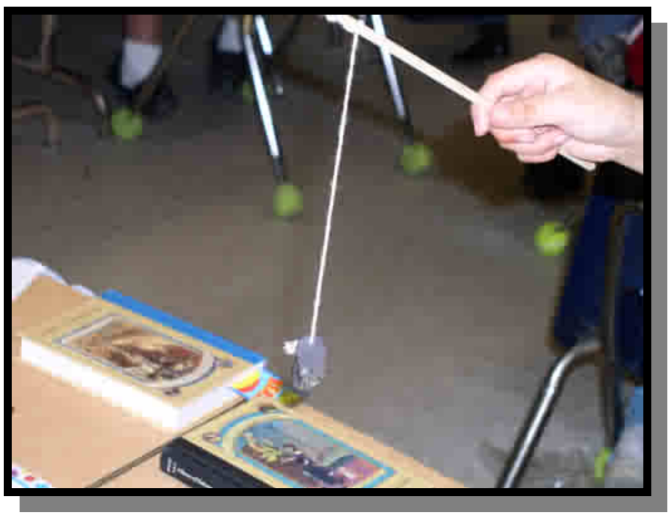
IS IT MAGIC

OR……….

MAGNETISM?

Magnetism - The Invisible Force



FISHING FOR A LODESTONE

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Table of Contents

Topic of the Module

Student will investigate the topic of magnetism. Specifically, they will explore how magnets work, discuss when magnets were first discovered, make their own electromagnets, discover the connection between electricity and magnetism and finally examine the magnetic forces in the universe.

Goal of the Module

This module provides the opportunity for students to gain a deeper understanding about magnets and magnetism, make electromagnets and realize the importance that magnetism plays as one of the invisible forces in the universe.

Targeted Grade Level

This module is designed for 4^{th} grade students. This module can be adapted to other grade levels, such as the 3^{rd} or 5^{th} grades.

Objectives

At the end of the module, students will reach the following objectives.

Students will be able to:

1. Describe a lodestone and identify where they were first discovered.
2. Describe the properties of a magnet.
3. Identify which items are attracted to a magnet and which items are not.
4. Explain why the items are attracted to a magnet.
5. Explain the importance of a magnetic compass and why it is used.
6. Explain how a magnet works.
7. Describe the magnetic field surrounding a magnet.

8. Draw and label the magnetic field lines around a magnet.
9. Define magnetism and describe its properties.
10. Indicate the location of the Earth's magnetic poles.
11. Build an electromagnet.
12. Explain the connection between electricity and magnetism.
13. Describe how a magnetic field is created.
14. Describe the practical uses of an electromagnet.
15. Determine the magnetic properties of the Earth, the Sun and other planets.
16. Explain how Auroras are created.

Time Needed

The expected timeline for this module is four days for one hour per day and an outline is presented below.

Day	**Topics**
1	Definition of a lodestone. History and location of where a lodestone was discovered. The invention of a compass and how the invention relates to a lodestone. The Earth's magnetic north pole. Magnetism and items that are magnetic. Properties of magnetic and non-magnetic materials.
2	The composition and properties of a magnet. The magnetic field - how it is created and it properties. Magnetic lines of force and how they are positioned around a magnet. Attracting and repelling magnets.
3	Construction of an electromagnet. Electricity and magnetic fields. Permanent and temporary magnets. Applications of electromagnets.

4 The Earth and the Earth's magnetic fields.
The Earth's Van Allen Belt
The Sun's solar winds and their affects in space.
How Auroras are created.
Earth, Sun and other planetary objects magnetic fields.

California Science Standards

For Grade 3

Physical Science

1. Energy and matter have multiple forms and can change from one form to another.

   a. Energy comes from the Sun to the Earth in the form of light.

   b. Sources of store energy take many forms, such as food fuel, and batteries.

   c. Energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.

   d. People once thought that Earth, wind, fire and water were the basic elements that make up all matter. Science experiments show that there are more than 100 different types of atoms, which are presented on the periodic tables of the elements.

Earth Science

1. Objects in the sky move in regular and predictable patterns.

   a. Earth is one of several planets that orbit the Sun and that the Moon.

For Grade 4

Physical Science

1. Electricity and magnetism are related effects that have many useful applications in everyday life. As a basis for understanding this concept:

    a. How to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.

    b. Electric currents produce magnetic fields and know how to build a simple electromagnet.

    c. The role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.

    d. Electrically charged objects attract or repel each other.

    e. That magnets have two poles (north and south) and that like poles repel each other while unlike poles attract each other.

For Grade 5

Physical Science

1. Elements and their combinations account for all varied types of matter in the world. As a basis for understanding this concept:

    a. Metals have properties in common, such as high electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag), and gold (Au), are pure elements: other, such as steel and brass, are composed of a combination of elemental metals.

    b. That each element is made of one kind of atom and that the elements are organized in the periodic table by their chemical properties.

National Science Education Standards

Physical Science Standards

Levels K-4

1. Position and motion of objects
2. Properties of objects and materials

Levels 5-8

1. Motions and forces
2. Properties and changes of properties in matter

Content Standard A: Science as Inquiry

Levels K-12

1. Abilities necessary to do scientific inquiry
2. Understanding about scientific inquiry

Earth and Space Science Standards

Levels K-4

1. Objects in the sky
2. Changes in Earth and sky

Pre-requisite Skills and Knowledge

There are no pre-requisite skills or knowledge needed to successfully complete this module.

Glossary

Attract: to pull to or towards or itself.

Compass: a device for determining direction by means of a magnetic needle turning freely on a pivot and pointing to the magnetic north.

Domains: the small regions in a magnetized substance.

Electromagnet: an iron or steel core with wire wound around it. It becomes magnetic when an electric passes through the wire.

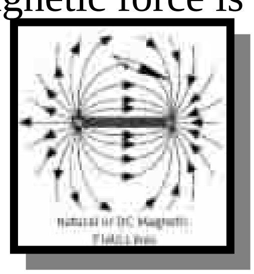
Elements: any of the 107 substances that cannot be separated into simpler substances by using chemistry. It is determined by the number of protons in an atom. Carbon, hydrogen lead, and gold are examples of elements.

Lodestones: a naturally occurring rock that acts as a magnet and attracts iron.

Magnet: an object that attracts items made of iron towards itself.

Magnetic: having to do with magnets and the way they work.

Magnetic Field: the space around a magnet in which a magnetic force is active.



Magnetic Pole: 1. either of the poles of a magnet.
2. either of the two small non-stationary regions which are located respectively in the polar areas of the northern and southern hemispheres and toward which the compass needle points from any direction throughout adjacent regions.

Magnetism: the power of a magnet to attract**.**

Repel: to ward off or force back

Science Content

Magnets and Magnetism

Introduction

Many life forms have evolved in the presence of the Earth's magnetic field. For example, humans were able to navigate the globe by using the Earth's magnetic field, a lodestone and a compass. But it wasn't until the 19^{th} century that humans learned to use the properties of magnetism and electricity. For example, the uses of electromagnetism are found in our everyday lives. Appliances, speakers, doorbells, radios and telephones are a few examples.

History of a Lodestone

Lodestones are magnetic rocks that were known by both ancient Greeks and early Chinese. Lodestones were called *tzhu shih*, the "loving stone", in China, due to its power to attract iron. *Lodestone* (*lode* meaning "guiding") is also an old English word used in reference to the magnetic compasses that aided in navigation. The word *magnet* was most likely derived, from a location near Greece called Magnesia, where lodestones were first discovered. It is the composition of the lodestone that is the source of its magnetic properties. They are made of *magnetite*, a compound of iron (Fe) and oxygen (O), an oxide, with the formula Fe_3O_4. It has been theorized that the lodestones were magnetized by lightning strikes, due to the large currents and magnetic fields carried in lightning.

A Magnets and a Compass

The force, known as magnetism, can be found on Earth as well as other places in the universe. If you suspend a magnet from a string it will rotate freely and finally stop in such a way that the ends of the needle will point in the north-south direction. The magnetic needle in a compass behaves in a similar way as a reaction to the weak magnetic field of the Earth. The magnet pointing north is what is typically referred to as the compass needle and it will point to the Earth's magnetic north pole. [Note: The Earth's magnetic north pole is not the same as the geographic north pole located on a globe.] The compass greatly assisted in the exploration of the New World.

Earth's Magnetic Poles

In 1600, William Gilbert, a physician of Queen Elizabeth I, wrote a book called *De Magnete,* suggesting that the Earth is a great magnet. While Gilbert thought the Earth was like a permanent magnet we know the magnetic field is constantly changing, and therefore, it is more like an electromagnet. The Earth's magnetic pole is not at the exact geographic pole, but it actually wanders hundreds of miles from the geographic pole. The magnetic poles are located approximately 1,800 kilometers from the geographic north pole in the northern hemisphere, and just south of Australia in the southern hemisphere. Also the magnetic field has reversed many times over the life span of the Earth.

About Magnets

A definition for magnetism is the power of a magnet to attract. Permanent magnets are attracted to items that contain the element of iron or steel. These items have the potential to become magnets when stimulated by a permanent magnet or by a coiled wire carrying electric current. Therefore, items that are attracted to permanent magnets can become temporary magnets until the permanent magnet is removed. The magnetic forces around a magnet can work beyond a non-magnetic barrier as long as the barrier is not too thick.

