Figure 47-1  A freely suspended natural magnet (lodestone) will point toward the magnetic north pole.

TECH TIP: A Cracked Magnet Becomes Two Magnets

Magnets are commonly used in vehicle crankshaft, camshaft, and wheel speed sensors. If a magnet is struck and cracks or breaks, the result is two smaller-strength magnets. Because the strength of the magnetic field is reduced, the sensor output voltage is also reduced. A typical problem occurs when a magnetic crankshaft sensor becomes cracked, resulting in a no-start condition. Sometimes the cracked sensor works well enough to start an engine that is cranking at normal speeds but will not work when the engine is cold.  

SEE FIGURE 47-2.
Figure 47-2: If a magnet breaks or is cracked, it becomes two weaker magnets.

Figure 47-3: Magnetic lines of force leave the north pole and return to the south pole of a bar magnet.

Figure 47-4: Iron filings and a compass can be used to observe the magnetic lines of force.
MAGNETISM AND ELECTROMAGNETISM

Figure 47-5  Magnetic poles behave like electrically charged particles—unlike poles attract and like poles repel.

TECH TIP: Magnetize a Steel Needle

A piece of steel can be magnetized by rubbing a magnet in one direction along the steel. This causes the atoms to line up in the steel, so it acts like a magnet. The steel often will not remain magnetized, whereas the true magnet is permanently magnetized.

When soft iron or steel is used, such as a paper clip, it will lose its magnetism quickly. The atoms in a magnetized needle can be disturbed by heating it or by dropping the needle on a hard object, which would cause the needle to lose its magnetism. Soft iron is used inside ignition coils because it will not keep its magnetism.

Figure 47-6  A crankshaft position sensor and reluctor (notched wheel).
TECH TIP: Electricity and Magnetism

Electricity and magnetism are closely related because any electrical current flowing through a conductor creates a magnetic field. Any conductor moving through a magnetic field creates an electrical current. This relationship can be summarized as follows:

• Electricity creates magnetism.
• Magnetism creates electricity.

From a service technician’s point of view, this relationship is important because wires carrying current should always be routed as the factory intended to avoid causing interference with another circuit or electronic component. This is especially important when installing or servicing spark plug wires, which carry high voltages and can cause high electromagnetic interference.

Figure 47-7 A magnetic field surrounds a straight, current-carrying conductor.

Figure 47-8 The left-hand rule for magnetic field direction is used with the electron flow theory.
Figure 47-9 The right-hand rule for magnetic field direction is used with the conventional theory of electron flow.

Figure 47-10 Conductors with opposing magnetic fields will move apart into weaker fields.

Figure 47-11 Electric motors use the interaction of magnetic fields to produce mechanical energy.
Figure 47-12 The magnetic lines of flux surrounding a coil look similar to those surrounding a bar magnet.

Figure 47-13 The left-hand rule for coils is shown.

Figure 47-14 An iron core concentrates the magnetic lines of force surrounding a coil.
Figure 47-15: An electromagnetic switch that has a movable arm is referred to as a relay.

FREQUENTLY ASKED QUESTION
Solenoid or Relay?
Often, either term is used to describe the same part in service information. SEE CHART 47-1 for a summary of the differences.

Chart 47-1: Comparison between a relay and a solenoid.
Figure 47-16 (a) A starter with attached solenoid. All of the current needed by the starter flows through the two large terminals of the solenoid and through the solenoid contacts inside.

Figure 47-16 (b) A relay is designed to carry lower current compared to a solenoid and uses a movable arm.

Figure 47-17 Voltage can be induced by the relative motion between a conductor and magnetic lines of force.
Figure 47-18 Maximum voltage is induced when conductors cut across the magnetic lines of force (flux lines) at a 90-degree angle.

Figure 47-19 Mutual induction occurs when the expansion or collapse of a magnetic field around one coil induces a voltage in a second coil.

Figure 47-20 Some ignition coils are electrically connected, called married (top figure) whereas others use separate primary and secondary windings, called divorced (bottom figure).
Figure 47-21 A GM waste-spark ignition coil showing the section of laminations that is shaped like the letter E. These mild steel laminations improve the efficiency of the coil.

Figure 47-22 The coil-on-plug (COP) design typically uses a bobbin-type coil.
To help prevent underhood electromagnetic devices from interfering with the antenna, it is important that all ground wires, including the one from the power antenna, be properly grounded.