Electricity and Magnetism: 4.F.6

Magnets, Electricity, and Electromagnets

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>4</th>
</tr>
</thead>
</table>
| Sessions    | Session 1 - 15 minutes  
              Session 2 - 50 minutes |
| Seasonality | N/A |
| Instructional Mode(s) | Small Group Activity |
| Team Size    | 2 – 4 students |
| WPS Benchmarks | 04.SC.IS.01-06  
                         04.SC.PS.05  
                         04.SC.PS.08  
                         04.SC.TE.01  
                         04.SC.TE.04-06 |
| MA Frameworks | 3-5.IS.1-6  
                         3-5.PS.8  
                         3-5.TE.1.1  
                         3-5.TE.2.1  
                         3-5.TE.2.2  
                         3-5.TE.2.3 |
| Key Words    | Magnet, electricity, electromagnetic, experiment, test |

**Summary**

The students will be introduced to magnets and electromagnets. The students will build electromagnets and perform an experiment to determine how the number of wire coils affects the strength of the electromagnet. The students will then be asked to design their own electromagnet using what they have learned.

**Learning Objectives**

*2002 Worcester Public Schools (WPS) Benchmarks for Grade 4*

- **04.SC.IS.01** Ask questions and make predictions that can be tested.
- **04.SC.IS.02** Select and use appropriate tools and technology (e.g., calculators, computers, balances, scales, meter sticks, graduated cylinders) in order to extend observations.
- **04.SC.IS.03** Keep accurate records while conducting simple investigations or experiments.
04.SC.IS.04 Conduct multiple trials to test a prediction. Compare the results of an investigation or experiment with the prediction.

04.SC.IS.05 Recognize simple patterns in data and use to create a reasonable explanation for the results of an investigation or experiment.

04.SC.IS.06 Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

04.SC.PS.05 Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat and sound.

04.SC.PS.08 Explain how electromagnets can be made, and give examples of how they can be used.

04.SC.TE.01 Identify materials used to accomplish a design task based on specific property (e.g., weight, strength, hardness, and flexibility).

04.SC.TE.04 Identify a problem that reflects the need for shelter, storage, or convenience.

04.SC.TE.05 Describe different ways in which a problem can be represented (e.g., sketches, diagrams, graphic organizers, and lists).

04.SC.TE.06 Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.

**Additional Learning Objectives**

1. 3-5.IS.1 Ask questions and make predictions that can be tested.

2. 3-5.IS.2 Select and use appropriate tools and technology (e.g., calculators, computers, balances, scales, meter sticks, graduated cylinders) in order to extend observations.

3. 3-5.IS.3 Keep accurate records while conducting simple investigations or experiments.

4. 3-5.IS.4 Conduct multiple trials to test a prediction. Compare the results of an investigation or experiment with the prediction.

5. 3-5.IS.5 Recognize simple patterns in data and use to create a reasonable explanation for the results of an investigation or experiment.
6. **3-5.IS.6** Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

7. **3-5.PS.8** Explain how electromagnets can be made, and give examples of how they can be used.

8. **3-5.TE.1.1** Identify materials used to accomplish a design task based on specific property (e.g., weight, strength, hardness, and flexibility).

9. **3-5.TE.2.1** Identify a problem that reflects the need for shelter, storage, or convenience.

10. **3-5.TE.2.2** Describe different ways in which a problem can be represented (e.g., sketches, diagrams, graphic organizers, and lists).

11. **3-5.TE.2.3** Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.

12. Understand properties of magnets.

13. Understand what electromagnetism is and how to build a simple electromagnet.

**Required Background Knowledge**

1. Students should have a basic idea of what electricity is.

2. Students should have a basic idea of what a magnet is.

**Essential Questions**

1. What is a magnet?

2. Are magnets and electricity related to each other?

3. How does an electromagnet work?

**Introduction / Motivation**

Ask the class if they know what a magnet is. Ask the class to give some examples of what magnets are used for. Have the class share what they know about magnets. Prompt the class if necessary. See *Magnets* for additional information and overhead options.
**Procedure**

*Part I – 20-35 minutes*

The instructor will:

1. Continue magnet discussion until the instructor is satisfied with the class’s understanding of magnetism. (5-10 minutes)

2. Hold up an easily identified magnet Ask the class if it is a magnet. Hold up a piece of magnetic metal. Ask the class if the metal is a magnet. *This demonstration is meant to clarify the difference between magnets and materials that are attracted to magnets which is also touched upon in *It’s Magnetic!* (5 minutes)

3. Pass out *It’s Magnetic!* Tell the class that they will be doing an experiment to find out if the materials they are given are magnetic.