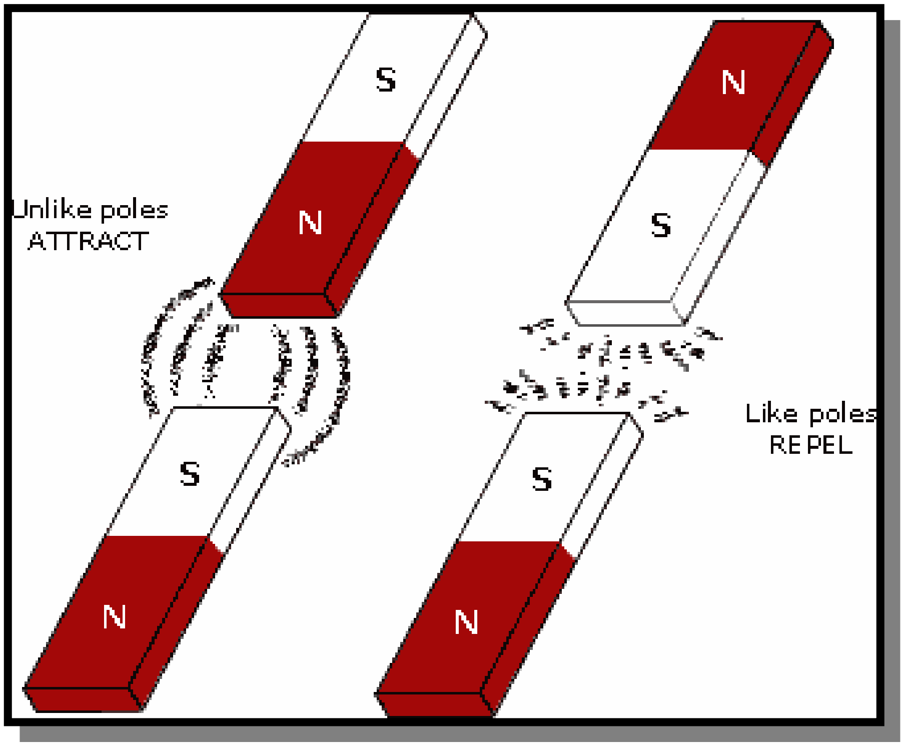
How A Magnet Works

In order for a magnet to work, large clusters of iron atoms need to line up with each other. These clusters of aligned atoms are called the magnetic domains. These domains contain millions of aligned atoms making the domains perfectly magnetized. It is the alignment of the domains that makes the iron magnetized. In a piece of iron that is not magnetized, the domains are randomly oriented. While in a magnetized piece of iron, the domains are oriented in the direction of the magnetic field. A magnetic field is the area around a magnet which a magnetic force is exerted. The motion of electric charge produces a magnetic field. Electrons in an atom are in constant motion spinning around the atomic nuclei. Therefore, to become magnetic, moving charges, or the motion of electrons, create tiny currents and produces a magnetic field.   In the atoms of iron, (atomic symbol Fe), and other magnetic materials, electrons spin about their own axis creating magnetism. When these atomic magnets, work in unison with the neighboring atoms, it makes the atoms point in the same direction, producing a permanent or temporary magnet. There is no magnetic field when electrons spin in opposite directions because they cancel each other out. It's a little more complicated, but at this level, it is enough to know that the atoms in iron are tiny magnets due to the spin of the electrons. For iron material to be a permanent magnet, most of the domain regions of the iron, must be pointing in the same direction.

Magnetic Field Lines

Lines of force around a magnet are called a magnetic field. These magnetic field lines are invisible but can be seen by placing iron filings on a piece of paper over a magnet. The filings are attracted to the magnet and will line up in the shape of the magnetic field. The magnetic field lines are strongest at the poles of the magnet. The magnetic field lines exit at the north pole end of the magnet. They form a continuous curve on either side of the magnet as they travel outside the magnet, entering again back into the south pole end. The magnetic field lines continue through the middle and then out of the north pole end.

The opposite end of the magnet and compass needle is called the south pole. When the north pole of one magnet is brought close to the north pole of another magnet, the two poles will repel or push away from each other; two south poles places near each other will also repel and want to push away from each other. However, when the north pole of one magnet is brought close to the south pole of another magnet, the two poles are attracted and come together. Therefore, like poles repel, unlike poles attract.



OPPOSITE POLE OF A MAGNET ATTRACT AND LIKE POLES OF A MAGNET REPEL

Magnetism And Electricity

It was Michael Faraday, a 19th century English scientist, who discovered the important effect of magnetic fields. He found that a wire exposed to changing magnetic fields, would "induce" an electric current in the wire. "Induction" allow us to generate an electric current from changing magnetic fields, which is used in the transformers and generators, to produce and deliver electric power to electrical wall outlets.

Electromagnets were developed from a series of observations. In 1820, Hans Christian Oersted discovered that a current-carrying wire set up a magnetic field. William Strugeon invented the first practical electromagnet early in the 19th century. He found that leaving the iron inside the coil greatly increased the magnetic field. He also found by bending the iron core into a U-shape, brings the poles closer together, and concentrated the magnetic field lines. Joseph Henry used insulating wire, and his largest electromagnet was built in 1832. This electromagnet could lift 3,600 pounds. One of his original electromagnets is in the Smithsonian Institute collection.

Electromagnetism is the foundation for all electrical engineering. We use and depend on electromagnets in much of our everyday lives. Electromagnets are in many of our household appliances, moving vehicles and used in many different industries.

How Electromagnets Work

A coil of wire can become a magnet when an electric current is flowing through it. The coil will have a north and south pole which can be reversed when the direction of the current is reversed. The more times the coil is turned the stronger the magnet becomes. However, the higher the electric current, the hotter the wire becomes and when the temperature of the wire reaches the point where the wire will melt, then a limited amount of current can go through the wire. This situation can be resolved by putting some iron inside the wire. This greatly increases the strength of this temporary magnet called an electromagnet.

A simple electromagnet can be designed by wrapping copper wire around a nail and attaching it to a battery, making the nail a stronger magnet. The magnetic force is switched off by switching off the electric current. Moving electrical charges in an electric current attract and repel each other through a magnetic field. Electric currents are the source of the magnetic field. Also, the electric currents respond to the force of the magnetic field. Specifically, electricity in motion, that is the current, generates a magnetic field while magnetism in motion generates an electric field. Electromagnets have iron cores, but similar magnetic materials are also used.

Electromagnets have many useful and practical applications. Appliances, such as washers, dryers, and refrigerators, use attractive and repulsive forces to do their work but the magnets are hidden. Speakers, doorbells, radios and telephones all have varying currents, with varying magnetic forces through a vibrating coil, generating vibrations in the air. These acoustic vibrations make sound from the electric input by way of the magnetic forces.

Superconductivity

Huge magnetic fields are created with the use of superconductivity, which was discovered by a Dutch physicist Heike Kamerlingh Onnes in the early 20th century. These superconducting magnets can produce fields between 50 to 90 kilogauss. One of today's major commercial use of superconducting magnets is in magnetic resonance imaging (MRI) often used by physicians as a diagnostic tool.

Earth as a Magnet

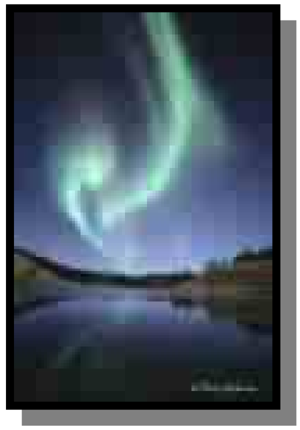
Since the interior temperature of the Earth is above that which magnetic material loose their magnetism, it is important to explain how the Earth behaves like an electromagnet. The Earth has a liquid metallic core with electric currents circulating in it as the fluid flows. This is theorized to be the source of the Earth's magnetic field. The motion of this liquid core generates an electric current, and the electric current generates a magnetic field. The energy needed for this process may come from the heat that is produced when some of the liquid core becomes a solid as the Earth cools.

The Magnetosphere

Earth's magnetic field, called the magnetosphere, can have some fluctuations from the charged particles coming from the Sun. However, most of the magnetic field surrounding the Earth is due to the electric currents deep in the molten metal core of the Earth's interior. The unit used to describe the strength of a magnetic field is the Gauss. Earth's magnetic field is about 0.5 Gauss. The major importance of the magnetosphere is to protect the Earth from the charged particles coming from the Sun.

Auroras

Solar winds carry charged particles that are deflected by the Earth's magnetosphere. Once in the Earth's magnetic field, the charged particles then travel spirally along the magnetic field lines, which run from pole to pole. In the polar regions, the charged particles collide with other atmospheric gases, exciting the atoms into emitting light as spectacular auroral displays. These colorful lights are called the Aurora Borelis in the northern hemisphere and the Aurora Australis in the southern hemisphere.



AURORA

The Sun and Other Planets

NASA's interplanetary probes have collected much information regarding other great magnets in our solar system as well as other stars and galaxies. The Sun and most of the planets have their own magnetic field. The Sun has a magnetic field of approximately one Gauss and the direction reverses every eleven years. Jupiter's surface magnetic field is measured at approximately four Gauss. Jupiter's magnetic field is ten times stronger than the Earth's magnetic field, and Mercury's magnetic field is nearly a hundred times less than Earth's. Neptune and Uranus have large magnetic fields, but their magnetic poles are positioned much further away from their geographic poles. The Earth's moon, as well as Mars and Venus, have little or no magnetic field. An asteroid, Gaspra, has a surface magnetic field similar to that of the Earth. White dwarf stars are known to have fields up to 100 million Gauss and neutron stars can have fields of a trillion Gauss. A galaxy is a very large (in size) electromagnet which spans a million trillion miles across but has a relatively weak magnetic field.

DAY ONE

Student will be able to discover the properties of magnets, enhancing their note-taking skills as they write their thoughts and observations in a "Magnetism Workbook". They will observe demonstrations on the magnetic characteristic of a lodestone, discovered the practical uses of a compass, and participate in a hands-on activity in which they will explore the kinds of items that are attracted to a magnet.

Objectives

Students will be able to:

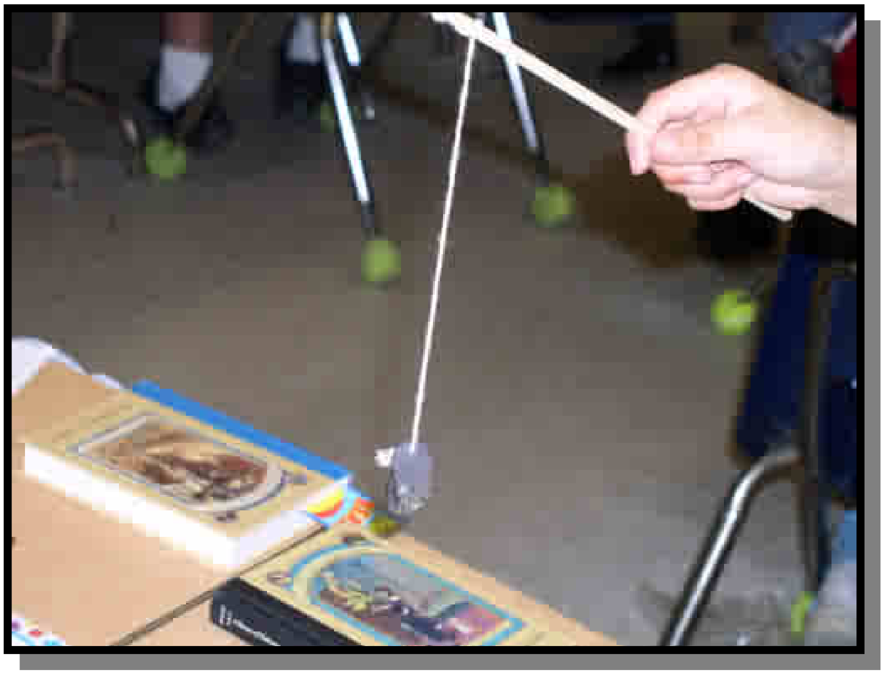
1. Describe a lodestone and identify where they were first discovery.
2. Investigate a compass and explain how the invention relates to a lodestone.
3. Identify Earth's Magnetic North Pole.
4. Define magnetism and identify items that are magnetic.
5. Describe the properties of magnetic and non-magnetic materials.

