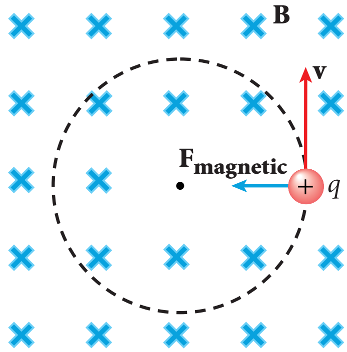

Figure 10
When the velocity, **v,** of a charged particle is perpendicular to a uniform magnetic field, the particle moves in a circle whose plane is perpendicular to **B.**

A charge moving through a magnetic field follows a circular path

Consider a positively charged particle moving in a uniform magnetic field. Suppose the direction of the particle's initial velocity is exactly perpendicular to the field, as in **Figure 10.** Application of the right-hand rule for the charge q shows that the direction of the magnetic force, $\mathbf{F}_{\mathbf{magnetic}}$, at the charge's location is to the left. Furthermore, application of the right-hand rule at any point shows that the magnetic force is always directed toward the center of the circular path. Therefore, the magnetic force is, in effect, a force that maintains circular motion and changes only the direction of **v,** not its magnitude.

Now consider a charged particle traveling with its initial velocity at some angle to a uniform magnetic field. A component of the particle's initial velocity is parallel to the magnetic field. This parallel part is not affected by the magnetic field, and that part of the motion will remain the same. The perpendicular part results in a circular motion, as described above. The particle will follow a helical path, like the red stripes on a candy cane, whose axis is parallel to the magnetic field.

MAGNETIC FORCE ON A CURRENT-CARRYING CONDUCTOR

Recall that current consists of many charged particles in motion. If a force is exerted on a single charged particle when the particle moves through a magnetic field, it should be no surprise that a current-carrying wire also experiences a force when it is placed in a magnetic field. The resultant force on the wire is the sum of the individual magnetic forces on the charged particles. The force on the particles is transmitted to the bulk of the wire through collisions with the atoms making up the wire.

Consider a straight segment of wire of length ℓ carrying current, I, in a uniform external magnetic field, **B,** as in **Figure 11.** When the current and magnetic field are perpendicular, the magnitude of the total magnetic force on the wire is given by the following relationship.

FORCE ON A CURRENT-CARRYING CONDUCTOR PERPENDICULAR TO A MAGNETIC FIELD

$$F_{magnetic} = BI\ell$$

magnitude of magnetic force = (magnitude of magnetic field)(current)(length of conductor within B)

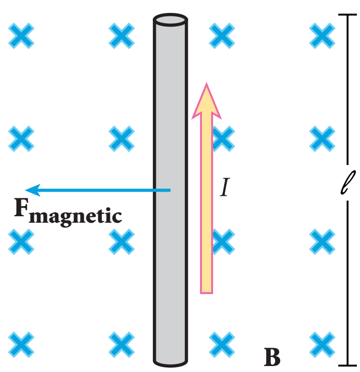

Figure 11
A current-carrying conductor in a magnetic field experiences a force that is perpendicular to the direction of the current.

The direction of the magnetic force on a wire can be obtained by using the right-hand rule. However, in this case, you must place your thumb in the direction of the current rather than in the direction of the velocity, **v.** In **Figure 11,** the direction of the magnetic force on the wire is to the left. When the current is either in the direction of the field or opposite the direction of the field, the magnetic force on the wire is zero.