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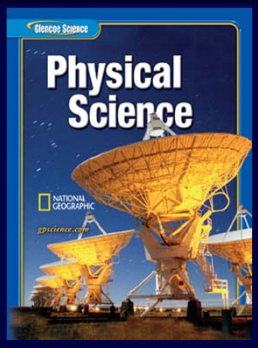

CHAPTER RESOURCES END

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8

Unit 2: Electricity and Energy Resources

CHAPTER RESOURCES END

Magnetism

8.1

Magnets

- More than 2,000 years ago Greeks discovered deposits of a mineral that was a natural magnet.
- The mineral is now called magnetite.

CHAPTER RESOURCES END

Magnetism

8.1

Magnets

- In the twelfth century Chinese sailors used magnetite to make compasses that improved navigation.
- Today, the word **magnetism** refers to the properties and interactions of magnets.

CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Force

- Depending on which ends of the magnets are close together, the magnets either repel or attract each other.
- The strength of the force between two magnets increases as magnets move closer together and decreases as the magnets move farther apart.

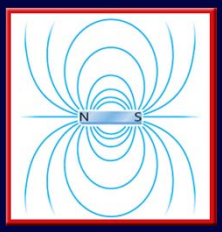
CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Field

- A magnet is surrounded by a magnetic field. A **magnetic field** exerts a force on other magnets and objects made of magnetic materials.
- The magnetic field is strongest close to the magnet and weaker far away.



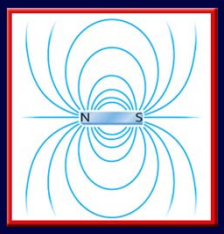
CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Field

- The magnetic field can be represented by lines of force, or magnetic field lines.
- A magnetic field also has a direction. The direction of the magnetic field around a bar magnet is shown by the arrows.



CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Poles

- **Magnetic poles** are where the magnetic force exerted by the magnet is strongest.
- All magnets have a north pole and a south pole.

Click image to play movie

- For a bar magnet, the north and south poles are at the opposite ends.

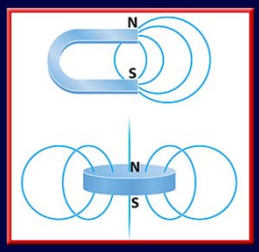
CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Poles

- The two ends of a horseshoe-shaped magnet are the north and south poles.
- A magnet shaped like a disk has opposite poles on the top and bottom of the disk.
- Magnetic field lines always connect the north pole and the south pole of a magnet.



CHAPTER RESOURCES END

Magnetism

8.1

How Magnets Interact

- Two magnets can either attract or repel each other.
- Two north poles or two south poles of two magnets repel each other. However, north poles and south poles always attract each other.
- When two magnets are brought close to each other, their magnetic fields combine to produce a new magnetic field.

CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Field Direction

- When a compass is brought near a bar magnet, the compass needle rotates.
- The force exerted on the compass needle by the magnetic field causes the needle to rotate.
- The compass needle rotates until it lines up with the magnetic field lines.

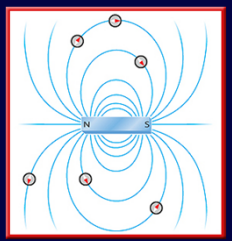
CHAPTER RESOURCES END

Magnetism

8.1

Magnetic Field Direction

- The north pole of a compass points in the direction of the magnetic field.
- This direction is always away from a north magnetic pole and toward a south magnetic pole.



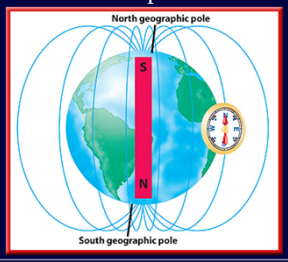
CHAPTER RESOURCES END

Magnetism

8.1

Earth's Magnetic Field

- A compass can help determine direction because the north pole of the compass needle points north.
- This is because Earth acts like a giant bar magnet and is surrounded by a magnetic field that extends into space.