4. Pass out the following items to each student or each group of students depending on the availability of materials. (5 minutes)
   - Magnet
   - Eraser
   - Nail
   - Plastic Disc
   - Glass Marble
   - Metal Marble

5. Explain to students that they will be testing and recording the materials that they were given. Test each material with the magnet to see if they are magnetic. If they are magnetic write “Yes” in the box next to the material. (5 minutes)

6. Allow students to work on the remainder of *It’s Magnetic!* In class as a group or assign it for homework. (0-10 minutes)

*Part II – 35-55 minutes*

The instructor will:

1. Review what the class has learned about electricity. If your class has not yet studied electricity see *Electricity Review*. (5-10 minutes)

2. Begin discussing electromagnetism (see *What is an electromagnet?* and *Magnet Fields*). An electromagnet is a magnet that is created by applying an
electric current to a metal. Ask the class if they think they could make an electromagnet in class? (5-10 minutes)

3. Divide the class into groups (group size depends on the availability of supplies). Pass out *How to make an electromagnet*. Read the directions aloud and ask if there are any questions. (5-10 minutes)

4. Pass out materials to the students. When the students are done with their experiment pass out *Science Lab Report*. (10-15 minutes)

5. Discuss the results. Have the students fill out their *Science Lab Report* either as a group, individually in class, or as homework. (10 minutes)

**Materials List**

<table>
<thead>
<tr>
<th>Materials per class</th>
<th>Amount</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet</td>
<td>Teacher discretion</td>
<td>Electronics Store or Toy Store</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials per student/group</th>
<th>Amount</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet</td>
<td>1</td>
<td>Electronics Store or Toy Store</td>
</tr>
<tr>
<td>Eraser</td>
<td>1</td>
<td>Supermarket or Office Supply Store</td>
</tr>
<tr>
<td>Nail</td>
<td>1</td>
<td>Home Improvement Store</td>
</tr>
<tr>
<td>Plastic Disc</td>
<td>1</td>
<td>Toy Store</td>
</tr>
<tr>
<td>Glass Sphere (marble)</td>
<td>1</td>
<td>Toy Store</td>
</tr>
<tr>
<td>Metal Sphere (marble)</td>
<td>1</td>
<td>Toy Store</td>
</tr>
<tr>
<td>Cloth</td>
<td>1</td>
<td>Craft Store</td>
</tr>
<tr>
<td>Paperclip</td>
<td>1</td>
<td>Supermarket or Office Supply Store</td>
</tr>
<tr>
<td>Penny</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Nickel</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Wire</td>
<td>20 – 30 cm</td>
<td>Electronics Store</td>
</tr>
<tr>
<td>Battery</td>
<td>1</td>
<td>Supermarket or Electronics Store</td>
</tr>
<tr>
<td>Paperclips</td>
<td>20-30</td>
<td>Supermarket or Office Supply Store</td>
</tr>
</tbody>
</table>
Vocabulary with Definitions

1. Electricity - The flow of electrons in a circuit.
2. Electromagnet – A magnetic field created by the flow of electricity.
3. Magnet – An object that attracts iron and steel and produces a magnetic field.

Assessment / Evaluation of Students

The instructor may assess the students in any/all of the following manners:

1. Check worksheets: ensure that students understand the engineering design process
2. Observe prototypes: ensure that students understand the correct uses of common tools

Lesson Extensions

The instructor may discuss some common applications of magnets and electromagnets (see What are magnets used for?).

The instructor may extend this lesson to include the magnet field of the earth (see The Earth is a Magnet!) The instructor may also extend this lesson by explaining to the class how many electric companies use electromagnetism to create the electricity that we use in our houses (see How does the electric company make electricity?).

