 0.447 \times 10^{-3} \text{ kg}
\]
PROBLEM 2.51

Situation: Two vertical glass plates are spaced 1 mm apart.

Find: Capillary rise \((h)\) between the plates.

Properties: From Table A.5, surface tension of water is \(7.3 \times 10^{-2}\) N/m.

APPROACH

Apply equilibrium, then the surface tension force equation.

ANALYSIS

Equilibrium

\[
\sum F_y = 0
\]

Force due to surface tension = Weight of fluid that has been pulled upward

\[
(2\ell)\sigma = (h\ell)\gamma
\]

Solve for capillary rise \((h)\)

\[
2\sigma\ell - h\ell\gamma = 0
\]

\[
h = \frac{2\sigma}{\gamma\ell}
\]

\[
h = \frac{2 \times (7.3 \times 10^{-2})}{9810 \times 0.0010}
\]

\[
h = 0.0149 \text{ m}
\]

\[
h = 14.9 \text{ mm}
\]
**PROBLEM 3.40**

**Situation:** A pipe system is described in the problem statement.

**Find:**
(a) Difference in pressure between points A and B.
(b) Difference in piezometric head between points A and B.

**APPROACH**

Apply the manometer equation.

**ANALYSIS**

Manometer equation

\[
p_A - (1 \text{ m}) (0.85 \times 9810 \text{ N/m}^3) + (0.5 \text{ m}) (0.85 \times 9810 \text{ N/m}^3) = p_B
\]

\[
p_A - p_B = 4169 \text{ Pa}
\]

\[
p_A - p_B = 4.169 \text{ kPa}
\]

Piezometric head

\[
h_A - h_B = \left( \frac{p_A}{\gamma} + z_A \right) - \left( \frac{p_B}{\gamma} + z_B \right)
\]

\[
= \frac{p_A - p_B}{\gamma} + (z_A - z_B)
\]

\[
= \frac{4169 \text{ N/m}^2}{0.85 \times 9810 \text{ N/m}^3} - 1 \text{ m}
\]

\[
= -0.5 \text{ m}
\]

\[
h_A - h_B = -0.50 \text{ m}
\]
PROBLEM 3.66

Situation: A submerged gate is described in the problem statement.

Find: Will gate fall or stay in position.

ANALYSIS

Hydrostatic force

\[ F = \bar{p}A \]
\[ = (1 + 1.5)9,810 \times 1 \times 3 \times \sqrt{2} \]
\[ = 104,050 \]

Center of pressure

\[ y_{cp} - \bar{y} = \frac{7}{\bar{y}A} \]
\[ = \frac{(1 \times (3\sqrt{2})^3)}{12} \]
\[ = \frac{(2.5 \times \sqrt{2})(1 \times 3\sqrt{2})}{(2.5 \times \sqrt{2})(1 \times 3\sqrt{2})} \]
\[ = 0.4243 \text{ m} \]

Overturning moment

\[ M_1 = 90,000 \times 1.5 \]
\[ = 135,000 \text{ N} \cdot \text{m} \]

Restoring moment

\[ M_2 = 104,050 \times (3\sqrt{2}/2 - 0.424) \]
\[ = 176,606 \text{ N} \cdot \text{m} \]
\[ > M_1 \]

So the gate will stay in position.
PROBLEM 3.92

Situation: A floating platform is described in the problem statement.

Find: Length of cylinder so that it floats 1 m above water surface.

**ANALYSIS**

\[ \sum F_y = 0 \]

\[ -30,000 - 4 \times 1,000L + 4 \times \left(\frac{\pi}{4}\right) \times 1^2 \times 10,000(L - 1) = 0 \]

\[ L = 2.24 \text{ m} \]