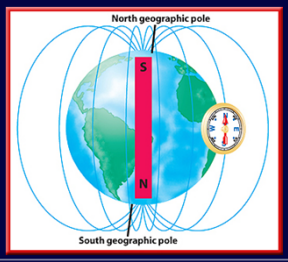
CHAPTER RESOURCES

Magnetism

8.1

Earth's Magnetic Field

- Just as with a bar magnet, the compass needle aligns with Earth's magnetic field lines.



CHAPTER RESOURCES

Magnetism

8.1

Earth's Magnetic Poles

- Currently, Earth's south magnetic pole is located in northern Canada about 1,500 km from the geographic north pole.
- Earth's magnetic poles move slowly with time.
- Sometimes Earth's magnetic poles switch places so that Earth's south magnetic pole is the southern hemisphere near the geographic south pole.

CHAPTER RESOURCES

Magnetism

8.1

Magnetic Materials

- You might have noticed that a magnet will not attract all metal objects.
- Only a few metals, such as iron, cobalt, or nickel, are attracted to magnets or can be made into permanent magnets.
- What makes these elements magnetic? Remember that every atom contains electrons.

CHAPTER RESOURCES

Magnetism

8.1

Magnetic Materials

- In the atoms of most elements, the magnetic properties of the electrons cancel out.
- But in the atoms of iron, cobalt, and nickel, these magnetic properties don't cancel out.
- Even though these atoms have their own magnetic fields, objects made from these metals are not always magnets.

CHAPTER RESOURCES

Magnetism

8.1

Magnetic Domains—A Model for Magnetism

- Groups of atoms with aligned magnetic poles are called **magnetic domains**.

CHAPTER RESOURCES

Magnetism

8.1

Magnetic Domains—A Model for Magnetism

- Each domain contains an enormous number of atoms, yet the domains are too small to be seen with the unaided eye.
- Because the magnetic poles of the individual atoms in a domain are aligned, the domain itself behaves like a magnet with a north pole and a south pole.

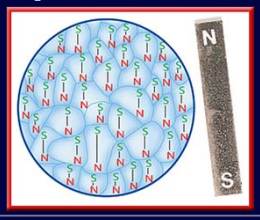
CHAPTER RESOURCES END

Magnetism

8.1

Lining Up Domains

- Even though each domain behaves like a magnet, the poles of the domains are arranged randomly and point in different directions.
- As a result the magnetic fields from all the domains cancel each other out.



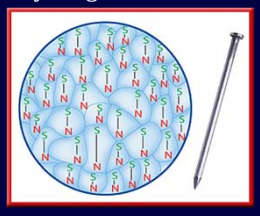
CHAPTER RESOURCES END

Magnetism

8.1

Lining Up Domains

- If you place a magnet against the same nail, the atoms in the domains orient themselves in the direction of the nearby magnetic field.
- The like poles of the domains point in the same direction and no longer cancel each other out.



CHAPTER RESOURCES END

Magnetism

8.1

Lining Up Domains

- The nail itself now acts as a magnet.
- The nail is only a temporary magnet.
- Paper clips and other objects containing iron also can become temporary magnets.

Click image to play movie

CHAPTER RESOURCES END

Magnetism

8.1

Permanent Magnets

- A permanent magnet can be made by placing a magnetic material, such as iron, in a strong magnetic field.
- The strong magnetic field causes the magnetic domains in the material to line up.
- The magnetic fields of these aligned domains add together and create a strong magnetic field inside the material.

CHAPTER RESOURCES END

Magnetism

8.1

Permanent Magnets

- This field prevents the constant motion of the atoms from bumping the domains out of alignment. The material is then a permanent magnet.
- If the permanent magnet is heated enough, its atoms may be moving fast enough to jostle the domains out of alignment.
- Then the permanent magnet loses its magnetic field and is no longer a magnet.

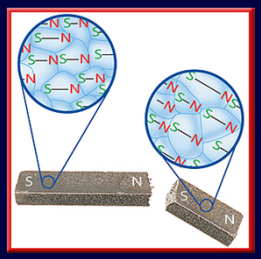
CHAPTER RESOURCES END

Magnetism

8.1

Can a pole be isolated?

- Look at the domain model of the broken magnet.
- Recall that even individual atoms of magnetic materials act as tiny magnets.