Materials Needed To Be Prepared By The Teacher Prior To Teaching

Lodestone Demonstration

1 Magnet wand (a magnet with a handle)

1 Lodestone and 2 rocks, similar in size, shape and color. [Note: Lodestones can be purchased through a teacher's supply catalogue (www.carolina.com).]



FISHING POLE

Going Fishing Activity

1 10 inch dowel one for each student.

1 piece of string - 12 inches in length

¾ inch button magnets

Directions to Make a Magnetic Fishing Pole

1. Take a string 12 inches long and tied it to one end of the 10 inch dowel.

2. Superglue the other end of the 12 inch string to a ¾ inch button magnet, (which can be purchased from a craft store).

   [Note: An alternative method to using superglue - drill a small hole in the center of the ¾ inch button magnet and tie a knot at the end of the 12 inch string.]

GOING FISHING WITH A MAGNET

Content in the Magnetic Fishing Bag

1 small plastic bag for each student filled with:
- 1 cotton ball
- 1 bolt, screw, or metal washer
- 1 toothpick
- 1 paperclip
- 1 penny
- 1 piece of aluminum foil
- 1 staple

[Note: A teacher may select any other items for the Magnetic Fishing Bag].

Materials Needed For The Student

1 Magnetic Fishing Bag for each student
1 Magnetic Fishing Pole for each student

Magnetism Workbook

The Magnetic Notebook will document each students work during the investigation of the concepts of magnetism. The Magnetic Notebook will enhance each student's note-taking skills through their work making predictions, drawing diagrams, making observations, and summarizing their understanding of magnetism.

The Magnetic Notebook for students can be found in Appendix A. The Teacher's Version of the Magnetic Notebook can be found in Appendix B.

Activity # 1 – Discovering Lodestones

The intent of this demonstration is for the student to observe the magnetic properties of a lodestone. Lodestones were discovered as having magnetic properties and later used to make a steel needle magnetized and used in a compass for navigational purposes. (See Science Content for additional information.)

Content Preparation the Teacher Before Teaching The Lesson

Teachers should be able to answer each of the following questions:

1. What is a lodestone?
2. Where lodestones were first discovered?
3. What are the uses of lodestones?
4. How did magnets get their name?
5. Which way does a compass needle point and why?
6. Why is a compass important to an explorer?

The answers to these questions are found in the Science Content section of this module.

Directions For The Teacher

1. On a table, place the two rocks and the lodestone in a row. The lodestone needs to be at the end of the row.

2. Ask students: “Do you think all these rocks are the same?” [Expected response: Yes] “Let’s see if they are?”

3. Slowly wave the magnet wand over each rock, one at a time, and then over the lodestone. The lodestone will stick to the wand. [Expected response: “Wow!”]

4. Ask the students - “Is it magic or…?” “What do you think?” [Expected response: Answer may vary.]

5. Have student refer to page 2 of the Magnetic Workbook and indicate their predictions and thoughts about what is causing the rock to stick to the magnet wand.

6. Continue placing the magnet wand over the three rocks and ask the students, “How does the wand work?” (The Magnet Workbook will pose this question on page 2. Ask students to respond to this question in their Magnetic Workbook.)

7. Ask several students to share their thoughts with the class. [Expected response: Answers will vary.]

8. Ask students to turn to page 3 in their Magnetic Workbook and respond to the question, “What happened when the teacher put the wand over the three rocks on the table”?

9. Have the students indicate their response on page 3 of the Magnetism Workbook.

10. Read aloud to the class the text on page 3 and page 4 in the Magnetic Workbook. The text is also presented in the box below.

A long, long time ago, the ancient Greeks and the early Chinese knew of rare and strange stones that had the power to attract iron. These rare and strange stones are called **LODESTONES**. It is possible the lodestones were chunks of iron ore that were struck by lightning, giving these rocks the power to attract iron. These stones were discovered in an area near the city of Magnesia, not far from the country of Greece. The word **MAGNET** comes from the city for which the rocks were originally discovered.

Not only did the lodestones have the power to attract iron, they found a steel needle would become **MAGNETIC** when a lodestone was stroked over the needle. Then about the year 1000, the Chinese noticed that when this magnetic needle was freely suspended it would point in a north-south direction.

This magnetic needle, when suspended freely, was used as a **COMPASS** by the European explorers, as they explored the New World. Christopher Columbus used the compass when he crossed the Atlantic Ocean. By using the compass and the nighttime stars, the voyagers were able to know where they were, as well as guide them home again. The compass needle points towards the north but not to the exact North Pole.

Around 1600, a man named William Gilbert of England, proposed an explanation. He suggested the Earth was a giant magnet. This giant magnet's poles were not at the exact place where the Earth turns, as it spins around each day. This place is called the **GEOGRAPHIC NORTH POLE**. Instead, the compass needle points towards the **MAGNETIC NORTH POLE**.

Now, let's go fishing!

<u>Activity # 2 - Going Fishing</u>

The intent of this activity is for the students to predict which items are magnetic. The students will observe that magnets are attracted to certain kinds of metals. The students will observe what these materials have in common. The students will write a definition for magnetism.

Content Preparation The Teacher Before Teaching The Lesson

Teachers should be able to answer each of the following questions:

1. What items are attracted to magnets?
2. What do the items have in common?
3. Magnetism is defined as?

The answers to these questions are found in the Science Content section of this module.

Directions For The Teacher

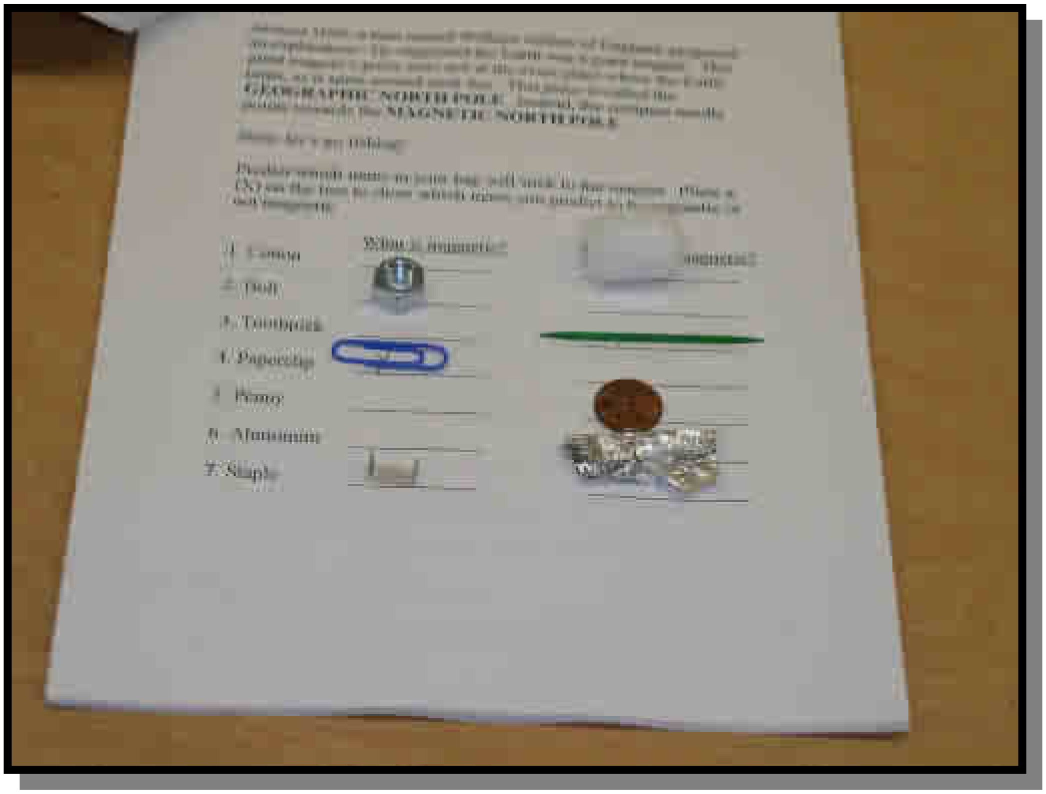
1. Ask students to predict, <u>without</u> using the Magnetic Fishing Pole, which items in the Magnetic Fishing Bag will be magnetic or not magnetic. Put a (X) on the appropriate lines on page 4 in the Magnetic Workbook.

2. **Go fishing! -** Have the students test the items in the bag on page 5 by using the Magnetic Fishing Pole and place a (X) on the appropriate line in the Magnetic Workbook.

3. Have the students answer questions 5 and 6 on page 5 in their Magnetism Workbook.

4. Ask the class to suggest some words that can be used to create a definition for magnetism. [Expected response: words will vary, but listen for key words like "power", "attract", and "magnet".]

5. After referring to the definition for magnetism in the glossary, on page 6 of the Magnetism Workbook, ask students to write the definition in the Magnetism Workbook for question 7.



ITEMS THAT ARE MAGNETIC AND ITEMS THAT ARE NOT MAGNETIC

Assessing Understanding For Day One

Once the lessons for day one are completed, have the students answer the review questions on page 7 of the Magnetism Workbook. Then have an informal review by orally answering the review questions which will serve as one method to ascertain the students' understanding of the materials presented during day one.

DAY TWO

Students will observe how iron shavings behave when they come in contact with a bar magnet. The students will explore how a magnet works. The students will investigate how magnetic field lines attract metals to a magnet.

