5. **THINK** The pressure difference between two sides of the window results in a net force acting on the window.

EXPRESS The air inside pushes outward with a force given by p_iA, where p_i is the pressure inside the room and A is the area of the window. Similarly, the air on the outside pushes inward with a force given by p_oA, where p_o is the pressure outside. The magnitude of the net force is $F = (p_i - p_o)A$.

ANALYZE Since 1 atm = 1.013×10^5 Pa, the net force is

$$\begin{aligned} F &= (p_i - p_o)A = (1.0\text{ atm} - 0.96\text{ atm})(1.013\times10^5\text{ Pa/atm})(3.4\text{ m})(2.1\text{ m}) \\ &= 2.9\times10^4\text{ N.} \end{aligned}$$

LEARN The net force on the window vanishes when the pressure inside the office is equal to the pressure outside.

10. With $A = 0.000500\text{ m}^2$ and $F = pA$ (with p given by Eq. 14-9), then we have ρghA = 9.80 N. This gives $h \approx 2.0$ m, which means $d + h = 2.80$ m.

19. We can integrate the pressure (which varies linearly with depth according to Eq. 14-7) over the area of the wall to find out the net force on it, and the result turns out fairly intuitive (because of that linear dependence): the force is the "average" water pressure multiplied by the area of the wall (or at least the part of the wall that is exposed to the water), where "average" pressure is taken to mean $\frac{1}{2}$(pressure at surface + pressure at bottom). Assuming the pressure at the surface can be taken to be zero (in the gauge pressure sense explained in section 14-4), then this means the force on the wall is $\frac{1}{2}\rho gh$ multiplied by the appropriate area. In this problem the area is hw (where w is the 8.00 m width), so the force is $\frac{1}{2}\rho gh^2w$, and the change in force (as h is changed) is

$$\tfrac{1}{2}\rho gw\,(h_f^{\,2} - h_i^{\,2}) = \tfrac{1}{2}(998\text{ kg/m}^3)(9.80\text{ m/s}^2)(8.00\text{ m})(4.00^2 - 2.00^2)\text{m}^2 = 4.69\times10^5\text{ N.}$$

27. **THINK** The atmospheric pressure at a given height depends on the density distribution of air.

EXPRESS If the air density were uniform, ρ =const., then the variation of pressure with height may be written as: $p_2 = p_1 - \rho g(y_2 - y_1)$. We take y_1 to be at the surface of Earth, where the pressure is $p_1 = 1.01\times10^5$ Pa, and y_2 to be at the top of the atmosphere, where the pressure is $p_2 = 0$. On the other hand, if the density varies with altitude, then

$$p_2 = p_1 - \int_0^h \rho g \, dy .$$

For the case where the density decreases linearly with height, $\rho = \rho_0 (1 - y/h)$, where ρ_0 is the density at Earth's surface and $g = 9.8 \text{ m/s}^2$ for $0 \le y \le h$, the integral becomes

$$p_2 = p_1 - \int_0^h \rho_0 g \left(1 - \frac{y}{h}\right) dy = p_1 - \frac{1}{2}\rho_0 gh.$$

ANALYZE (a) For uniform density with $\rho = 1.3 \text{ kg/m}^3$, we find the height of the atmosphere to be

$$y_2 - y_1 = \frac{p_1}{\rho g} = \frac{1.01 \times 10^5 \text{ Pa}}{(1.3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)} = 7.9 \times 10^3 \text{ m} = 7.9 \text{ km}.$$

(b) With density decreasing linearly with height, $p_2 = p_1 - \rho_0 gh/2$. The condition $p_2 = 0$ implies

$$h = \frac{2p_1}{\rho_0 g} = \frac{2(1.01 \times 10^5 \text{ Pa})}{(1.3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)} = 16 \times 10^3 \text{ m} = 16 \text{ km}.$$

LEARN Actually the decrease in air density is approximately exponential, with pressure halved at a height of about 5.6 km.

29. Equation 14-13 combined with Eq. 5-8 and Eq. 7-21 (in absolute value) gives

$$mg = kx \frac{A_1}{A_2} .$$

With $A_2 = 18A_1$ (and the other values given in the problem) we find $m = 8.50$ kg.