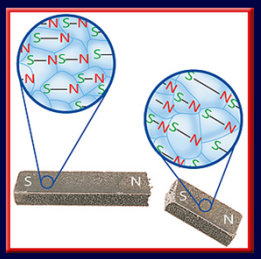
CHAPTER RESOURCES

Magnetism

8.1

Can a pole be isolated?

- Because every magnet is made of many aligned smaller magnets, even the smallest pieces have both a north pole and a south pole.



CHAPTER RESOURCES

Section Check

8.1

Question 1

What is the difference between a magnetic field and a magnetic pole?

CHAPTER RESOURCES

Section Check

8.1

Answer

A magnetic field is the area surrounding a magnet that exerts a force on other magnets and magnetic materials. A magnetic pole is the region on a magnet where the magnetic force is strongest.

CHAPTER RESOURCES

Section Check

8.1

Question 2

How do unlike magnetic poles interact?

Answer

Two magnets can either attract or repel each other. Like magnetic poles repel each other and unlike poles attract each other.

CHAPTER RESOURCES

Section Check

8.1

Question 3

Groups of atoms with aligned magnetic poles are called _____.

A. magnetic charges
B. magnetic domains
C. magnetic fields
D. magnetic materials

CHAPTER RESOURCES

Section Check

8.1

Answer

The answer is B, magnetic domains. Magnetic materials contain magnetic domains.

CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Electric Current and Magnetism

- In 1820, Han Christian Oersted, a Danish physics teacher, found that electricity and magnetism are related.
- Oersted hypothesized that the electric current must produce a magnetic field around the wire, and the direction of the field changes with the direction of the current.

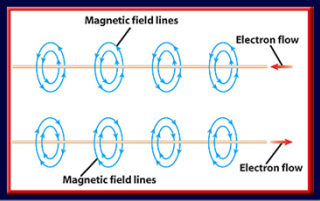
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Moving Charges and Magnetic Fields

- It is now known that moving charges, like those in an electric current, produce magnetic fields.
- Around a current-carrying wire the magnetic field lines form circles.



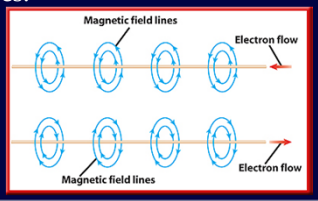
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Moving Charges and Magnetic Fields

- The direction of the magnetic field around the wire reverses when the direction of the current in the wire reverses.
- As the current in the wire increases the strength of the magnetic field increases.



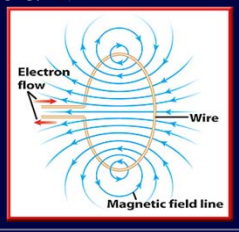
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Electromagnets

- An **electromagnet** is a temporary magnet made by wrapping a wire coil carrying a current around an iron core.
- When a current flows through a wire loop, the magnetic field inside the loop is stronger than the field around a straight wire.



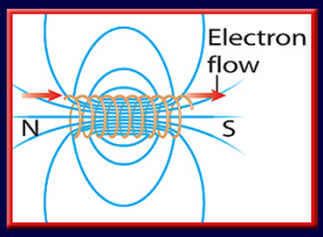
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Electromagnets

- A single wire wrapped into a cylindrical wire coil is called a **solenoid**.
- The magnetic field inside a solenoid is stronger than the field in a single loop.



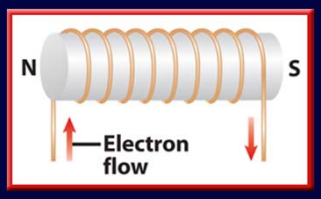
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Electromagnets

- If the solenoid is wrapped around an iron core, an electromagnet is formed.



CHAPTER RESOURCES

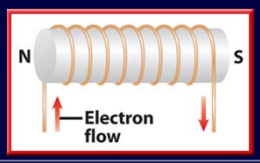
END

Electricity and Magnetism

8.2

Electromagnets

- The solenoid's magnetic field magnetizes the iron core. As a result, the field inside the solenoid with the iron core can be more than 1,000 times greater than the field inside the solenoid without the iron core.



CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Properties of Electromagnets

- Electromagnets are temporary magnets because the magnetic field is present only when current is flowing in the solenoid.
- The strength of the magnetic field can be increased by adding more turns of wire to the solenoid or by increasing the current passing through the wire.

CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Properties of Electromagnets

- One end of the electromagnet is a north pole and the other end is a south pole.
- If placed in a magnetic field, an electromagnet will align itself along the magnetic field lines, just as a compass needle will.
- An electromagnet also will attract magnetic materials and be attracted or repelled by other magnets.

CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Using Electromagnets to Make Sound

- How does musical information stored on a CD become sound you can hear?
- The sound is produced by a loudspeaker that contains an electromagnet connected to a flexible speaker cone that is usually made from paper, plastic, or metal.

CHAPTER RESOURCES

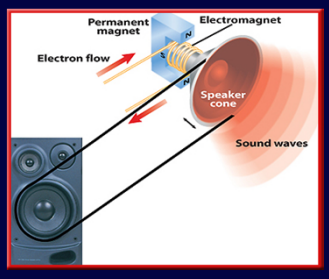
END

Electricity and Magnetism

8.2

Using Electromagnets to Make Sound

- The electromagnet changes electrical energy to mechanical energy that vibrates the speaker cone to produce sound.



CHAPTER RESOURCES

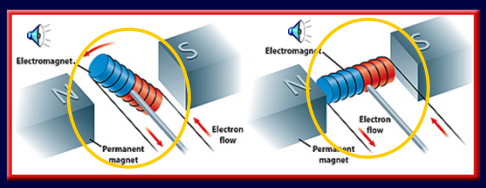
END

Electricity and Magnetism

8.2

Making an Electromagnet Rotate

- The forces exerted on an electromagnet by another magnet can be used to make the electromagnet rotate.



CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Making an Electromagnet Rotate

- One way to change the forces that make the electromagnet rotate is to change the current in the electromagnet.
- Increasing the current increases the strength of the forces between the two magnets.

CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Galvanometers

- How does a change in the amount of gasoline in a tank or the water temperature in the engine make a needle move in a gauge on the dashboard?
- These gauges are **galvanometers**, which are devices that use an electromagnet to measure electric current.

CHAPTER RESOURCES

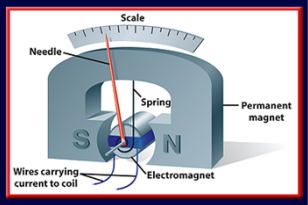
END

Electricity and Magnetism

8.2

Using Galvanometers

- In a galvanometer, the electromagnet is connected to a small spring.
- Then the electromagnet rotates until the force exerted by the spring is balanced by the magnetic forces on the electromagnet.



CHAPTER RESOURCES

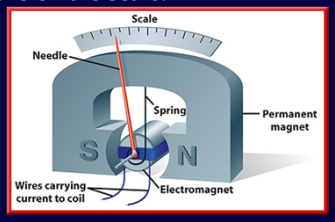
END

Electricity and Magnetism

8.2

Using Galvanometers

- Changing the current in the electromagnet causes the needle to rotate to different positions on the scale.



CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

Electric Motors

- A fan uses an **electric motor**, which is a device that changes electrical energy into mechanical energy.
- The motor in a fan turns the fan blades, moving air past your skin to make you feel cooler.
- Almost every appliance in which something moves contains an electric motor.

CHAPTER RESOURCES

END

Electricity and Magnetism

8.2

A Simple Electric Motor

- The main parts of a simple electric motor include a wire coil, a permanent magnet, and a source of electric current, such as a battery.
- The battery produces the current that makes the coil an electromagnet.

CHAPTER RESOURCES END

Electricity and Magnetism

8.2

A Simple Electric Motor

- A simple electric motor also includes components called brushes and a commutator.
- The brushes are conducting pads connected to the battery.
- The brushes make contact with the commutator, which is a conducting metal ring that is split.
- The brushes and the commutator form a closed electric circuit between the battery and the coil.