Objectives

Students will be able to:

1. Explain why iron shavings form a particular pattern around a bar magnet.
2. Describe how a magnetic field is created around a magnet.
3. Draw and label how magnetic field lines travel through a magnet.
4. Define magnetism and describe its properties.
5. Explain how a magnet works.

Materials Needed To Be Prepared By The Teacher Prior To Teaching

Iron Shaving Demonstration

1 Bar magnet
1 Small container of iron shavings
1 Overhead projector and a transparency

IRON FILINGS AROUNG A BAR MAGNET

Activity # 3 – Discovering The Invisible Force Of Magnetism

The intent of this demonstration is for the student to observe what happens to iron shavings when they are near a bar magnet. This demonstration allows the student to visually see the invisible force of magnetism around a magnet.

Content Preparation the Teacher Before Teaching The Lesson

Teachers should be able to answer each of the following questions:

1. What is an element?
2. What element is a magnet is made of?
3. What are the properties of magnetism?
4. How is a magnet field created?
5. How do magnetic field lines form around a magnet?
6. How do magnets attract and repel?

The answers to these questions are found in the Science Content Section of this module.

Directions For The Teacher

1. Have the students rewrite the definition of magnetism on page 8 in the Magnetic Workbook.

2. Place a bar magnet on an overhead projector with a transparency on top of the bar magnet.

3. Carefully sprinkle some iron shavings on to the transparency around the bar magnet.

4. Lightly tap the overhead with your finger to spread the iron shavings more evenly around the bar magnet.

6. On the chalkboard, draw a replica of the magnet and iron shavings as they appear on the overhead. Turn the overhead off for the students to view the pattern on the chalkboard.

6. Ask the students to draw what they observe on page 8 of the Magnetic Workbook, and answer question 10.

7. Read to the class page 9 of the Magnetism Workbook. The text is also presented in the box below.

> So, let us explore how a magnet works?
>
> Everything on Earth is made of **ELEMENTS**. There are many different kinds of elements, such as hydrogen, oxygen, copper and iron. Magnets are made of the element **IRON**.
>
> Inside the iron, there are regions called **DOMAINS.** When all these domains point in the same direction, the iron material becomes **MAGNETIC**. But, if all the domains are <u>not</u> pointing in the same direction, the iron material is no longer magnetic. Also, when all these domains are pointing in the same direction, a **MAGNETIC FIELD** is created. This magnetic field is all around the magnet**.**

8. Ask students draw, on page 10 of the Magnetism Workbook, by using arrows to represent the direction all the domains need to be pointing in order for a magnet to be magnetic.

9. Then ask the students to draw, by using arrows, what the domains will look like when the magnet will not work.

Activity # 4 - Demonstrating the Way Magnetic Field Lines Travel

The intent of this activity is for the student to better understand the direction magnetic field lines travel around and through a magnet. The students will observe and participate in this activity to make certain they grasp the concept of the invisible force around a magnet.

Content Preparation The Teacher Before Teaching The Lesson

Teacher should be able to answer each of the following questions:

1. How is a magnetic field created?
2. How must the domains be positioned in order to create a magnetic field?
3. How does the element of iron become magnetized?
4. Which way do magnetic field lines travel?
5. Why do magnets have a north pole and a south pole?
6. How do two magnets attract and repel?

The answer to these questions can be found in the Science Content section of this module.

Directions For The Teacher

1. Read to the class the bottom of page 10 and the top of page 11 in the Magnetism Workbook. The text is also presented in the box below.

In a magnet, there are two poles at each end. The NORTH POLE at one end, and a SOUTH POLE at the other end. For the magnet to work, the magnetic field must be working in a very specific way. **MAGNETIC FIELD LINES** leave from the north pole and enter back into the south pole. The magnetic field lines travel through the magnet. And again, the magnetic field lines leave the north pole and go back to the south pole, passing through the magnet.

It is like a hot dog! The magnetic field lines pass through one end of the hot dog (the north pole of the magnet) and go around the hot dog bun, then back into the hot dog (the south pole of the magnet) at the other end. It forms a closed curve that goes around and around.

2. Ask several students to help demonstrate to the class the direction magnetic field lines travel through and around a magnet.

3. Position one student to represent the north pole of a magnet.

4. Position another student to represent the south pole of a magnet.

5. Position three other students, in between the north and south pole, so there is an arms length space between each of them.

6. Ask three to four other students to be the magnetic field lines. One student can start at the north pole, another at the south pole, and two other to start outside the magnet.

7. Ask the students to travel as magnetic field lines. The student at the north pole will walk outside the magnet, entering at the south pole. The students outside the magnet will also enter at the south pole. The student at the south pole will walk through the magnet, weaving in and out of the students that are positioned there. All students entering at the south pole will follow in this same pattern.

X X X X X

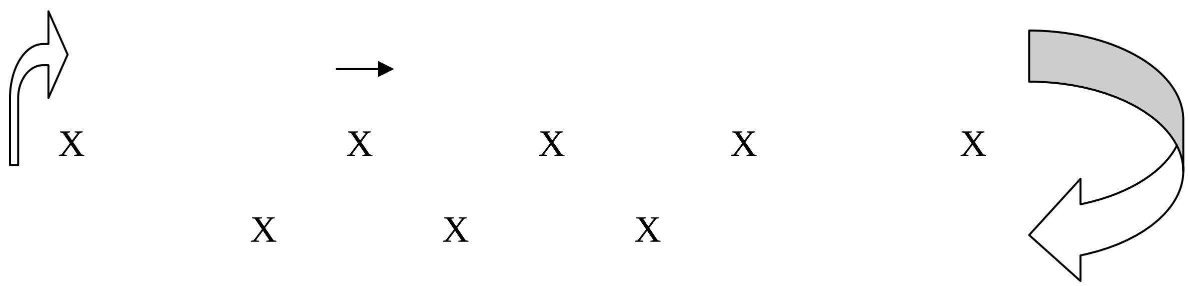
X X X

Student representing the magnetic north pole

Students representing the magnet

Student representing the magnetic south pole

Diagram # 1 – Position of the Magnet



Magnetic north pole

Magnetic south pole

Diagram # 2 – Movement of the Magnetic Field Lines

8. Ask another group of students to demonstrate this activity to include everyone in the class.

9. Ask the students to draw the magnetic field lines and write their answer for question 13, on page 11 in the Magnetism Workbook.

10. Read to the class the bottom of page 11 in the Magnetism Workbook. The text is also presented in the box below.

If two magnets are put together, the north pole of one magnet will stick to the south pole of the other magnet. They **ATTRACT** each other. But, if you put the north pole to another north pole, they push each other away, or **REPEL**.
Opposite poles attract, like poles repel.

Assessing Understanding For Day Two

Once the lessons for day two are completed, have the students answer the review questions on page 12 of the Magnetism Workbook. Then have an informal review of the answers to assess the students' understanding of the materials presented to them.

DAY THREE

Students will make an electromagnetic.   Students will explore the connection between electricity and magnetism. The students will investigate the practical applications and the many uses of electromagnets in our ever day lives.

Objectives

Students will be able to:

1. Build an electromagnet.
2. Investigate the connection between electricity and magnetism.
3. Describe the lines of force around a copper wire.
4. Determine the properties of a permanent and temporary magnet.
5. Explain how magnets attract and repel.
6. Describe the foundation of electrical engineering.
7. Explain useful applications of electromagnets.

Materials Needed To Be Prepared By The Teacher Prior To Teaching

One 3 inch iron nail for each pair of students
One 3 feet long insulated copper wire for each pair of students
One 6 volt battery for each pair of students
Some paperclips and other light items that are attracted to magnets
Electrical tape

Activity # 5 - Building An Electromagnet

The intent of this activity is for the student to build an electromagnet. Students will explore the connection between electricity and magnetism as well as discover the difference between a permanent magnet and a temporary magnet. Students will investigate the magnetic field, which is created as an electric current travels through a wire. Also, the students will discover the many applications of electromagnets.

Content Preparation the Teacher Before Teaching The Lesson

Teachers should be able to answer each of the following questions:

1. What is an electromagnet?
2. How were electromagnets first discovered?
3. How does one increase the power of an electromagnet?
4. How is a magnetic field created in a wire?

The answer to these questions can be found in the Science Content section of this module.

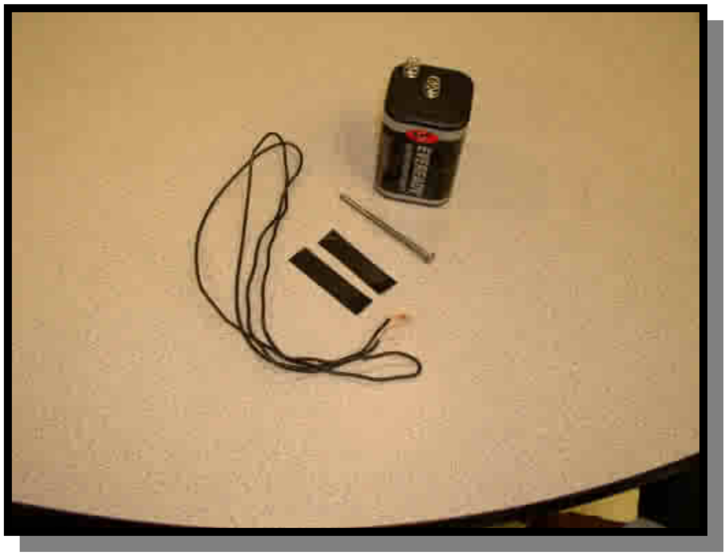
Directions To The Teacher

1. Place students into small groups, depending on how many 6-volt batteries are available to the class. Two students are ideal.

2. Pose the question indicated on page 13 of the Magnetism Workbook,
   "What can you build with only a long piece of copper wire, an iron nail and a small battery? Do you have any ideas?" Give students time to think about it and write their thoughts in their workbooks.

3. Ask several students to share their ideas with the class.

4. Follow the directions on page 14 of the Magnetism Workbook. The directions are also presented in the box below.



MATERIALS NEEDED TO BUILD AN ELECTROMAGNET

A simple **ELECTROMAGNET** can be built with a few common household items.

<u>Materials For An Electromagnet</u>

A large iron nail (about 3 inches)
About 3 feet of <u>thin</u> insulated copper wire
A new 6 volt battery
Paper clips or other light items that are attracted to magnets.

