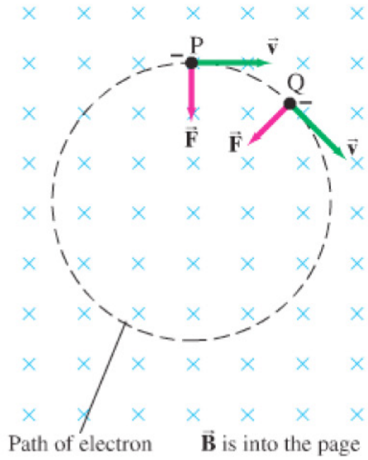

FIGURE 20–16 Force exerted by a uniform magnetic field on a moving charged particle (in this case, an electron) produces a circular path.

The path of a charged particle moving in a plane perpendicular to a uniform magnetic field is a circle as we shall now show. In Fig. 20–16 the magnetic field is directed *into* the paper, as represented by ×'s. An electron at point P is moving to the right, and the force on it at this point is downward as shown (use the right-hand rule and reverse the direction for negative charge). The electron is thus deflected downward. A moment later, say, when it reaches point Q, the force is still perpendicular to the velocity and is in the direction shown. Because the force is always perpendicular to $\vec{\mathbf{v}}$, the magnitude of $\vec{\mathbf{v}}$ does not change—the electron moves at constant speed. We saw in Chapter 5 that if the force on a particle is always perpendicular to its velocity $\vec{\mathbf{v}}$, the particle moves in a circle and undergoes a centripetal acceleration $a = v^2/r$ (Eq. 5–1). Thus a charged particle moves in a circular path with constant centripetal acceleration (see Example 20–5) in a uniform magnetic field. The electron moves clockwise in Fig. 20–16. A positive particle would feel a force in the opposite direction and would thus move counterclockwise.

EXAMPLE 20–5 **Electron's path in a uniform magnetic field.** An electron travels at $2.0 \times 10^7\,\mathrm{m/s}$ in a plane perpendicular to a uniform 0.010-T magnetic field. Describe its path quantitatively.

APPROACH The electron moves at speed v in a curved path and so must have a centripetal acceleration $a = v^2/r$ (Eq. 5–1). We find the radius of curvature using Newton's second law. The force is given by Eq. 20–3 with $\sin\theta = 1,\ F = qvB$.

SOLUTION We insert F and a into Newton's second law:

$$\Sigma F = ma$$

$$qvB = \frac{mv^2}{r}.$$

We solve for r and find

$$r = \frac{mv}{qB}.$$

Since $\vec{\mathbf{F}}$ is perpendicular to $\vec{\mathbf{v}}$, the magnitude of $\vec{\mathbf{v}}$ doesn't change. From this equation we see that if $\vec{\mathbf{B}} = \text{constant}$, then $r = \text{constant}$, and the curve must be a circle as we claimed above. To get r we put in the numbers:

$$r = \frac{(9.1 \times 10^{-31}\,\mathrm{kg})(2.0 \times 10^7\,\mathrm{m/s})}{(1.6 \times 10^{-19}\,\mathrm{C})(0.010\,\mathrm{T})} = 1.1 \times 10^{-2}\,\mathrm{m} = 1.1\,\mathrm{cm}.$$