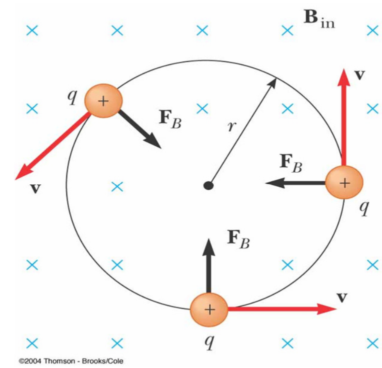
29.4 **Motion of charged particle in a uniform magnetic field**

The magnetic force acting on a charged particle moving in a magnetic field is perpendicular to the velocity of the particle and that consequently the work done on the particle by the magnetic force is zero.



Because F_B always points toward the center of the circle, it changes only the direction of v and not its magnitude.

the rotation is counterclockwise for a positive charge. If *q were negative, the rotation would be clockwise.*

$$F_m = F_C$$

$$qvB = m\frac{v^2}{r} \qquad \textbf{29.2}$$

From this equation (29.2), one can calculate the radius of the path of charged particle,

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

Also, we can calculate the angular speed,

$$\omega = \frac{v}{r} = \frac{qB}{m}$$

Moreover, the time period,

$$T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}$$

Please remember that the period of the motion T is the time that the particle takes to complete one revolution and is equal to the circumference of the circle divided by the linear speed of the particle.

Example 29.6

A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35-T magnetic field perpendicular to the velocity of the proton. Find the linear speed of the proton.

Example 29.6 A Proton Moving Perpendicular to a Uniform Magnetic Field

A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35-T magnetic field perpendicular to the velocity of the proton. Find the linear speed of the proton.

Solution From Equation 29.13, we have

$$v = \frac{qBr}{m_p} = \frac{(1.60 \times 10^{-19}\ \mathrm{C})(0.35\ \mathrm{T})(0.14\ \mathrm{m})}{1.67 \times 10^{-27}\ \mathrm{kg}}$$

$$= 4.7 \times 10^{6}\ \mathrm{m/s}$$

What If? **What if an electron, rather than a proton, moves in a direction perpendicular to the same magnetic field with this same linear speed? Will the radius of its orbit be different?**

Answer An electron has a much smaller mass than a proton, so the magnetic force should be able to change its velocity much easier than for the proton. Thus, we should expect the radius to be smaller. Looking at Equation 29.13, we see that r is proportional to m with q, B, and v the same for the electron as for the proton. Consequently, the radius will be smaller by the same factor as the ratio of masses m_e/m_p.

Exercise If an electron moves in a direction perpendicular to the same magnetic field with this same linear speed, what is the radius of its circular orbit?

2- If an electron moves with linear velocity 5×10^{3} m/s, under a perpendicular magnetic field of 8 T, what is the radius of its angular path.

A. 5 mm B. 3.6 nm C. 1.6 nm D. 1.4 µm

3- A 20 mC charge moves in a circular orbit making 20 turns/s. If the magnetic field, perpendicular to the motion, is 3 T, what is the mass of the particle?

A) 4.77×10^{-4} B) 9.54×10^{-4} C) 1.59×10^{-4} D) 0.24×10^{-4}