<u>Directions to Build An Electromagnet</u>

1. Leave about 8 inches of wire at one end and wrap the wire around the nail about 10-20 turns, trying not to overlap the wires.

2. Cut the wire (if not already cut) so that there is about another 8 inches loose at the other end. You should be able to see the top of the nail and the tip of the nail.

3. Now remove about an inch of the wire's insulation coating from both ends of the wire, and attach one end to the battery terminal and the other end of the wire to the other terminal of the battery. Tape the ends of the wires to the battery terminals. The wire will get very **HOT-** so be careful.

Be safe and have fun!

5. Demonstrate to the class how to build the electromagnet.

6. Demonstrate the procedure again to reinforce the directions and cautions of building an electromagnet.

7. Review and reinforce the importance of using the electricians tape on the battery terminals since the exposed copper wire will become **HOT** when attached to the battery**. Use the electricians tape to prevent a student from becoming burned.**

8. Ask the students to follow the steps to build an electromagnet. The directions are presented on page 14 in the Magnetism Workbook.

9. Have the student test the electromagnet by trying to pick up the metal items, found in the Magnetic Fishing Bag, used in Activity #2 - Going Fishing.

10. After every student has successfully built an electromagnet, read page 15 and 16 of the Magnetism Workbook. The text is presented in the box below.

Congratulations! You have just built an **ELECTROMAGNET**. If you put the point of the nail near a few paper clips it should pick them up! But how does it really work? Let's explore. Is it MAGIC or MAGNETISM?

Most magnets, like the ones we looked at earlier, which cannot be turned off, are called permanent magnets. The kind of magnet that you built is called **ELECTROMAGNETS**. They are only magnetic when a current of electricity, from the battery, is flowing. They do not work when the electricity from the battery is turned off. It is the current of electricity flowing through the wire that arranges the **DOMAINS** regions of the iron nail. When these domains are all in the same direction the nail becomes magnetic and can attracted some metals.

When the battery is on, an electric current travels through the wire. A **MAGNETIC FIELD** is created. The magnetic field becomes stronger when a wire is coiled around a piece of iron. **LINES OF FORCE** form around the wire. When the wire is coiled around the nail, these lines of force link up with each other. The more the wire is coiled around the nail, the stronger the electromagnet. The iron nail concentrates the lines of force increasing the power of the electromagnet.

Electromagnets obey the same rules as permanent magnets; they have a north pole and south pole and like poles **REPEL** each other while unlike poles **ATTRACT** each other.

11. Ask the students to think about and list some applications of an electromagnet on page 16 of the Magnetic Workbook.

12. Ask several students to share some of their ideas with the class.

13. Continue reading from the Magnetism Workbook on page 17. The text is presented in the box below.

Electromagnets are in doorbells, loud speakers and circuit breaker. We use electromagnets to generate electricity, store memory in computers, generate a picture on our televisions, and they can be found in some automobile brakes and clutches.

Very powerful electromagnets are used in scrape yards where they can lift whole car.

Some special electromagnets, called superconducting magnets, are essential to **MAGNETIC LEVITIATION TRAINS**. Magnetic repulsion is used to lift the trains up, clear of the track. These very powerful magnets lift the whole train so it floats a fraction of an inch above the track. These trains can reach speeds of 298 miles per hour smoothly. Other superconducting magnets are in magnetic-resonance imaging machines used by doctors to diagnose illnesses.

Assessing Understanding For Day Three

Once lessons for the day three are completed, have the students answer the review questions on page 18 of the Magnetism Workbook. Then have an informal review by orally answering the review questions which will serve as one method to ascertain the students' understanding of the materials presented to during day three.

DAY FOUR

Students will explore the concept of Earth as a giant magnet. Students will investigate the magnetic properties of Earth, the Sun and other planets. They will also determine the importance of the magnetosphere and describe how Auroras are created.

Objectives

Students will be able to:

1. Describe the magnetic properties of Earth, the Sun and other planets.
2. Identify a magnetosphere.
3. Explain the importance of the Earth's magnetosphere.
4. Identify the solar winds of the Sun.
5. Describe how Auroras are created.

Materials Needed To Be Prepared By The Teacher Prior To Teaching

At least four or more photographs or diagrams of the following:

1. The Sun's solar spot found in the National Geographic July 2004 [www.nationalgeographic.com/magazine and go to archives July 2004 and November 2001]. The Earth's magnetosphere is found in the National Geographic July 2004.

2. Auroras [www.caryanderson.com and/or www.climate.gi.alaska.edu/curtis/curtis.html - Jan Curtis Images of the Auroras. Auroras earth's grand show of lights Nov 2001].

3. Magnetosphere of other planets [www.gsfc.nasa.gov and/or www.solar-center.standford.edu/index.html request solar posters free except for shipping].

<u>Activity # 6 - Magnetism in the Universe</u>

Students will become familiar with the magnetic properties of Earth, the Sun and other planets. Students will realize the importance of the magnetosphere and what atmospheric conditions are needed to create Auroras.

Content Preparation The Teacher Before Teaching The Lesson

Teachers should be able to answer each of the following questions:

1. Why does a compass needle point to the Earth's magnetic north pole?
2. How is Earth like a giant magnet?
3. How is the magnetosphere formed?
4. What do solar winds do to the magnetosphere?
5. What is the importance of the magnetosphere?
6. What atmospheric conditions create Auroras?
7. What other planets have magnetospheres?

The answer to these questions can be found in the Science Content section of this module.

Directions For The Teacher

1. Place photographs and diagrams around the class for students to view.

2. From page 19 in the Magnetism Workbook, read the text and refer to the photographs or diagram when appropriate. The text is also presented in the box below.

Around 1600 William Gilbert, physician to Queen Elizabeth of England, proposed that the EARTH was a giant magnet, with its magnetic poles some distance away from its geographic ones (i.e. near the point where Earth turns on its axis). A **COMPASS** needle will point to Earth's the magnetic north pole. The compass has been used to help explorers navigate on their voyages.

It is not completely understood how Earth is like a big magnet. Under the Earth's surface is the **OUTER CORE**. The outer core is made of spinning liquid metals of iron and nickel. This combination, as well as other conditions taking place in the core, creates an electrical current.

Magnetic Field lines travel between Earth's north and south magnetic poles just as they do between the poles of a bar magnet. The Earth's field lines actually start near the south pole and curve around space and enter again near the north pole. These magnetic field lines around Earth form the **MAGNETOSPHERE**. Charged particles can get trapped in an area of the magnetosphere called the **VAN ALLEN BELT**. The charged particles are trapped in this area much like the iron filing were trapped around the bar magnet.

Earth's magnetic field lines are not as curved as the iron filings around the bar magnet. The Sun's **SOLAR WINDS** cause the lines facing the sun to compress or squished toward the Earth. This part of the magnetosphere extends out 50 to 37,280 miles. The field lines facing away from the sun steam back into a very long "tail", like a comet. This forms the Earth's **MAGNETOTAIL**. The tail trails out more than 186,500 miles.

3. Pose question 17, "Why is the magnetosphere important?" indicated on page 18 of the Magnetism Workbook.

4. Give student time to think about and write their thoughts on page 17 of the Magnetism Workbook.

5. Ask several students to share their response with the class.

6. Continue reading on page 20 of the Magnetism Workbook. The text is also presented in the box below.

The magnetosphere is very important to everyone because it keeps most solar winds away from Earth. The Sun's solar winds can hurt satellites, power and communication lines. The charged particles in the solar wind cannot jump from one field line to the next to get down to Earth. The charged particles tend to remain attached to the "lines of force" like beads on wires. They are trapped in the field lines and circle around the lines in a long spiral.

7. Continue reading page 20 discussing how auroras are created. The text is also presented in the box below.

In the Earth's atmosphere, there are many gas elements like nitrogen, oxygen and argon.
The energetic electrically charged particles, found in the solar winds, begin to speed up along the magnetic field lines.
They follow a path leading into the upper atmosphere near the north and south poles.
They collide into these gas elements.
Energy is released when the particles collide which causes light to be emitted. The light can be seen at night in the northern and southern hemispheres.

These lights are called **AURORAS.**
In the Northern Hemisphere these lights are called AURORA BORELIS.
In the Southern Hemisphere they are called AURORA AUSTRALIS.

The auroras are centered over the Earth's magnetic poles.
The aurora are very colorful and,
they float and move around in the sky.
The different colors can be orange, red, green-yellow and sometimes blue and purple. The colors are different depending on the type of gas the charged particles collided into.
They also can make noises such as hissing, swishing and crackling.

8. Pose question 18 indicated on page 20 of the Magnetism Workbook, "What other objects in space have magnetic fields around them?"

9. Give the students time to think about and write their thoughts on page 20 of the Magnetism Workbook.

10. Ask several students to share their responses with the class.

11. Read to the students, page 21, of the Magnetism Workbook. The text is also presented in the box below.

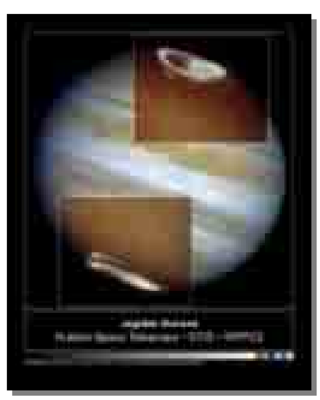
The Earth is not the only object in the solar system to have a magnetosphere.

Mercury, Jupiter, Saturn, Uranus, Neptune and the Sun all have magnetic fields.

Our sister planets, Venus and Mars are the oddballs. Space probes have found no evidence of magnetic field lines on these planets. It is believed that since magnets lose their magnetism when heated, and Venus is so hot it can make lead melt, it may explain why it does not have a magnetic field. Mars is pretty cold and so it is a real mystery why there is no magnetic field.

Jupiter is the largest planet and has the most powerful magnetic field. Jupiter's magnetotail extends all the way to Saturn. Jupiter spins very rapidly and has a metallic hydrogen interior. The top of its magnetic field is 10 times stronger than Earth's. Jupiter also has auroras near its poles but probable not due to the solar winds.

The sun's magnetic field surrounds all the planets. It is carried out through the solar system by the solar winds. Its rotation winds up the magnetic field into a large rotating spiral, known as the PARKER SPIRAL.



