MAGNETIC FIELDS

magnetic field

a region in which a magnetic force can be detected

You know that the interaction between charged objects can be described using the concept of an electric field. A similar approach can be used to describe the **magnetic field** that surrounds any magnetized material. As with an electric field, a magnetic field, **B,** is a vector quantity that has both magnitude and direction.

Magnetic field lines can be drawn with the aid of a compass

The magnetic field of a bar magnet can be explored using a compass, as illustrated in **Figure 3.** If a small, freely suspended bar magnet, such as the needle of a compass, is brought near a magnetic field, the compass needle will align with the magnetic field lines. The direction of the magnetic field, **B,** at any location is defined as the direction that the north pole of a compass needle points to at that location.

Magnetic field lines appear to begin at the north pole of a magnet and to end at the south pole of a magnet. However, magnetic field lines have no beginning or end. Rather, they always form a closed loop. In a permanent magnet, the field lines actually continue within the magnet itself to form a closed loop. (These lines are not shown in the illustration.)

This text will follow a simple convention to indicate the direction of **B.** An arrow will be used to show a magnetic field that is in the same plane as the page, as shown in **Table 1.** When the field is directed into the page, we will use a series of blue crosses to represent the tails of arrows. If the field is directed out of the page, we will use a series of blue dots to represent the tips of arrows.

Table 1
Conventions for Representing the Direction of a Magnetic Field

In the plane of the page	↑
Into the page	✕
Out of the page	●

Magnetic flux relates to the strength of a magnetic field

One useful way to model magnetic field strength is to define a quantity called *magnetic flux*, Φ_M. It is defined as the number of field lines that cross a certain area at right angles to that area. Magnetic flux can be calculated by the following equation.

MAGNETIC FLUX

$$\Phi_M = AB\cos\theta$$

magnetic flux = (surface area) × (magnetic field component normal to the plane of surface)

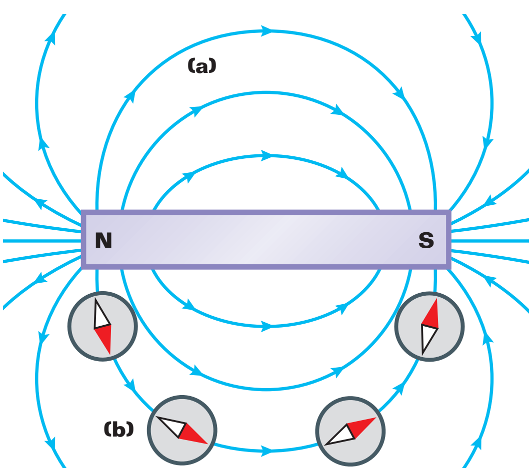

Figure 3
The magnetic field **(a)** of a bar magnet can be traced with a compass **(b).** Note that the north poles of the compasses point in the direction of the field lines from the magnet's north pole to its south pole.

Now look again at **Figure 3.** Imagine two circles of the same size that are perpendicular to the axis of the magnet. One circle is located near one pole of the magnet, and the other circle is alongside the magnet. More magnetic field lines cross the circle that is near the pole of the magnet. This greater flux indicates that the magnetic field is strongest at the magnet's poles.