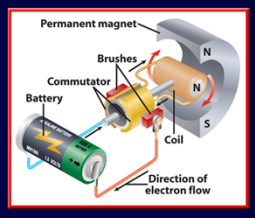
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Making the Motor Spin

- **Step 1.** When a current flows in the coil, the magnetic forces between the permanent magnet and the coil cause the coil to rotate.



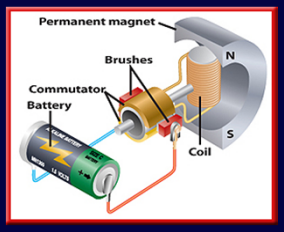
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Making the Motor Spin

- **Step 2.** In this position, the brushes are not in contact with the commutator and no current flows in the coil.
- The inertia of the coil keeps it rotating.



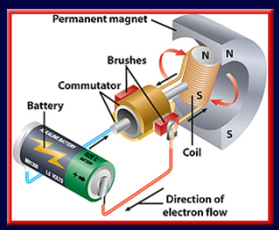
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Making the Motor Spin

- **Step 3.** The commutator reverses the direction of the current in the coil.
- This flips the north and south poles of the magnetic field around the coil.



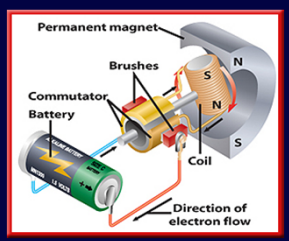
CHAPTER RESOURCES END

Electricity and Magnetism

8.2

Making the Motor Spin

- **Step 4.** The coil rotates until its poles are opposite the poles of the permanent magnet.
- The commutator reverses the current, and the coil keeps rotating.



CHAPTER RESOURCES END

Section Check

8.2

Question 1

Who correctly hypothesized that electric current produces a magnetic field?

A. Neils Bohr
B. Heinrich Hertz
C. Hans Christian Oersted
D. Max Planck

CHAPTER RESOURCES END

Section Check

8.2

Answer

The answer is C. In 1820, Oersted hypothesized that electric current produces a magnetic field and that the direction of the field changes with the direction of the current.

CHAPTER RESOURCES END

Section Check

8.2

Question 2

How can you make an electromagnet?

Answer

An electromagnet is a temporary magnet made by wrapping a wire coil carrying a current around an iron core.

CHAPTER RESOURCES END

Section Check

8.2

Question 3

Which of the following is a device that uses an electromagnet to measure current?

A. electric motor
B. galvanometer
C. generator
D. transformer

CHAPTER RESOURCES END

Section Check

8.2

Answer

The answer is B. In a galvanometer, the electromagnet is connected to a small spring.

CHAPTER RESOURCES END

Producing Electric Current

8.3

From Mechanical to Electrical Energy

- Working independently in 1831, Michael Faraday in Britain and Joseph Henry in the United States both found that moving a loop of wire through a magnetic field caused an electric current to flow in the wire.
- They also found that moving a magnet through a loop of wire produces a current.

CHAPTER RESOURCES END

Producing Electric Current

8.3

From Mechanical to Electrical Energy

- The magnet and wire loop must be moving relative to each other for an electric current to be produced.
- This causes the magnetic field inside the loop to change with time.
- The generation of a current by a changing magnetic field is **electromagnetic induction**.

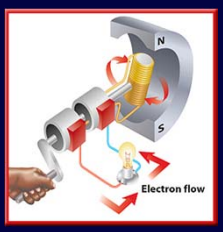
CHAPTER RESOURCES END

Producing Electric Current

8.3

Generators

- A **generator** uses electromagnetic induction to transform mechanical energy into electrical energy.
- An example of a simple generator is shown. In this type of generator, a current is produced in the coil as the coil rotates between the poles of a permanent magnet.



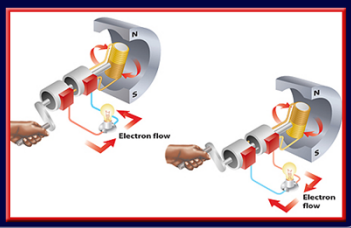
CHAPTER RESOURCES END

Producing Electric Current

8.3

Switching Direction

- In a generator, as the coil keeps rotating, the current that is produced periodically changes direction.
- The direction of the current in the coil changes twice with each revolution.



