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General Physics I, Quiz 4
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SN:_______________, Name:________________

Chapter 12-15, Serway; ABSOLUTELY NO CHEATING!

P14.59 **Note:** Variation of atmospheric pressure with altitude is included in this solution. Because of the small distances involved, this effect is unimportant in the final answers.

(a) Consider the pressure at points A and B in part (b) of the figure:

Using the left tube: $P_A = P_{atm} + \rho_a g h + \rho_w g(L-h)$ where the second term is due to the variation of air pressure with altitude.

Using the right tube: $P_B = P_{atm} + \rho_0 g L$

But Pascal's principle says that $P_A = P_B$.

Therefore, $P_{atm} + \rho_0 g L = P_{atm} + \rho_a g h + \rho_w g(L-h)$

or $(\rho_w - \rho_a)h = (\rho_w - \rho_0)L$, giving

$$h = \left(\frac{\rho_w - \rho_0}{\rho_w - \rho_a}\right)L = \left(\frac{1\,000 - 750}{1\,000 - 1.29}\right)5.00 \text{ cm} = \boxed{1.25 \text{ cm}}$$

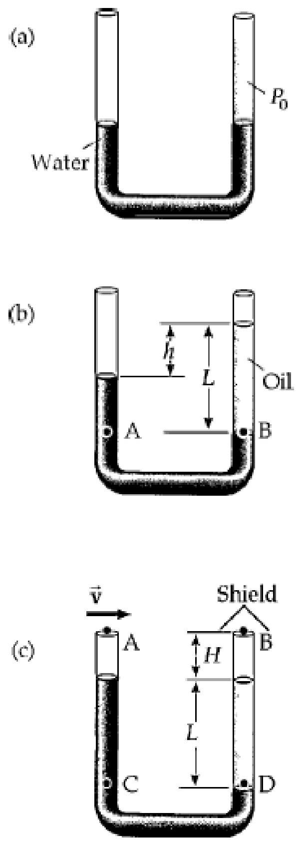

FIG. P14.59

(b) Consider part (c) of the diagram showing the situation when the air flow over the left tube equalizes the fluid levels in the two tubes. First, apply Bernoulli's equation to points A and B $(y_A = y_B,\ v_A = v,\ \text{and } v_B = 0)$

This gives: $P_A + \frac{1}{2}\rho_a v^2 + \rho_a g y_A = P_B + \frac{1}{2}\rho_a (0)^2 + \rho_a g y_B$

and since $y_A = y_B$, this reduces to: $P_B - P_A = \frac{1}{2}\rho_a v^2$ (1)

Now consider points C and D, both at the level of the oil–water interface in the right tube. Using the variation of pressure with depth in static fluids, we have:

$P_C = P_A + \rho_a g H + \rho_w g L$ and $P_D = P_B + \rho_a g H + \rho_0 g L$

But Pascal's principle says that $P_C = P_D$. Equating these two gives:

$P_B + \rho_a g H + \rho_0 g L = P_A + \rho_a g H + \rho_w g L$ or $P_B - P_A = (\rho_w - \rho_0) g L$ (2)

Substitute equation (1) for $P_B - P_A$ into (2) to obtain $\frac{1}{2}\rho_a v^2 = (\rho_w - \rho_0) g L$

or

$$v = \sqrt{\frac{2gL(\rho_w - \rho_0)}{\rho_a}} = \sqrt{2(9.80 \text{ m/s}^2)(0.050\,0 \text{ m})\left(\frac{1\,000 - 750}{1.29}\right)}$$

$$v = \boxed{13.8 \text{ m/s}}$$

P15.59 (a) When the mass is displaced a distance x from equilibrium, spring 1 is stretched a distance x_1 and spring 2 is stretched a distance x_2.

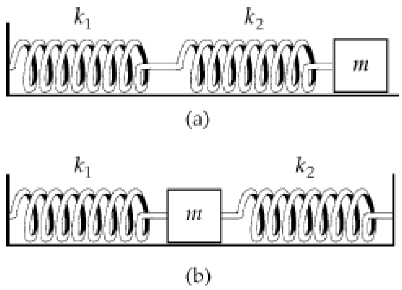

FIG. P15.59

By Newton's third law, we expect

$$k_1 x_1 = k_2 x_2.$$

When this is combined with the requirement that

$$x = x_1 + x_2,$$

we find $\qquad x_1 = \left[\frac{k_2}{k_1 + k_2}\right] x$

The force on either spring is given by $\qquad F_1 = \left[\frac{k_1 k_2}{k_1 + k_2}\right] x = ma$

where a is the acceleration of the mass m.

This is in the form $\qquad F = k_{eff} x = ma$

and $\qquad T = 2\pi\sqrt{\frac{m}{k_{eff}}} = \boxed{2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}}$

(b) In this case each spring is distorted by the distance x which the mass is displaced. Therefore, the restoring force is

$$F = -(k_1 + k_2)x \qquad \text{and} \qquad k_{eff} = k_1 + k_2$$

so that $\qquad T = \boxed{2\pi\sqrt{\frac{m}{(k_1 + k_2)}}}$