Consider a conducting wire pulled through a magnetic field, as shown on the left in **Figure 2.** You learned when studying magnetism that charged particles moving with a velocity at an angle to the magnetic field will experience a magnetic force. According to the right-hand rule, this force will be perpendicular to both the magnetic field and the motion of the charges. For free positive charges in the wire, the force is directed downward along the wire. For negative charges, the force is upward. This effect is equivalent to replacing the segment of wire and the magnetic field with a battery that has a potential difference, or emf, between its terminals, as shown on the right in **Figure 2.** As long as the conducting wire moves through the magnetic field, the emf will be maintained.

The polarity of the induced emf depends on the direction in which the wire is moved through the magnetic field. For instance, if the wire in **Figure 2** is moved to the right, the right-hand rule predicts that the negative charges will be pushed upward. If the wire is moved to the left, the negative charges will be pushed downward. The magnitude of the induced emf depends on the velocity with which the wire is moving through the magnetic field, on the length of the wire in the field, and on the strength of the magnetic field.

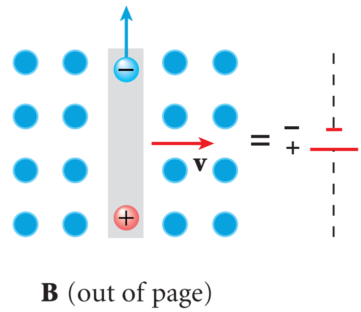

Figure 2
The separation of positive and negative moving charges by the magnetic force creates a potential difference (emf) between the ends of the conductor.

The angle between a magnetic field and a circuit affects induction

One way to induce an emf in a closed loop of wire is to move all or part of the loop into or out of a constant magnetic field. No emf is induced if the loop is static and the magnetic field is constant.

The magnitude of the induced emf and current depend partly on how the loop is oriented to the magnetic field, as shown in **Figure 3.** The induced current is largest if the plane of the loop is perpendicular to the magnetic field, as in **(a);** it is smaller if the plane is tilted into the field, as in **(b);** and it is zero if the plane is parallel to the field, as in **(c).**

The role that the orientation of the loop plays in inducing the current can be explained by the force that the magnetic field exerts on the charges in the moving loop. Only the component of the magnetic field *perpendicular* to both the plane and the motion of the loop exerts a magnetic force on the charges in the loop. If the area of the loop is moved *parallel* to the magnetic field, there is no magnetic field component perpendicular to the plane of the loop and therefore no induced emf to move the charges around the circuit.

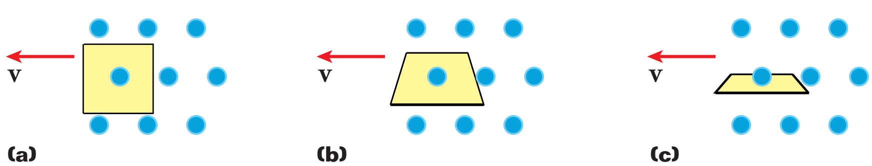

Figure 3
These three loops of wire are moving out of a region that has a constant magnetic field. The induced emf and current are largest when the plane of the loop is perpendicular to the magnetic field **(a),** smaller when the plane of the loop is tilted **(b),** and zero when the plane of the loop and the magnetic field are parallel **(c).**