10–4 Atmospheric Pressure and Gauge Pressure

Atmospheric Pressure

The pressure of the Earth's atmosphere, as in any fluid, changes with depth. But the Earth's atmosphere is somewhat complicated: not only does the density of air vary greatly with altitude but there is no distinct top surface to the atmosphere from which h (in Eq. 10–3a) could be measured. We can, however, calculate the approximate difference in pressure between two altitudes using Eq. 10–3b.

The pressure of the air at a given place varies slightly according to the weather. At sea level, the pressure of the atmosphere on average is $1.013 \times 10^5\,\mathrm{N/m^2}$ (or $14.7\,\mathrm{lb/in.^2}$). This value lets us define a commonly used unit of pressure, the **atmosphere** (abbreviated atm):

One atmosphere (unit of pressure)

$$1\,\mathrm{atm} = 1.013 \times 10^5\,\mathrm{N/m^2} = 101.3\,\mathrm{kPa}.$$

Another unit of pressure sometimes used (in meteorology and on weather maps) is the **bar**, which is defined as

The bar (unit of pressure)

$$1\,\mathrm{bar} = 1.00 \times 10^5\,\mathrm{N/m^2}.$$

Thus standard atmospheric pressure is slightly more than 1 bar.

PHYSICS APPLIED
Pressure on living cells

The pressure due to the weight of the atmosphere is exerted on all objects immersed in this great sea of air, including our bodies. How does a human body withstand the enormous pressure on its surface? The answer is that living cells maintain an internal pressure that closely equals the external pressure, just as the pressure inside a balloon closely matches the outside pressure of the atmosphere. An automobile tire, because of its rigidity, can maintain internal pressures much greater than the external pressure.

CONCEPTUAL EXAMPLE 10–4 **Finger holds water in a straw.** You insert a straw of length L into a tall glass of water. You place your finger over the top of the straw, capturing some air above the water but preventing any additional air from getting in or out, and then you lift the straw from the water. You find that the straw retains most of the water. (See Fig. 10–6a.) Does the air in the space between your finger and the top of the water have a pressure P that is greater than, equal to, or less than, the atmospheric pressure P_A outside the straw?

RESPONSE Consider the forces on the column of water (Fig. 10–6b). Atmospheric pressure outside the straw pushes upward on the water at the bottom of the straw, gravity pulls the water downward, and the air pressure inside the top of the straw pushes downward on the water. Since the water is in equilibrium, the upward force due to atmospheric pressure must balance the two downward forces. The only way this is possible is for the air pressure inside the straw to be less than the atmosphere pressure outside the straw. (When you initially remove the straw, a little water may leave the bottom of the straw, thus increasing the volume of trapped air and reducing its density and pressure.)

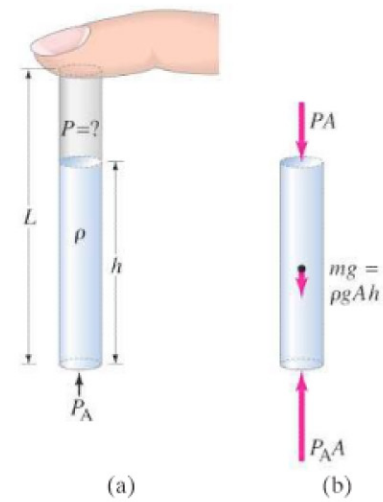

FIGURE 10–6 Example 10–4.

Gauge Pressure

It is important to note that tire gauges, and most other pressure gauges, register the pressure above and beyond atmospheric pressure. This is called **gauge pressure**. Thus, to get the **absolute pressure**, P, we must add the atmospheric pressure, P_A, to the gauge pressure, P_G:

Gauge pressure

Absolute pressure = atmospheric pressure + gauge pressure

$$P = P_A + P_G.$$

If a tire gauge registers 220 kPa, the absolute pressure within the tire is $220\,\mathrm{kPa} + 101\,\mathrm{kPa} = 321\,\mathrm{kPa}$, equivalent to about 3.2 atm (2.2 atm gauge pressure).