Chapter Project Worksheet 1
1–6. Students’ data will vary greatly depending on the appliances and devices they examine as well as on the size and power of those devices.

Chapter Project Worksheet 2
Encourage students to read their home meters and compare the readings they record to the values they calculate in carrying out the project.

What Is Electromagnetism?
Guided Reading and Study
Use Target Reading Skills
This is one possible way to complete the graphic organizer. Accept all logical answers.

Sample answers:
1. field
2. The relationship between electricity and magnetism
3. a, c
4. The iron filings show the magnetic field lines around the wire.
5. a. The field can be turned on or off.
   b. The field can have its direction reversed.
6. Turn the current off.
7. false
8. A coil of wire with a current
9. a, b, d
10. You have strengthened the magnetic field in the center of the coil.
11. true
12. A solenoid with a ferromagnetic core
13. The current in the wire and the magnetized core produces the magnetic field.
14. a. You can increase the current in the solenoid.
   b. You can add more loops of wire.
   c. You can wind the coils closer together.
   d. You can use a stronger ferromagnetic material for the core.

What Is Electromagnetism?
Review and Reinforce
1. A coil of wire with a current.
2. The magnets shown are electromagnets.
3. B, because the coil of wire has more loops.
4. You can increase the current in the solenoid. You can add more loops of wire. You can wind the coils closer together. You can use a stronger ferromagnetic material for the core.
5. b, c, a
6. c
7. a

What Is Electromagnetism?
Enrich
1. 3,500
2. 16
3. 1,800 ampere-turns
4. Increase the current to 9 amp or increase the number of turns to 300.
   1,200 ampere-turns × 1.5 = 1,800 ampere-turns
   200 turns × current = 1,800 ampere-turns/200 turns = 9 amp
   6 amp × turns = 1,800 ampere-turns
   turns = 1,800 ampere-turns/6amp = 300 turns
5. Double the number of turns.
   20 amp × number of turns = 800 ampere-turns
   number of turns = 800 ampere-turns/20 amp = 40 turns
   10 amp × number of turns = 800 ampere-turns
   number of turns = 800 ampere-turns/10 amp = 80 turns

Electricity, Magnetism, and Motion
Guided Reading and Study
Use Target Reading Skills
This is one possible way to complete the graphic organizer. Accept all logical answers.
1. Electrical Energy and Motion
   A. Types of Energy
   B. Energy Transformation
2. Galvanometers
3. Electric Motors
   A. How a Motor Works
   B. Parts of a Motor
1. The magnetic field of the wire interacts with the magnetic field of the magnets. As a result, the wire moves.
2. The ability to move an object over a distance
3. Electrical energy is transformed into mechanical energy.
4. a. Electrical energy
   b. The energy an object has due to its movement or position
5. galvanometer
6. The magnetic field of the electromagnet’s coil interacts with the permanent magnet’s field, causing the loops of wire and the pointer to rotate.
7. a, c, d
8. electric current
9. It depends on the amount of current in the wire.
10. They use them to know when to stop for fuel.
11. electric motor
12. An electric motor transforms electrical energy into mechanical energy.
13. commutator
14. armature
15. A commutator is a ring split in half.
16. brushes

**Electricity, Magnetism, and Motion Review and Reinforce**

1. c, f, h
2. a, b
3. d, e, g
4. electric motor
5. mechanical energy
6. galvanometer
7. energy
8. electrical energy

**Electricity, Magnetism, and Motion Enrich**

1. The fan
2. Cool air is pulled into the back of the hair dryer by the turning fan blades. This cool air is moved over the heating element. The warmed air is blown out the front of the hair dryer.
3. Vacuum cleaner, air conditioner; they all work by moving air from one place to another.
4. Answers may vary. Sample: Electric motors can also be used to blow hot air through ducts that lead to the rooms of a house.

**Building an Electric Motor Skills Lab**

For answers, see the Teacher’s Edition.

**Electricity From Magnetism Guided Reading and Study**

Use Target Reading Skills This is one possible way to complete the graphic organizer. Accept all logical answers. Sample questions and answers:

Q. What are the parts of a generator?
   A. Magnets, crank, slip ring, armature, and brushes are parts of a generator.

Q. How is a current induced in the armature?
   A. As a crank is turned, the armature rotates in a magnetic field. The up and down motion of the armature induces a current in the wire.

