Magnetic Force

SECTION 3

SECTION OBJECTIVES

- **Given the force on a charge in a magnetic field, determine the strength of the magnetic field.**
- **Use the right-hand rule to find the direction of the force on a charge moving through a magnetic field.**
- **Determine the magnitude and direction of the force on a wire carrying current in a magnetic field.**

CHARGED PARTICLES IN A MAGNETIC FIELD

Although experiments show that a constant magnetic field does not exert a net force on a stationary charged particle, charges moving through a magnetic field do experience a magnetic force. This force has its maximum value when the charge moves perpendicular to the magnetic field, decreases in value at other angles, and becomes zero when the particle moves along the field lines. To keep the math simple in this book, we will limit our discussion to situations in which charges move parallel or perpendicular to the magnetic field lines.

A charge moving through a magnetic field experiences a force

Recall that the electric field at a point in space is defined as the electric force per unit charge acting on some test charge placed at that point. In a similar manner, we can describe the properties of the magnetic field, **B,** in terms of the magnetic force exerted on a test charge at a given point. Our test object is assumed to be a positive charge, q, moving with velocity **v** perpendicular to **B.** It has been found experimentally that the strength of the magnetic force on the particle moving perpendicular to the field is equal to the product of the magnitude of the charge, q, the magnitude of the velocity, v, and the strength of the external magnetic field, B, as shown by the following relationship.

$$F_{magnetic} = qvB$$

This expression can be rearranged as follows:

MAGNITUDE OF A MAGNETIC FIELD

$$B = \frac{F_{magnetic}}{qv}$$

$$\text{magnetic field} = \frac{\text{magnetic force on a charged particle}}{(\text{magnitude of charge})(\text{speed of charge})}$$

If the force is in newtons, the charge is in coulombs, and the speed is in meters per second, the unit of magnetic field strength is the tesla (T). Thus, if a 1 C charge moving at 1 m/s perpendicular to a magnetic field experiences a magnetic force of 1 N, the magnitude of the magnetic field is equal to 1 T. Most magnetic fields are much smaller than 1 T. We can express the units of the magnetic field as follows:

$$T = \frac{N}{C \bullet m/s} = \frac{N}{A \bullet m} = \frac{V \bullet s}{m^2}$$

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