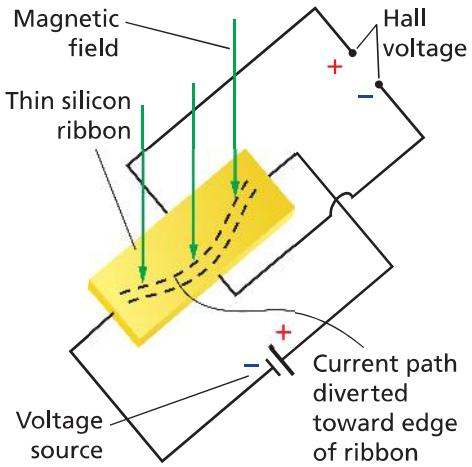
The Hall Effect

Something as simple as magnetic fields deflecting charged particles has led to a revolution in how we measure or detect the movement of things, such as bicycle wheels and automotive crankshafts. It all starts when current passes through a wide, flat conductor, in the presence of a magnetic field.



A magnetic field forces more electrons to the edge of a thin metal strip. This creates the Hall voltage.

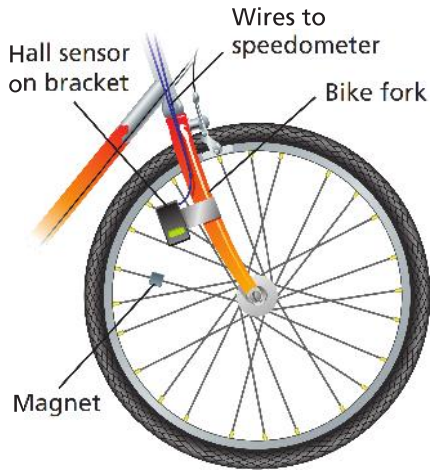
The magnetic lines of force are perpendicular to the ribbon's broad surface. This makes the flowing electrons crowd into one side of the ribbon. Because there are more electrons on one edge of the ribbon than on the other, a voltage, called the *Hall voltage,* is generated across the width of the ribbon. The magnitude of the Hall voltage is dependent upon the strength of the magnetic field.

E.H. Hall discovered this effect in 1879. Its industrial and scientific significance were discovered only recently because the Hall voltage is small in ribbons of conventional metals. Now, very thin layers of semiconducting silicon yield substantial Hall voltages.

The Hall effect can be used to explore conduction in different types of materials. The sign of the Hall-effect voltage gives the sign of the moving charge, and the magnitude of the voltage tells us about the density and velocity of the charge. Such experiments have shown that in copper and most other metals, electrons carry the charge, but in zinc it is the positive charges that move.

A Useful Sensor Engineers have developed the Hall-effect sensor. These tiny black plastic devices contain a thin film of silicon with wires connected, as shown in the diagram. The Hall voltage wires are connected to a tiny amplifier so that other instruments can detect it.

If a permanent magnet is moved near a Hall-effect sensor, the voltage from the amplifier will increase. Thus, the sensor can be used to detect the proximity of the magnet.



Bicycle speedometers use a Hall-effect sensor to display the speed at which a bicycle is moving.

Everyday Applications Bicycle speedometers use a permanent magnet attached to the front wheel. Each revolution of the wheel brings the magnet close to a Hall-effect sensor. The resulting pulses are counted and timed. Hall-effect sensors also are used to time the spark in automobile engines. When a magnet mounted on the crankshaft or distributor rotor moves near a sensor, a voltage pulse is produced, and the ignition system instantly fires the spark plug.

Going Further

1. **Analyze** Why are the Hall-voltage electrodes positioned directly across from each other? What if they weren't?
2. **Critical Thinking** Might a strong magnetic field applied across a conducting ribbon change the resistance of that ribbon as a result of the Hall effect? Consider what you learned about the cross-sectional areas of wires.