Magnetism

chapter 14

section ● Electricity and Magnetism

Before You Read

List some machines that use motors to make them work.

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What You'll Learn

- how an electric current and an electromagnet produce magnetic fields
- about electromagnets and electric motors

Read to Learn

Electric Current and Magnetism

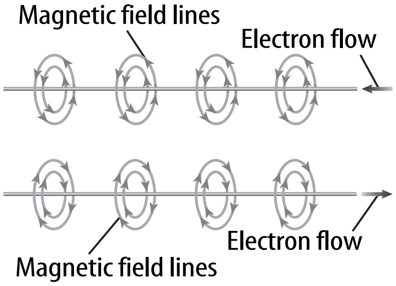
In 1820, a Danish physics teacher found that there is a link between electricity and magnetism. He was demonstrating electric current. There was a compass near the electric circuit. He saw that the compass needle changed direction depending on the flow of the electric current. The teacher hypothesized that an electric current produces a magnetic field around the wire and that the direction of a magnetic field changes with the direction of the electric current.

Mark the Text

Highlight As you read this section, use a highlighter to mark the most important ideas in each paragraph.

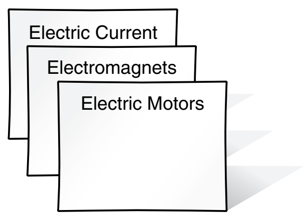
How do magnetic field lines change?

The teacher's hypothesis was correct. Moving charges create a magnetic field. When an electric current flows in a wire, a magnetic field forms around the wire. The direction of the magnetic field depends on the direction of the current in the wire. Look at the figure below. Magnetic field lines form circles around a wire carrying electric current. When the current changes direction, then the direction of the magnetic field lines also change. If the current gets stronger, the magnetic field gets stronger. As the distance from the wire increases, the strength of the magnetic field decreases.



FOLDABLES

● **Note Cards** As you read this section, make note cards out of half-sheets of paper to write notes about the three main topics.



Electromagnets

The magnetic field that surrounds a wire carrying current can be made much stronger in an electromagnet. An **electromagnet** is a temporary magnet made by wrapping wire coil carrying electricity around an iron core. The figure below at right is an electromagnet.

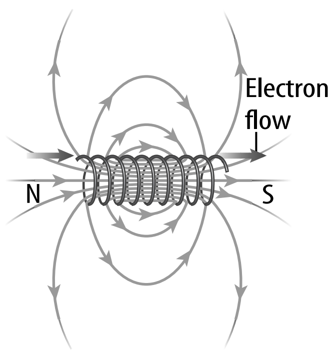
The magnetic field inside a loop of wire is stronger than the magnetic field around a straight wire. The magnetic field is stronger because the magnetic fields inside the loop combine. A **solenoid** (SOH luh noyd) is a single wire wrapped into a coil. The magnetic field inside a solennoid is stronger that the magnetic field inside a single loop of wire. The figure below at left is a solenoid.

If a solenoid is wrapped around an iron core, it forms an electromagnet. The solenoid's magnetic field magnetizes the iron core. As a result, the magnetic field inside the electromagnet can be 1,000 times stronger than the field inside a solenoid without a core.

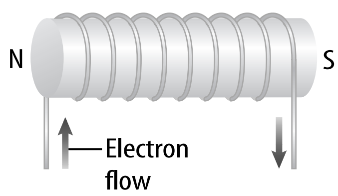
Picture This

1. **Identify** Label the part of the electromagnet that is different from the solenoid.

Solenoid



Electromagnet



How do electromagnets work?

Electromagnets are temporary magnets. The magnetic field is present only when current is flowing in the solenoid. The magnetic field of an electromagnet can be made stronger by adding more coils of wire or by adding more current.

An electromagnet acts like any other magnet when current flows through the solenoid. It has a north and a south pole, attracts magnetic materials, and is attracted or repelled by other magnets. If put in a magnetic field, an electromagnet will line itself up along the magnetic field lines. Electromagnets are useful because you can control how they act by changing the electric current flowing through the solenoid.

When the current moves toward or away from another magnet, electrical energy is changed into mechanical energy. The mechanical energy will do work. Electromagnets make mechanical energy to do work in many devices, such as stereo speakers and electric motors.

Think it Over

2. **Describe** two ways to increase the strength of the field of an electromagnet.

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How do electromagnets make sound?

There is an electromagnet in the speaker you use when you listen to a CD. The electromagnet is connected to a speaker cone made from paper, plastic, or metal. A permanent magnet surrounds the electromagnet.

Changing Electric Current Recall that increasing the current passing through a wire increases the strength of a magnetic field. A CD player produces a voltage, a measure of electrical potential energy that can be changed into other forms of energy. As voltage increases, more electrical potential energy is ready to be changed into other forms of energy. The CD player's voltage produces an electric current in the electromagnet next to the speaker cone.