AREA OF AURORA ACTIVITY ON JUPITER

Assessing Understanding For Day Four

Once the lessons for day four are completed, have the students answer the review questions on page 22 of the Magnetism Workbook. Then have an informal review by orally answering the review questions which will be one method to ascertain the students' understanding of the material presented during day four.

Resources and References

The following resources and references were helpful in designing this module.

Books

Carmi, Rebecca, *"The Magic School Bus: Amazing Magnetism"*, (2001) Scholastic Inc., ISBM 0-439-31432-1

Gonick, Larry, *"The Cartoon Guide To Physics,"* (1991) HarperCollins Publishers, Inc., ISBN 0-064-63618-6

Keen, Martin L., *"How It Works"*, (1972) Grosset & Dunlap, ISBN 0-448-03918-4

Lehrman, Robert L., *"Physics The Easy Way,"* (1998) Barron's Educational ISBN 0-764-10236-2

Livingston, James D., *"Driving Force: The Natural Magic of Magnets,"* (2004) Harvard University Press, ISBN 0-674-21645-8

Websites

"Astronomy Picture of the Day Archives," www.antwarp.gsfc.nasa.gov/apod/archivepix.html

Auroras: What is the Solar Connection?" http://cse.ssl.berkeley.edu/segwayed/lessons/auroras/aboutsun.html

"Build Your Own Electromagnet," www.sciencebob.com

"How Atoms Work," www.howstuffworks.com/atom.htm

"How Electromagnets Work," http://science.howstuffworks.com/electromagnet3.htm

"Jan Curtis Images of the Auroras," www.climate.gi.alaska.edu/curtis/curtis.html

"The Magnetosphere," http://www-spof.gsfc.nasa.gov/Education/wms1.html

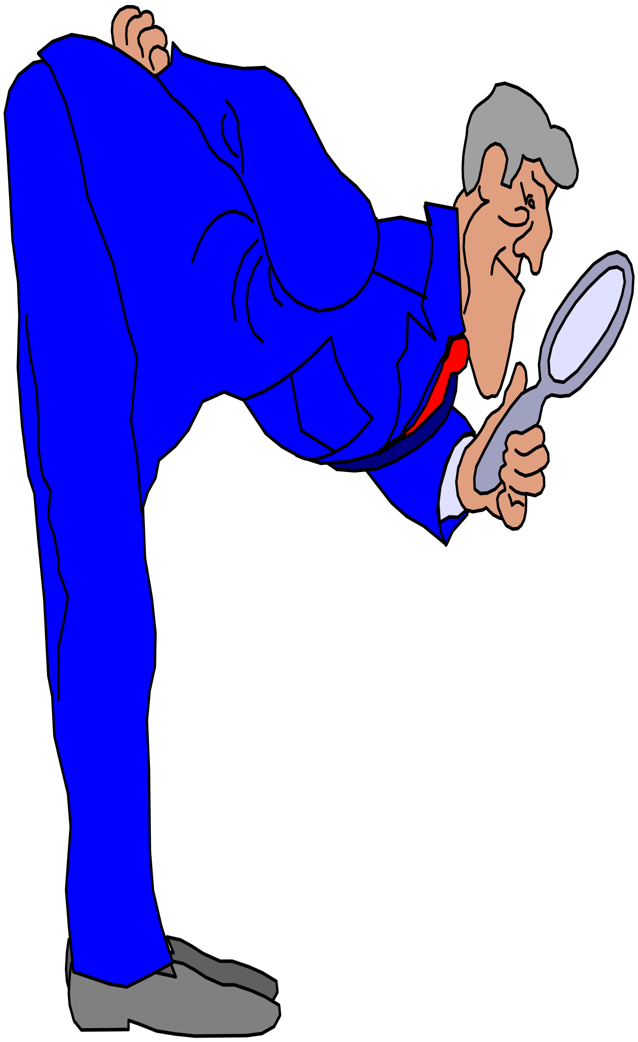
"Earth's Magnetic Field (Magnetosphere),"
http://liftoff.msfc.nasa.gov/academy/space/mag_field.html

"Magnetic Fields and Mars,"
http://mgs-mager.gsfc.nasa.gov/Kids/magfield.html

"The Sun: Living With a Stormy Star,"
www.nationalgeographic.com/magazine

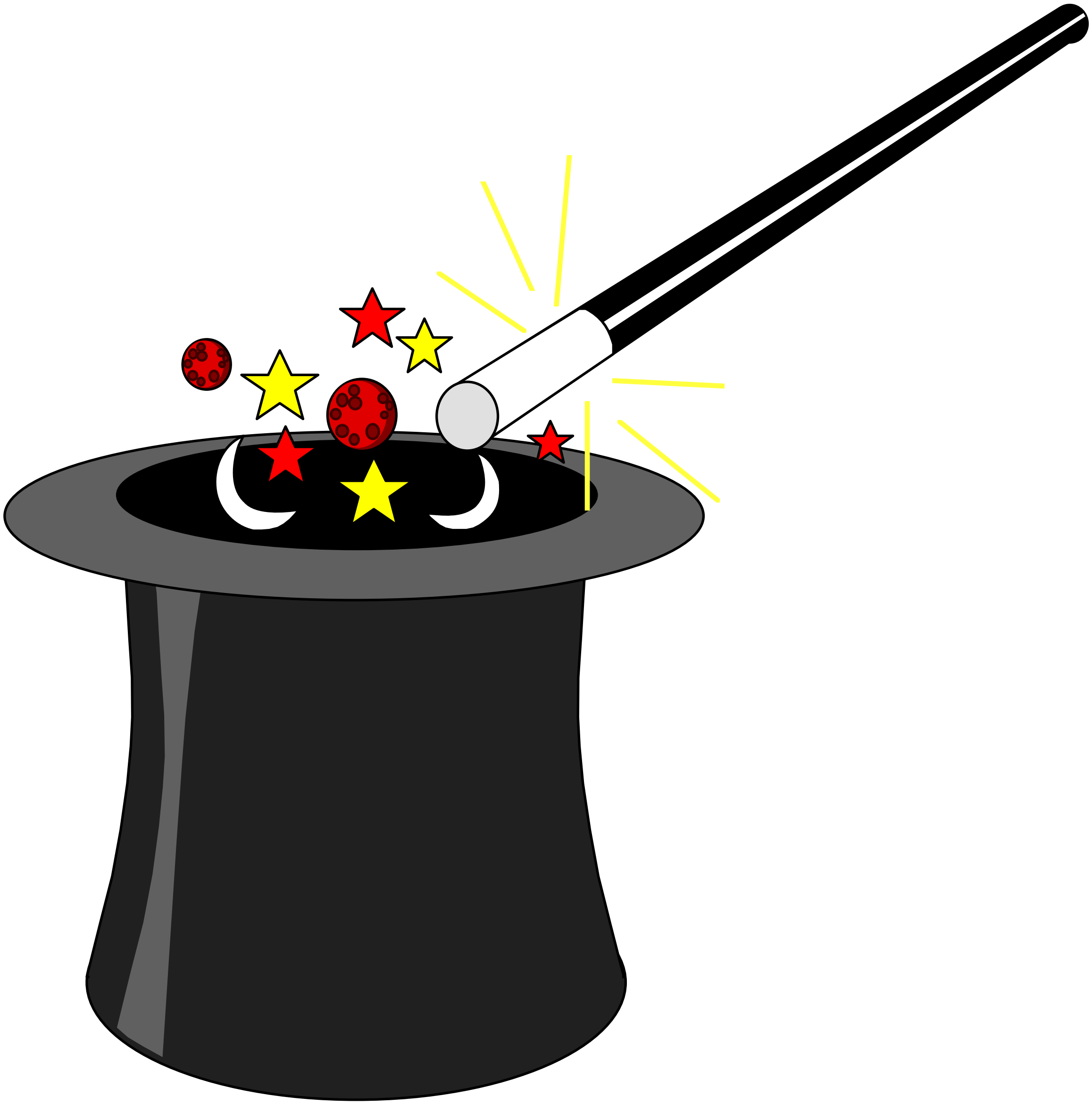
<u>Appendix A</u>

Magnetism Workbook – Student Version



IS IT MAGIC OR MAGNETISM?

NAME ______________________________



1. How does the wand work? Does it work by magic, or something else? Write down what you think it is. Also, write about how you think it works.

____

2. What happened when the teacher put the wand over the three rocks on the table?

Rock # 1____

Rock # 2____

Rock # 3____

A long, long time ago, the ancient Greeks and the early Chinese knew of rare and strange stones that had the power to attract iron. These rare and strange stones are called **LODESTONES**. It is possible the lodestones were chunks of iron ore that were struck by lightning, giving these rocks the power to attract iron. These stones were discovered in an area near the city of Magnesia, not far from the country of Greece. The word **MAGNET** comes from the city where the rocks were originally discovered.

Not only did the lodestones have the power to attract iron, they found a steel needle would become **MAGNETIC** when a lodestone was stroked over the needle. Then about the year 1000, the Chinese noticed that when this magnetic needle was freely suspended it would point in a north-south direction.

This magnetic needle, when suspended freely, was used as a **COMPASS** by the European explorers, as they explored the New World. Christopher Columbus used the compass when he crossed the Atlantic Ocean. By using the compass and the nighttime stars, the voyagers were able to know where they were, as well as guide them home again. The compass needle points towards the north but not to the exact north Pole.

Around 1600, a man named William Gilbert of England, proposed an explanation. He suggested the Earth was a giant magnet. This giant magnet's poles were not at the exact place where the Earth turns, as it spins around each day. This place is called the **GEOGRAPHIC NORTH POLE**. Instead, the compass needle points towards the **MAGNETIC NORTH POLE**.

Now, let's go fishing!

3. Predict which items in your bag will stick to the magnet. Place a (X) on the line to show which items you predict to be magnetic or not magnetic.

	What is magnetic?	What is not magnetic?
a. Cotton	______________	_________________
b. Bolt	______________	_________________
c. Toothpick	______________	_________________
d. Paperclip	______________	_________________
e. Penny	______________	_________________
f. Aluminum	______________	_________________
g. Staple	______________	_________________

4. Now, test these items to determine which are attracted to the magnet. Place a (X) on the line to show which items stick to the magnet.

	Magnetic	Not Magnetic
a. Cotton		
b. Bolt		
c. Toothpick		
d. Paperclip		
e. Penny		
f. Aluminum		
g. Staple		

5. Why do you think the items were attracted to the magnet?

6. What do these items have in common?

7. Write a definition of magnetism.

Glossary

Attract: to cause to come near.

