EXAMPLE 20–10 **Force between two current-carrying wires.** The two wires of a 2.0-m-long appliance cord are 3.0 mm apart and carry a current of 8.0 A dc. Calculate the force one wire exerts on the other.

APPROACH Each wire is in the magnetic field of the other when the current is on, so we can apply Eq. 20–7. We can write $\mu_0/2\pi = 2.0 \times 10^{-7}\,\mathrm{T\cdot m/A}$.

SOLUTION Equation 20–7 gives

$$F = \frac{(2.0 \times 10^{-7}\,\mathrm{T\cdot m/A})(8.0\,\mathrm{A})^2(2.0\,\mathrm{m})}{(3.0 \times 10^{-3}\,\mathrm{m})} = 8.5 \times 10^{-3}\,\mathrm{N}.$$

The currents are in opposite directions (one toward the appliance, the other away from it), so the force would be repulsive and tend to spread the wires apart.

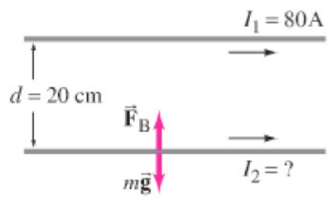

FIGURE 20–25 Example 20–11.

EXAMPLE 20–11 **Suspending a current with a current.** A horizontal wire carries a current $I_1 = 80$ A dc. A second parallel wire 20 cm below it (Fig. 20–25) must carry how much current I_2 so that it doesn't fall due to gravity? The lower wire has a mass of 0.12 g per meter of length.

APPROACH If wire 2 is not to fall under gravity, which acts downward, the magnetic force on it must be upward. This means that the current in the two wires must be in the same direction. We can find the current I_2 by equating the magnitudes of the magnetic force and the gravitational force on the wire.

SOLUTION The force of gravity on wire 2 is downward. For each 1.0 m of wire length, the gravitational force has magnitude

$$F = mg = (0.12 \times 10^{-3}\,\mathrm{kg/m})(1.0\,\mathrm{m})(9.8\,\mathrm{m/s^2}) = 1.18 \times 10^{-3}\,\mathrm{N}.$$

The magnetic force on wire 2 must be upward, and Eq. 20–7 gives

$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}\, l$$

where $d = 0.20$ m and $I_1 = 80$ A. We solve this for I_2 and set the two force magnitudes equal (letting $l = 1.0$ m):

$$I_2 = \frac{2\pi d}{\mu_0 I_1}\left(\frac{F}{l}\right) = \frac{2\pi(0.20\,\mathrm{m})}{(4\pi \times 10^{-7}\,\mathrm{T\cdot m/A})(80\,\mathrm{A})}(1.18 \times 10^{-3}\,\mathrm{N/m}) = 15\,\mathrm{A}.$$

* Definition of the Ampere and the Coulomb

You may have wondered how the constant μ_0 in Eq. 20–6 could be exactly $4\pi \times 10^{-7}\,\mathrm{T\cdot m/A}$. Here is how it happened. With an older definition of the ampere, μ_0 was measured experimentally to be very close to this value. Today, however, μ_0 is *defined* to be exactly $4\pi \times 10^{-7}\,\mathrm{T\cdot m/A}$. This, of course, could not be done if the ampere were defined independently. The ampere, the unit of current, is now defined in terms of the magnetic field B it produces using the defined value of μ_0.

In particular, we use the force between two parallel current-carrying wires, Eq. 20–7, to define the ampere precisely. If $I_1 = I_2 = 1$ A exactly, and the two wires are exactly 1 m apart, then

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} = \frac{(4\pi \times 10^{-7}\,\mathrm{T\cdot m/A})}{(2\pi)}\frac{(1\,\mathrm{A})(1\,\mathrm{A})}{(1\,\mathrm{m})} = 2 \times 10^{-7}\,\mathrm{N/m}.$$

Definitions of ampere and coloumb

Thus, *one* **ampere** *is defined as that current flowing in each of two long parallel wires, 1 m apart, which results in a force of exactly 2×10^{-7} N/m of length of each wire.*

This is the precise definition of the ampere. The **coulomb** is then defined as being *exactly* one ampere-second: $1\,\mathrm{C} = 1\,\mathrm{A\cdot s}$.