1. The key is motion.
2. magnetic field
3. Generating an electric current from the motion of a conductor through a magnetic field
4. a. The conductor can move through the magnetic field
   b. The magnet can move.
5. false
6. The direction depends on the direction in which the wire or magnet moves.
7. true
8. a. Alternating current
   b. A current consisting of charges that move back and forth in a circuit
   c. Direct current
   d. A current consisting of charges that flow in one direction only
9. electric generator
10. An electric motor uses electric current to produce motion. An electric generator uses motion to produce an electric current.
11. true
12. slip rings
13. transformer
14. When a current is in the primary coil, it produces a magnetic field, which changes as the current alternates. This changing magnetic field induces a current in the secondary coil.
15. A transformer works only if the current in the primary coil is changing, or alternating.
16. The voltage will be higher.
17. The most efficient way to transmit current over long distances is to maintain very high voltages. Current is used at much lower voltages in the home, and a transformer can decrease the voltage.
18. a. Step-down transformer  
b. Decreases  
c. Step-up transformer  
d. Increases  

Electricity From Magnetism  
Review and Reinforce  
a. armature  
b. current  
c. reverses  
d. alternating  
1. The primary coil is connected to a circuit with a voltage source and alternating current. The secondary coil is connected to a separate circuit that does not have a voltage source.  
2. An electric motor converts electrical energy to mechanical energy. A generator converts mechanical energy to electrical energy.  
3. c  
4. e  
5. f  
6. g  
7. b  
8. d  
9. a  

Electricity From Magnetism  
Enrich  
1. 6 turns; 4 turns  
2. 60 V  
3. Drawing B is a step-down transformer. You can tell because there are more wire turns in the primary coil than in the secondary coil. You can also tell because the voltage is greater in the primary coil than in the secondary coil.  
4. 9 turns  
5. 4 turns  

Key Terms  
a. electric motor  
b. electric generator  
c. direct current  
d. solenoid  
e. mechanical energy  
f. electromagnetism  
g. step-down transformer  

Hidden Key Term electromagnet
Connecting Concepts

This concept map is only one way to represent the main ideas and relationships in this chapter. Accept other logical answers from students.

Electricity Magnetism

- Electricity
- Magnetic field
- Induction of electric field
- Electric current
- Step-up transformers
- Step-down transformers
- Direct current
- Alternating current
- Mechanical energy
- Electrical energy
- Generator
- Electric motor
- Solenoid
- Electromagnet
- Generators which transform electrical energy into mechanical energy
- Electrical energy into mechanical energy
- Alternating current
- Step-up transformers which use transformers
- Solenoid which is a device that makes an electromagnet
- Electromagnet which uses a ferromagnetic core to produce magnetic field
- The addition of a ferromagnetic core makes an electromagnet
- Galvanometer

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Laboratory Investigation

Electromagnetism

Pre-Lab Discussion

1. An electromagnet uses electric current and can create a stronger magnetic field. It can be turned on and off, and its strength can be increased in a number of ways.
2. Sample answer: An electromagnet could be used in a crane at a junkyard to lift wrecked cars.

Data Table

<table>
<thead>
<tr>
<th>Test</th>
<th>Object</th>
<th>Attraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>5 nails alone</td>
<td>aluminum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>foil</td>
</tr>
<tr>
<td></td>
<td>penny</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>nickel</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>dime</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>wood</td>
<td>no</td>
</tr>
<tr>
<td>2.</td>
<td>Number of paper clips held = 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steel</td>
<td>yes</td>
</tr>
<tr>
<td>3.</td>
<td>Five nails, 25 cm of wire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>aluminum foil</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>penny</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>nickel</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>dime</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>wood</td>
<td>no</td>
</tr>
<tr>
<td>4.</td>
<td>Number of paper clips held = 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steel</td>
<td>yes</td>
</tr>
<tr>
<td>5.</td>
<td>Five nails, two layers of wire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>aluminum foil</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>penny</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>nickel</td>
<td>a little</td>
</tr>
<tr>
<td></td>
<td>dime</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>wood</td>
<td>no</td>
</tr>
<tr>
<td>6.</td>
<td>Number of paper clips held = 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steel</td>
<td>yes</td>
</tr>
<tr>
<td>7.</td>
<td>Five nails, two layers of wire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>aluminum foil</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>penny</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>nickel</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>dime</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>wood</td>
<td>no</td>
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</tbody>
</table>