Compass: an instrument for showing direction**.**

Domains: any of the small randomly orients regions in a magnetized substance**.**

Electromagnet: an iron or steel core with wire wound around it. It becomes magnetic when an electric current passes through the wire.

Elements: any of the 107 substances that cannot be separated into simpler substances by using chemistry**.**

Lodestones: a rock that acts as a magnet and attracts iron**.**

Magnet: an object that has the power to pull items made of iron towards itself.

Magnetic: having to do with magnets and the way they work**.**

Magnetic Field: the space around a magnet in which a magnetic force is active.

Magnetic Pole: either of the two areas on the earth's surface, one near the geographic north pole and one near the south pole, where the earth's magnetic fields are strongest**.**

Magnetism: the power of a magnet to attract**.**

Repel: to ward off or force back.

Review

1. A __________________ is a rock with the power to attract iron?

2. Lodestones were first discovered near the country of _______________?

3. When a lodestone is stroked over a steel needle several times, the needle becomes _________________?

4. Christopher Columbus used a ____________________ when he crossed the Atlantic Ocean?

5. In 1600, William Gilbert thought that Earth was a giant __________________?

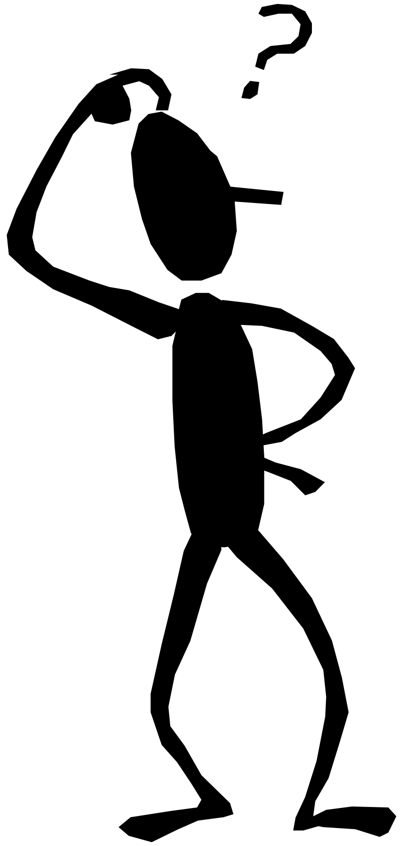
6. The needle of a compass points to the ___________________ _____________ ___________.

7. Name two items from your bag that stuck to the fishing pole magnet. __________________ and __________________

8. What was our definition of magnetism?

9. Draw what you see when the teacher put iron shavings over the overhead. First, make a picture of the magnet. Then draw the iron shavings around the magnet.

10. Do you think that the movement of the iron shavings is MAGIC or MAGNETISM?

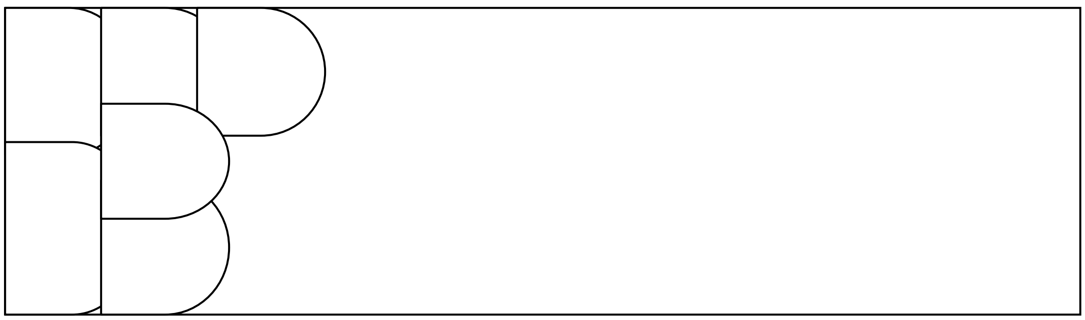


So, let us explore how a magnet works?

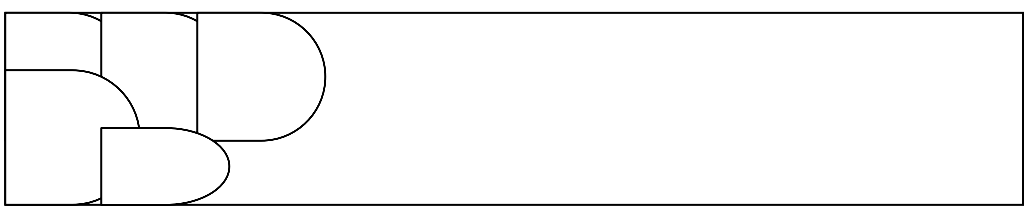
Everything on Earth is made of **ELEMENTS**. There are many different kinds of elements, such as hydrogen, oxygen, copper and iron. Magnets are made of the element **IRON**.

Inside the iron, there are regions called **DOMAINS.** When all these domains point in the same direction, the iron material becomes **MAGNETIC**. But, if all the domains are <u>not</u> pointing in the same direction, the iron material is no longer magnetic.   Also, when all these domains are pointing in the same direction, a **MAGNETIC FIELD** is created. This magnetic field is all around the magnet.

11. Using arrows, draw a picture of the direction all the **DOMAINS** need to be pointing for a magnet to work.



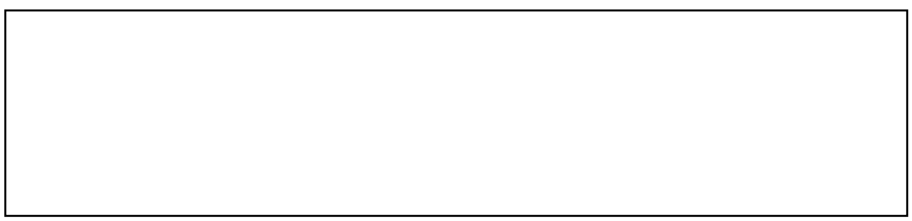
12. Using arrows, draw a picture of what the **DOMAINS** will look like when a magnet will not work.



In a magnet, there are two poles at each end. The NORTH POLE is at one end, and the SOUTH POLE at the other end. For the magnet to work, the magnetic field must be working in a very specific way. **MAGNETIC FIELD LINES** leave from the north pole and enter back into the south pole. The magnetic field lines travel through the magnet. And again, the magnetic field lines leave the north pole and go back to the south pole, passing through the magnet.

It is like a hot dog! The magnetic field lines pass through one end of the hot dog (the north pole of the magnet) and go around the hot dog bun, then back into the hot dog (the south pole of the magnet) at the other end. It forms a closed curve that goes around and around.

13. In the picture below, draw a magnet showing the **MAGNETIC FIELD LINES** traveling around the magnet. Use arrows to show the correct direction the lines are traveling. Label this magnet, with a (N) or a (S), at the north and the south poles.



If two magnets are put together, the north pole of one magnet will stick to the south pole of the other magnet. They **ATTRACT** each other. But, if you put the north pole to another north pole, they push each other away, or **REPEL**.
Opposite poles attract, like poles repel.

<u>REVIEW</u>

1. Everything on Earth is made of ______________________?
2. A magnet is made of the element ________________?
3. Domains are regions inside the _____________ material?
4. The iron material becomes ______________ when all the _____________ are pointing in the same direction.
5. ______________________ ______________ _________ leave the north pole and enter back onto the south pole of a magnet.
6. Opposites poles ______________ and like poles ___________.
7. The iron shavings were _______________ to the magnet.

Here is a question for you!

14. What can you build with only a long piece of copper wire, an iron nail and a small battery? Do you have any ideas?
(Here is a clue. It has something to do with MAGNETISM and ELECTRICITY).

Write down your ideas.

A simple **ELECTROMAGNET** can be built with a few common household items.

Materials For An Electromagnet

A large iron nail (about 3 inches)
About 3 feet of thin insulated copper wire
A new 6 volt battery
Paper clips or other light items that are attracted to magnets

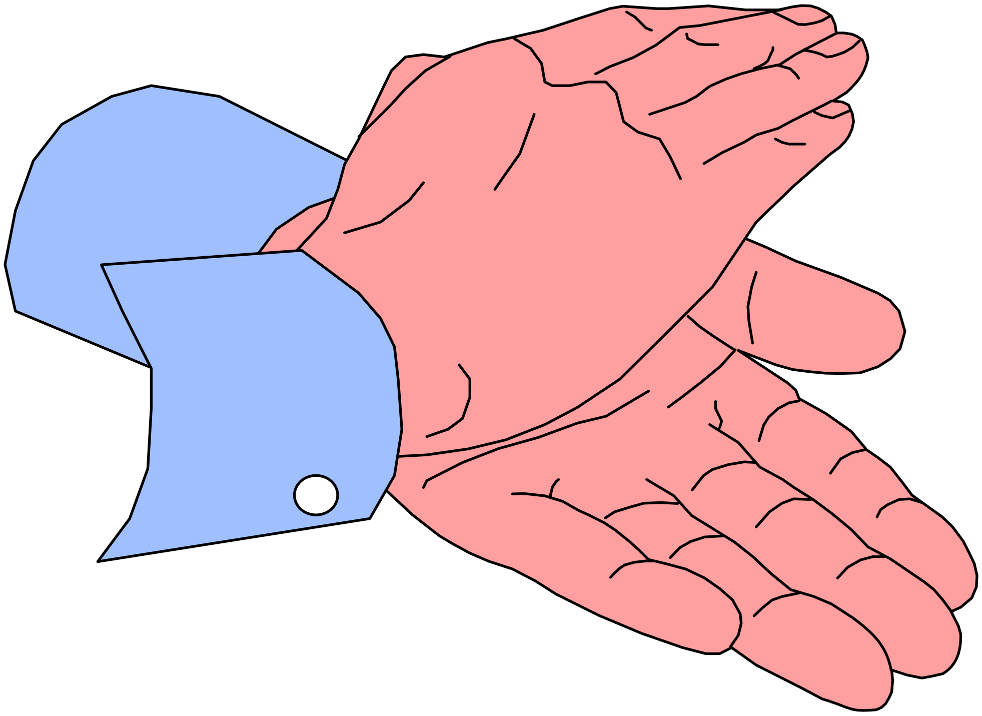
Directions To Build An Electromagnet

1. Leave about 8 inches of wire at one end and wrap the wire around the nail about 10-20 turns, trying not to overlap the wires.