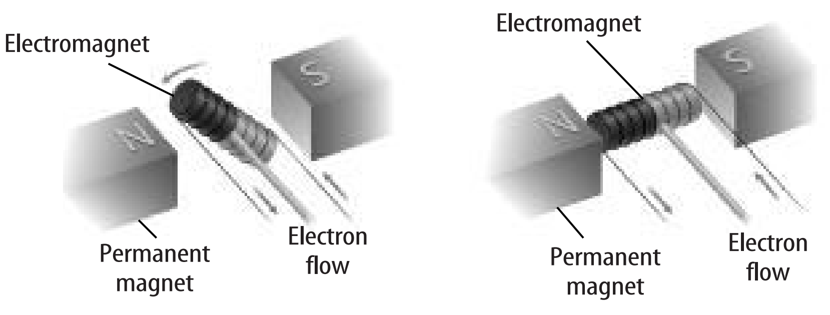
The CD has data that changes the amount and direction of electric current. The changing current causes the direction and the strength of the magnetic field around the electromagnet to change. A change in direction causes the electromagnet to attract or repel the permanent magnet. This attracton and repulsion moves the electromagnets back and forth.

The electromagnet changes electrical energy to mechanical energy. The mechanical energy vibrates the speaker cone so it reproduces the sound that was recorded on the CD. ☑

What makes an electromagnet rotate?

A permanent magnet can apply forces to an electromagnet to make it rotate. The figure below shows an electromagnet between the north and south poles of a permanent magnet. The north and south poles of the electromagnet are attracted to the opposite poles of the permanent magnet. This causes a downward force on the left side of the electromagnet in the figure and an upward force on the right side. These forces make the electromagnet rotate until opposite poles are lined up.

The electromagnet continues to rotate until its poles are next to the opposite poles of the permanent magnet. Once the north and south poles of the electromagnet are in opposite directions, the electromagnet stops rotating.



Reading Check

3. **Determine** What causes the speaker cone of a CD player to vibrate?

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Picture This

4. **Identify** Which pole of the electromagnet is attracted to the north pole of the permanent magnet?

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How does a fuel gauge work?

A **galvanometer** is a device that uses an electromagnet to measure electric current. Look at the first figure below. On the left is a galvanometer. An electromagnet is located between the poles of a permanent magnet and is connected to a small spring. The electromagnet rotates until the force applied by the spring is balanced by the magnetic forces on the electromagnet. A needle is attached to the electromagnet, so it turns also.

In the same figure, on the right, is a fuel gauge from a car's dashboard. A fuel gauge is a galvanometer. When the amount of gasoline in the car's fuel tank changes, the needle in the gauge moves. A sensor in the fuel tank tells when the fuel level changes. This sensor sends an electric current to the galvanometer. The current change causes the electromagnet to turn. This makes the needle move to different positions on the gauge. The gas gauge is set so that when the fuel tank is full, the needle moves to the full mark on the gauge.

Picture This

5. Analyze What would make the needle in the fuel gauge turn to the right?

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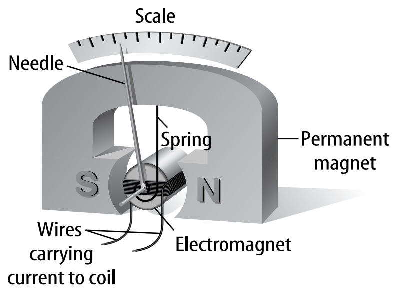

Galvanometer

Fuel Gauge

Electric Motors

An **electric motor** is a machine that changes electrical energy into mechanical energy. The wires carrying electric current produce a magnetic field. This magnetic field acts the same way as the magnetic field of a magnet. Two wires carrying electric current can attract each other as if they were two magnets, as in the figure below. ☑

Reading Check

6. Identify What is a machine that changes electric energy into mechanical energy called?

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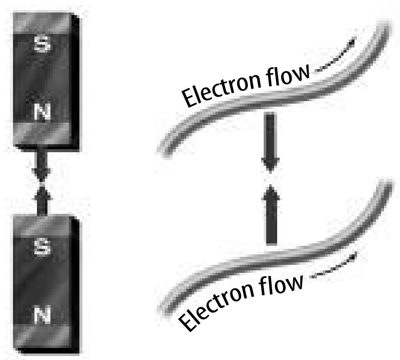


Where are electric motors used?

Electric motors are used in many types of machines in industry, agriculture, and transportation. Objects as large as airplanes and cars use electric motors, and as small as CD players also use motors.