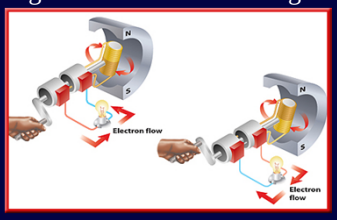
CHAPTER RESOURCES END

Producing Electric Current

8.3

Switching Direction

- The frequency with which the current changes direction can be controlled by regulating the rotation rate of the generator.



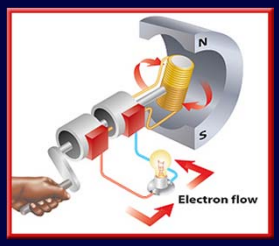
CHAPTER RESOURCES END

Producing Electric Current

8.3

Using Electric Generators

- The type of generator shown is used in a car, where it is called an alternator.
- The alternator provides electrical energy to operate lights and other accessories.



CHAPTER RESOURCES END

Producing Electric Current

8.3

Generating Electricity for Your Home

- Electrical energy comes from a power plant with huge generators.
- The coils in these generators have many coils of wire wrapped around huge iron cores.

CHAPTER RESOURCES END

Producing Electric Current

8.3

Generating Electricity for Your Home

- The rotating magnets are connected to a **turbine** (TUR bine)—a large wheel that rotates when pushed by water, wind, or steam.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Generating Electricity for Your Home

- Some power plants first produce thermal energy by burning fossil fuels or using the heat produced by nuclear reactions.
- This thermal energy is used to heat water and produce steam.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Generating Electricity for Your Home

- Thermal energy is then converted to mechanical energy as the steam pushes the turbine blades.
- The generator then changes the mechanical energy of the rotating turbine into the electrical energy you use.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Generating Electricity for Your Home

- In some areas, fields of windmills can be used to capture the mechanical energy in wind to turn generators.

- Other power plants use the mechanical energy in falling water to drive the turbine.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Generating Electricity for Your Home

- Both generators and electric motors use magnets to produce energy conversions between electrical and mechanical energy.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Direct and Alternating Currents

- Because power outages sometimes occur, some electrical devices use batteries as a backup source of electrical energy.
- However, the current produced by a battery is different than the current from an electric generator.

CHAPTER RESOURCES

END

Producing Electric Current

8.3

Direct and Alternating Currents

- A battery produces a direct current.
- **Direct current** (DC) flows only in one direction through a wire.
- When you plug your CD player or any other appliance into a wall outlet, you are using alternating current. **Alternating current** (AC) reverses the direction of the current in a regular pattern.

CHAPTER RESOURCES END

Producing Electric Current

8.3

Transmitting Electrical Energy

- When the electric energy is transmitted along power lines, some of the electrical energy is converted into heat due to the electrical resistance of the wires.
- The electrical resistance and heat production increases as the wires get longer.

CHAPTER RESOURCES END

Producing Electric Current

8.3

Transmitting Electrical Energy

- One way to reduce the heat produced in a power line is to transmit the electrical energy at high voltages, typically around 150,000 V.
- Electrical energy at such high voltage cannot enter your home safely, nor can it be used in home appliances.
- A transformer is used to decrease the voltage.

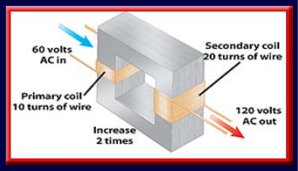
CHAPTER RESOURCES END

Producing Electric Current

8.3

Transformers

- A **transformer** is a device that increases or decreases the voltage of an alternating current.
- A transformer is made of a primary coil and a secondary coil.
- These wire coils are wrapped around the same iron core.



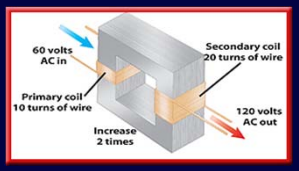
CHAPTER RESOURCES END

Producing Electric Current

8.3

Transformers

- As an alternating current passes through the primary coil, the coil's magnetic field magnetizes the iron core.
- The magnetic field in the primary coil changes direction as the current in the primary coil changes direction.