Test Object Attraction

<table>
<thead>
<tr>
<th>Test</th>
<th>Object</th>
<th>Attraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>steel</td>
<td>yes</td>
</tr>
</tbody>
</table>

Analyze and Conclude

1. Steel or iron objects and the paper clips were strongly attracted. The nickel was weakly attracted. The aluminum foil, the penny, the dime, and the wood were not attracted.
2. Materials that were attracted have domains that align with the magnetic field of the magnet. Materials that were not attracted do not have domains that align with the magnetic field.
3. The magnetic attraction increased. The extra turns of the wire strengthen the magnetic field, increasing the magnetic attraction.
4. The magnetic attraction decreased. The result was a weaker electromagnet.

Critical Thinking and Applications

1. The materials are all iron or iron alloys.
2. Audiotapes, videotapes, and computer disks have information encoded with magnetic fields. A magnet could scramble the coding.
3. Sample answer: Add more nails to the core of the electromagnet.

Performance Assessment

1. Answers will vary. Sample: At the top of my page, I drew a diagram that shows how electrical energy is produced at a generating plant, then travels through electric lines to a step-up transformer, then to a step-down transformer, and then to an electric motor in a house. I divided the bottom of my page into four sections: one for a generator, one for a step-up transformer, one for a step-down transformer, and one for an electric motor. In each section, I described how the device works and what its purpose is.
2. Answers will vary. Sample: My page shows that a generator transforms mechanical energy to electrical energy. Mechanical energy can be supplied to a generator by burning fossil fuels to heat water. The resulting steam can turn a turbine. The turbine turns an armature, which consists of loops of wire around an iron core. The armature is turned inside a magnetic field. This induces an electric current in the loops of the armature. This current is alternating current, which means that it reverses direction at each half-turn of the armature. The current travels through power lines to a step-up transformer. A step-up transformer increases voltage. The voltage is increased.
because electrical energy can be delivered more efficiently at higher voltages. The alternating current in the primary coil induces a current in the secondary coil. In a step-up transformer, the primary coil has fewer loops than the secondary coil. Before the electricity reaches a person’s home, its voltage is decreased by a step-down transformer. In a step-down transformer, there are more loops in the primary coil than in the secondary coil. An electric motor transforms electrical energy to mechanical energy. A motor has an armature inside a magnetic field. When current flows through the armature, it begins to turn. The motion of the armature can be used to turn an axle. The axle can be used to turn the blades of a fan.

Chapter Test
1. c
2. a
3. b
4. d
5. c
6. a
7. d
8. b
9. b
10. c
11. armature
12. mechanical energy
13. electromagnet
14. energy
15. transformer
16. electric motor
17. true
18. electrical energy
19. true
20. true
21. Transformer 2 is a step-up transformer and transformer 1 is a step-down transformer. When current is produced at a generating plant, its voltage is increased so that it is transmitted efficiently through electric lines. Then it is decreased for use in people’s homes.
22. Section B has the greatest voltage because it is on the “up” side of the step-up transformer.
23. The field can be turned on or off, have its direction reversed, or have its strength changed.
24. No, a transformer works only if the current in the primary coil is changing. If the current does not change, the magnetic field does not change. No current will be induced in the secondary coil.
25. The magnetic field of the electromagnet’s coil interacts with the permanent magnet’s field, causing the loops of wire and the attached pointer to rotate.
26. It is connected to a battery and has a commutator, therefore the device is an electric motor. It uses current from a battery to turn a wire loop in a magnetic field. A commutator reverses the current in the loop after each half-turn so that the loop can turn continuously.
27. This motor won’t work because the magnetic field is produced by two “like” poles. Each half of the loop will be equally pushed or pulled by the two poles, so the loop will not turn. The motor could be made to work by using two “unlike” magnetic poles.
28. The current produced by an AC generator is alternating current. It reverses directions. This current is produced by transforming mechanical energy into electrical energy. The current produced by a battery is direct current. This current in only one direction. It is produced by transforming chemical energy into electrical energy.
29. You can increase the current in the solenoid. You can add more loops of wire. You can wind the coils closer together. You can use a stronger ferromagnetic material for the core.
30. In an electric motor, current moves to the wire loop from the rest of the circuit. In a generator, current moves from the wire loop to the rest of the circuit.

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