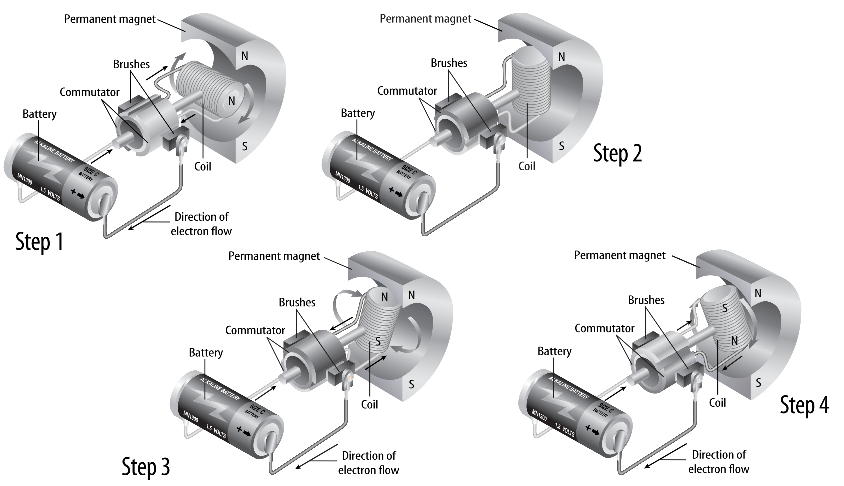
How does a simple electric motor work?

The main parts of a simple electric motor include a wire coil, a permanent magnet, and a source of electricity, such as a battery. The battery supplies the electric current that makes the coil an electromagnet. In the figure below, the current flows into the coil and this causes the coil to rotate. A simple electric motor also contains brushes and a commutator. The brushes are connecting pads attached to the battery. The brushes touch the commutator, which is a split metal ring that conducts current. Each half of the commutator is attached to one end of the coil. The commutator rotates with the coil. The brushes and commutator make a closed electric circuit between the battery and the coil. ☑

When the current flows in the coil, the forces between the coil and permanent coil make the coil turn, as shown below in step 1. The coil turns until it reaches the position shown in step 2. The brushes do not touch the communicator and no current flows to the coil. Inertia keeps the coil turning.

In step 3, the coil has turned so the brushes touch the communicator. However, the halves of the communicator that connected to the positive and negative terminals of the battery have switched. The current reverses direction. The magnetic poles of the coil reverse and are repelled by the permanent magnet. The coil keeps turning.

In step 4, the coil spins until its poles are opposite the poles of the permanent magnet. Then the communicator again reverses the direction of the current and the coil keeps turning.



Reading Check

7. **Identify** What are the main parts of a simple electric motor?

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Picture This

8. **Identify** Circle the steps when the communicators are not touching the brushes.

After You Read

Mini Glossary

electric motor: a device that changes electrical energy into mechanical energy

electromagnet: a single wire carrying an electric current that is wrapped around an iron core

galvanometer: a device that uses an electromagnet to measure electric current

solenoid: a single wire carrying electric current that is wrapped into a coil shaped like a cylinder

1. Review the vocabulary words and their definitions in the Mini Glossary. Write a sentence that shows how a solenoid and an electromagnetic are related.

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2. Complete the chart to list three items that use electromagnets to make them work.

Use electromagnets to make them work	

3. Look at the parts of the text that you highlighted. How did this help you learn about electricity and magnetism?

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End of Section

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chapter 14

Magnetism

section ● Producing Electric Current

Before You Read

Name three things you used today that use electrical energy to make them work. Where do you think the electrical energy came from?

What You'll Learn

- what electromagnetic induction is
- how a generator produces current
- the difference between direct and alternating current
- how to change the voltage of an alternating current

Read to Learn

From Mechanical to Electrical Energy

In 1831, two scientists discovered the same thing independently. If they moved a loop of wire through a magnetic field, it caused an electric current to flow in the wire. They also found that moving a magnet through a loop of wire produced a current in the wire. In both cases, the movement caused an electric flow in the wire. In other words, mechanical energy was changed into electrical energy.

The loop of wire or the magnet has to move to make an electric current. This makes the magnetic field inside the loop change. When the magnetic field changes, it causes an electric current to flow in the wire. The current change in the wire can start a current in a nearby coil. **Electromagnetic induction** is the generation of a current by a changing magnetic field.

How do electric generators work?

A **generator** uses electromagnetic induction to change mechanical energy into electrical energy. Generators make most of the electricity that you use each day. On the following page, you will see a simple hand-cranked generator. Turning the handle provides mechanical energy to rotate a coil. The coil spins between the poles of a permanent magnet. This action produces an electric current in the coil. The electric current can then be sent through wires to do useful work.

Study Coach

Sticky-Note Discussions Place sticky notes at parts of the section you find interesting orthat you have a question about. Write the question on the sticky note.

FOLDABLES™

Build Vocabulary As you read this section, make a vocabulary Foldable to show that you understand the vocabulary terms.