Attachments

1. Magnets
2. What are magnets used for?
3. What is an electromagnet?
4. Magnetic Field
5. Electricity Review
6. It’s Magnetic!
7. How to make an electromagnet
8. Science Lab Report
Troubleshooting Tips

The students may notice that the nails become magnets after applying an electrical current. If this occurs, replace the nail with one that is not magnetic. Iron or steel nails are ideal and should lose most of their magnetic field when the electrical current is stopped, however they will gradually become magnets the longer they are exposed to the electrical field (the field is lining up with free electrons).

Safety Issues

None

Additional Resources

None

Key Words

Magnet, electricity, electromagnetic, experiment, test
Magnets

Universal Law of Magnets -
Opposites Attract and Likes Repel

All of the Magnets shown above are Permanent Magnets
What are magnets used for?

Magnets are used by lots of things you use everyday. Here are a few examples:

* Speakers
* Motors
* Computers
* X-ray machines
* Lasers

What are electromagnets used for?

* Maglev trains
* Computers
* Doorbells
* Car crushers
* Tape recorders
What is an electromagnet?

Electromagnets are produced when an electric circuit is applied to a material.

We know about electricity is the flow of electrons. Electrons flow from the negative side of the battery to the positive side of the battery.

- They flow through something (a conductor) like a wire.
- A small magnetic field is generated in that wire.
Magnetic Field

What is a magnetic field?

A magnetic field is the space around an object that exerts a magnetic force on most metals.

(http://my.execpc.com/~rhoadley/fldmag1.JPG)

(http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/solenoid.html#c1)
Electricity Review

Electricity is created by the flow of electrons.

Within every atom there are positively and negatively charged particles.

Photo from: www3.iptv.org
It's Magnetic!

Directions: Fill in the table with information you collect from the items you were given.

<table>
<thead>
<tr>
<th>Item</th>
<th>Magnetic (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eraser</td>
<td></td>
</tr>
<tr>
<td>Nail</td>
<td></td>
</tr>
<tr>
<td>Disc</td>
<td></td>
</tr>
<tr>
<td>Glass Sphere</td>
<td></td>
</tr>
<tr>
<td>Metal Sphere</td>
<td></td>
</tr>
<tr>
<td>Cloth</td>
<td></td>
</tr>
<tr>
<td>Paperclip</td>
<td></td>
</tr>
</tbody>
</table>

What conclusions can you draw for this experiment?
How to make an electromagnet

Materials Needed: Nail, Battery, Wire, Paperclips

You will be conducting an experiment to figure out if the number of wire coils around the nail affects how strong the electromagnet is.

1. Try to pick up paperclips with only the nail. Record your result in the table below.

2. Connect one end of the wire to one end of the battery.

3. Coil the wire around the nail. Be sure to count the number coils. Attach the free end of the wire to the other end of the battery.

4. Try to pick up paperclips with the nail. Record how many paperclips you pick up.

5. Try it again with more wire coils around the nail. Record your results below.

<table>
<thead>
<tr>
<th>Number of coils</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of paperclips</td>
<td></td>
</tr>
</tbody>
</table>
1. Does the number of wire coils around an electromagnetic nail affect the strength of the magnetic field that is produced?

2. Draw a sketch of your experimental setup.

3. What are electromagnets?
The Earth is a Magnet!

Ever wonder how a compass works?

The needle of a compass is a small magnet. The red side of the magnet is always attracted to the North Pole.

The earth has a very weak magnetic field. It is this field that makes compasses work. If you were to put a compass close to a strong magnetic field (example: an electromagnet) the compass would be affected by that field more than the earth’s magnetic field.

The next time you are wondering what pole of a magnetic you are looking at, you can use a compass to figure it out.
How does the electric company make electricity?

Think back to how we build the electromagnets.

What if we replaced the nail with a magnet and moved it back and forth?

Moving a magnet back and forth within a coil of wires creates an electrical charge.

Many power plants are built on this concept. Where steam causes large propellers with magnets on them to turn near huge coils of wire.