CHAPTER RESOURCES END

Producing Electric Current

8.3

Transformers

- This produces a magnetic field in the iron core that changes direction at the same frequency.
- The changing magnetic field in the iron core then induces an alternating current with the same frequency in the secondary coil.

CHAPTER RESOURCES END

Producing Electric Current

8.3

Transformers

- The changing magnetic field in the iron core then induces an alternating current with the same frequency in the secondary coil.

CHAPTER RESOURCES END

Producing Electric Current

8.3

Transformers

- The voltage in the primary coil is the input voltage and the voltage in the secondary coil is the output voltage.
- The output voltage divided by the input voltage equals the number of turns in the secondary coil divided by the number of turns in the primary coil.

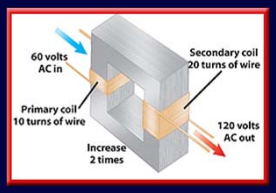
CHAPTER RESOURCES END

Producing Electric Current

8.3

Step-Up Transformer

- A transformer that increases the voltage so that the output voltage is greater than the input voltage is a step-up transformer.
- In a step-up transformer the number of wire turns on the secondary coil is greater than the number of turns on the primary coil.



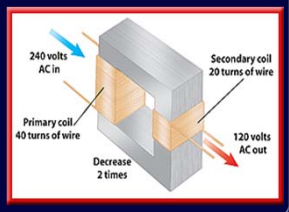
CHAPTER RESOURCES END

Producing Electric Current

8.3

Step-Down Transformer

- A transformer that decreases the voltage so that the output voltage is less than the input voltage is a step-down transformer.
- In a step-down transformer the number of wire turns on the secondary coil is less than the number of turns on the primary coil.



CHAPTER RESOURCES END

Producing Electric Current

8.3

Transmitting Alternating Current

- Although step-up transformers and step-down transformers change the voltage at which electrical energy is transmitted, they do not change the amount of electrical energy transmitted.

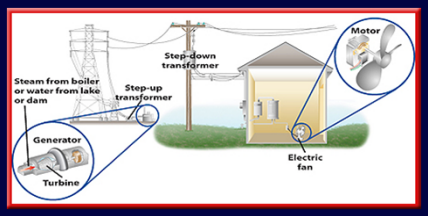
CHAPTER RESOURCES END

Producing Electric Current

8.3

Transmitting Alternating Current

- This figure shows how step-up and step-down transformers are used in transmitting electrical energy from power plants to your home.



CHAPTER RESOURCES END

Section Check

8.3

Question 1

What is electromagnetic induction?

Answer

Electromagnetic induction is the generation of a current by a changing magnetic field.

CHAPTER RESOURCES

Section Check

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Question 2

In a power plant, what is the function of the turbine?

CHAPTER RESOURCES

Section Check

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Answer

The turbine is a large wheel that rotates when pushed by water, wind or steam. The plant's generator changes the mechanical energy of the rotating turbine into electrical energy.

CHAPTER RESOURCES

Section Check

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Question 3

Which will increase the voltage of an alternating current?

A. battery
B. generator
C. motor
D. transformer

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Answer

The answer is D. Transformers can also decrease voltage, such as in a step-down transformer.

CHAPTER RESOURCES

Help

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CHAPTER RESOURCES Click on this icon to open the resources file.

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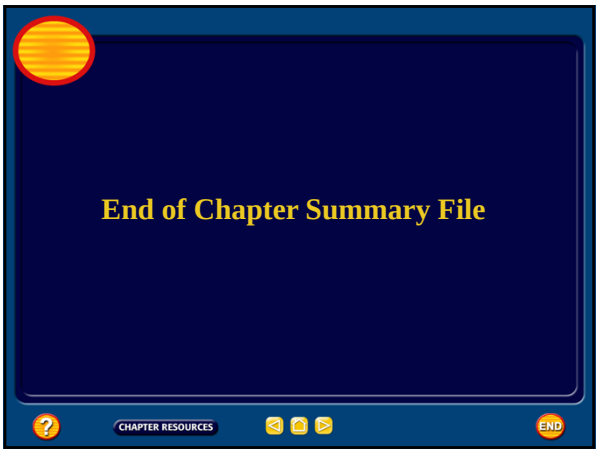
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