The rule for finding the direction of the induced current is called *Lenz's law* and is expressed as follows:

*The magnetic field of the induced current is in a direction to produce a field that opposes the change causing it.*

Note that the field of the induced current does not oppose the applied field but rather the change in the applied field. If the applied field changes, the induced field tends to keep the total field strength constant.

### Faraday's law of induction predicts the magnitude of the induced emf

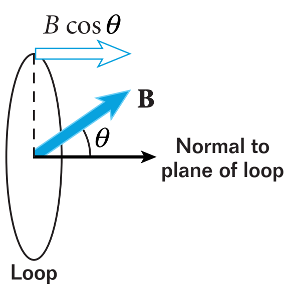


**Figure 6**
The angle $\theta$ is defined as the angle between the magnetic field and the normal to the plane of the loop. $B\cos\theta$ equals the strength of the magnetic field perpendicular to the plane of the loop.

Lenz's law allows you to determine the direction of an induced current in a circuit. Lenz's law does not provide information on the magnitude of the induced current or the induced emf. To calculate the magnitude of the induced emf, you must use *Faraday's law of magnetic induction.* For a single loop of a circuit, this may be expressed as follows:

$$\text{emf} = -\frac{\Delta\Phi_M}{\Delta t}$$

Recall from the chapter on magnetism that the magnetic flux, $\Phi_M$, can be written as $AB\cos\theta$. This equation means that a change with time of any of the three variables—applied magnetic field strength, $B$; circuit area, $A$; or angle of orientation, $\theta$—can give rise to an induced emf. The term $B\cos\theta$ represents the component of the magnetic field perpendicular to the plane of the loop. The angle $\theta$ is measured between the applied magnetic field and the normal to the plane of the loop, as indicated in **Figure 6.**

The minus sign in front of the equation is included to indicate the polarity of the induced emf. The sign indicates that the induced magnetic field opposes the change in the applied magnetic field as stated by Lenz's law.

If a circuit contains a number, $N$, of tightly wound loops, the average induced emf is simply $N$ times the induced emf for a single loop. The equation thus takes the general form of Faraday's law of magnetic induction.

**FARADAY'S LAW OF MAGNETIC INDUCTION**

$$\text{emf} = -N\frac{\Delta\Phi_M}{\Delta t}$$

**average induced emf = –the number of loops in the circuit × the time rate of change of the magnetic flux**

In this chapter, $N$ is always assumed to be a whole number.

Recall that the SI unit for magnetic field strength is the tesla (T), which equals one newton per ampere-meter, or N/(A•m). The tesla can also be expressed in the equivalent units of one volt-second per meter squared, or (V•s)/$m^2$. Thus, the unit for emf, as for electric potential, is the volt.