2. Cut the wire (if not already cut) so that there is about another 8 inches loose at the other end. You should be able to see the top of the nail and the tip of the nail.

3. Now remove about an inch of the wire's insulation coating from both ends of the wire and attach the one end of the battery and the other wire to the other end of the battery. Tape the ends of the wires to the battery. The wire could get very **HOT-**so be careful.

Be safe and have fun!



Congratulations! You have just built an **ELECTROMAGNET**. If you put the point of the nail near a few paper clips it should pick them up! But how does it really work? Let's explore.   Is it MAGIC or MAGNETISM?

Most magnets, like the ones we looked at earlier, which cannot be turned off, are called permanent magnets. The kind of magnet that you built is called an **ELECTROMAGNET**. They are only magnetic when a current of electricity, from the battery, is flowing. They do not work when the electricity from the battery is turned off. It is the current of electricity flowing through the wire that arranges the **DOMAINS** regions of the iron nail. When these domains are all in the same direction the nail becomes magnetic and can attracted some metals.

When the battery is on, an electric current travels through the wire. A **MAGNETIC FIELD** is created.   The magnetic field becomes stronger when a wire is coiled around a piece of iron. **LINES OF FORCE** form around the wire. When the wire is coiled around the nail, these lines of force link up with each other. The more the wire is coiled around the nail, the stronger the electromagnet. The iron nail concentrates the lines of force increasing the power of the electromagnet.
Electromagnets obey the same rules as permanent magnets; they have a north pole and south pole and like poles **REPEL** each other while unlike poles **ATTRACT** each other.

Electromagnets were developed from a series of observations. In 1820, Hans Christian Oersted discovered that a current-carrying wire set up a magnetic field. **William Strugeon** invented the first practical electromagnet early in the **19th century**. He found that leaving the iron inside the coil greatly increased the magnetic field. He also found by bending the iron core into a U-shape, brings the poles closer together, and concentrated the magnetic field lines. Joseph Henry used insulating wire, and his largest electromagnet was built in 1832. This electromagnet could lift 3,600 pounds. One of his original electromagnets is in the Smithsonian Institute collection.

ELECTROMAGNETISM is the foundation for all **electrical engineering**. We use and depend on electromagnets in much of our everyday lives. Electromagnets are in many of our household appliances, moving vehicles and used in many different industries. Can you think of any uses for electromagnets?

15. List some appliances, machines or industries you think uses for electromagnets. There are many.

____

____

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Electromagnets are used in many useful things. Electromagnets are in doorbells, loud speakers and circuit breaker. We use electromagnets to generate electricity, store memory in computers, generate a picture on our televisions, and they can be found in some automobile brakes and clutches.

Very powerful electromagnets are used in scrapeyards where they can lift whole car.

Some special electromagnets, called superconducting magnets, are essential to **MAGNETIC LEVITIATION TRAINS**. Magnetic repulsion is used to lift the trains up, clear of the track. These very powerful magnets lift the whole train so it floats a fraction of an inch above the track. These trains can reach speeds of 298 miles per hour smoothly. Other superconducting magnets are in magnetic-resonance imaging machines used by doctors to diagnose illnesses.

16. Test your electromagnets to see what it can pick up.

		Magnetic	Not Magnetic
a.	Cotton	____________	_______________
b.	Bolt	____________	_______________
c.	Toothpick	____________	_______________
d.	Paperclip	____________	_______________
e.	Penny	____________	_______________
f.	Aluminum	____________	_______________
g.	Staple	____________	_______________

<u>Review</u>

1. List three things needed to build an electromagnet?
   ___________________, _________________, ___________________.

2. When the battery is on, an electric current travels through the wire, creating a ________________________ ________________________.

3. If the wire is coiled, the _____________ ___ ________________ link with each other, making a stronger electromagnet.

4. Special electromagnets, called superconducting magnets, are essential to ________________________ ________________________ TRAINS.

5. William ___________________ built the first practical electromagnet in the early ________________ century.

6. _______________________________ is the foundation for all electrical engineering.

7. List four things where you would find an electromagnet.

   ________________________ ________________________

   ________________________ ________________________

Around 1600 William Gilbert, physician to Queen Elizabeth of England, proposed that the EARTH was a giant magnet, with its magnetic poles some distance away from its geographic ones (i.e. near the point where Earth turns on its axis). A **COMPASS** needle will point to the Earth's magnetic north pole. The compass has been used to help explorers navigate on their voyages.

It is not completely understood how Earth is like a big magnet. Under the Earth's surface is the **OUTER CORE**. The outer core is made of spinning liquid metals of iron and nickel. This combination, as well as other conditions taking place in the core, creates an electrical current.

Magnetic Field lines travel between Earth's north and south magnetic poles just as they do between the poles of a bar magnet. The Earth's field lines actually start near the south pole and curve around in space and enter again near the north pole. These magnetic field lines around Earth form the **MAGNETOSPHERE**. Charged particles can get trapped in an area of the magnetosphere called the **VAN ALLEN BELT**. The charged particles are trapped in this area much like the iron filing were trapped around the bar magnet.

Earth's magnetic field lines are not as curved as the iron filings around the bar magnet. The Sun's **SOLAR WINDS** cause the lines facing the sun to compress or squished toward the Earth. This part of the magnetosphere extends out 50 to 37,280 miles. The field lines facing away from the sun steam back into a very long "tail", like a comet. This forms the Earth's **MAGNETOTAIL**. The tail trails out more than 186,500 miles.

17. Why is the magnetosphere important?

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The magnetosphere is very important to everyone because it keeps most solar winds away from Earth. The Sun's solar winds can hurt satellites and power and communication lines. The charged particles in the solar wind cannot jump from one field line to the next to get down to Earth. The charged particles tend to remain attached to the "lines of force" like beads on wires. They are trapped in the field lines and circle around the lines in a long spiral.

In the Earth's atmosphere, there are many gas elements like nitrogen, oxygen and argon.
The energetic electrically charged particles, found in the solar winds, begin to speed up along the magnetic field lines.
They follow a path leading into the upper atmosphere near the north and south poles.
They collide into these gas elements.
Energy is released when the particles collide which causes light to be emitted. The light can be seen at night in the northern and southern hemispheres.

These lights are called **AURORAS.**
In the Northern Hemisphere these lights are called AURORA BORELIS.
In the Southern Hemisphere they are called AURORA AUSTRALIS.

The auroras are centered over the Earth's magnetic poles.
The aurora are very colorful and,
they float and move around in the sky.
The different colors can be orange, red, green-yellow and sometimes blue and purple. The colors are different depending on the type of gas the charged particles collided into.
They also can make noises such as hissing, swishing and crackling.

18. What other objects in space have magnetic fields around them?

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The Earth is not the only object in the solar system to have a magnetosphere.

Mercury, Jupiter, Saturn, Uranus, Neptune and the Sun all have magnetic fields.

Our sister planets, Venus and Mars are the oddballs. Space probes have found no evidence of magnetic field lines on these planets. It is believed that since magnets lose their magnetism when heated, and Venus is so hot it can make lead melt, it may explain why it does not have a magnetic field. Mars is pretty cold and so it is a real mystery why there is no magnetic field.

Jupiter is the largest planet and has the most powerful magnetic field. Jupiter's magnetotail extends all the way to Saturn. Jupiter spins very rapidly and has a metallic hydrogen interior. The top of its magnetic field is 10 times stronger than Earth's. Jupiter also has auroras near its poles but probable not due to the solar winds.

The sun's magnetic field surrounds all the planets. It is carried out through the solar system by the solar winds. Its rotation winds up the magnetic field into a large rotating spiral, known as the PARKER SPIRAL.

REVIEW

1. Under the Earth's surface is the _______________ ______________.

2. Magnetic field lines around the Earth form the ___________________.

3. An area in the magnetosphere where charged particles can get trapped is called the ____________ ________________ _______________.

4. The charged particles come from the Sun's ____________ __________.

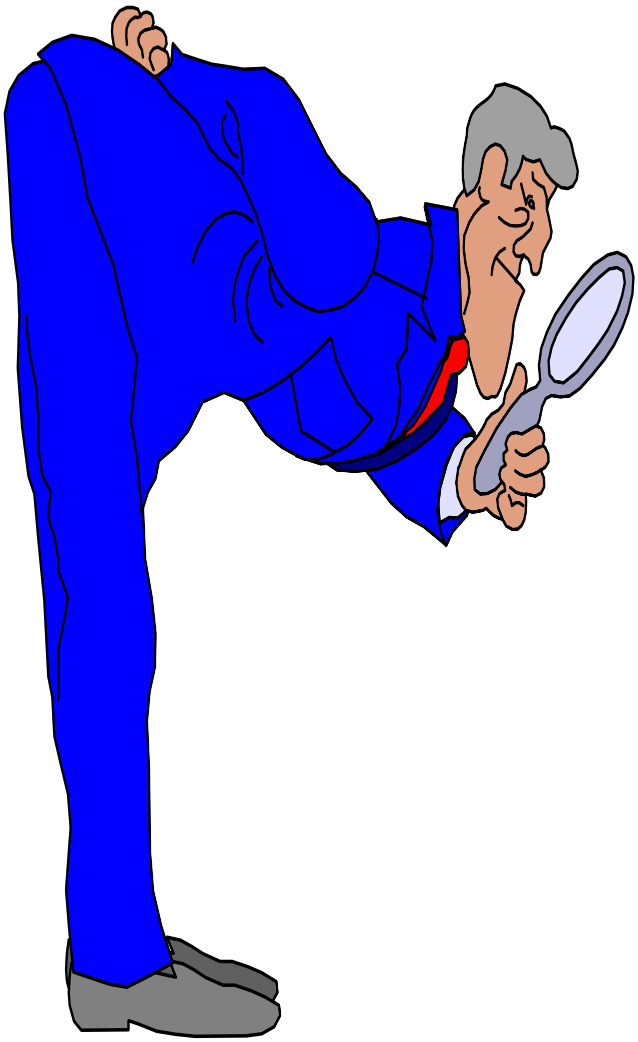
5. _________________ are lights that can be seen in the northern and southern hemispheres.

6. Name four other objects in the solar system that have a magnetic field.
   ____________________ _________________
   ____________________ _________________

7. Our sister planets, _________________ and _____________ are the oddballs.

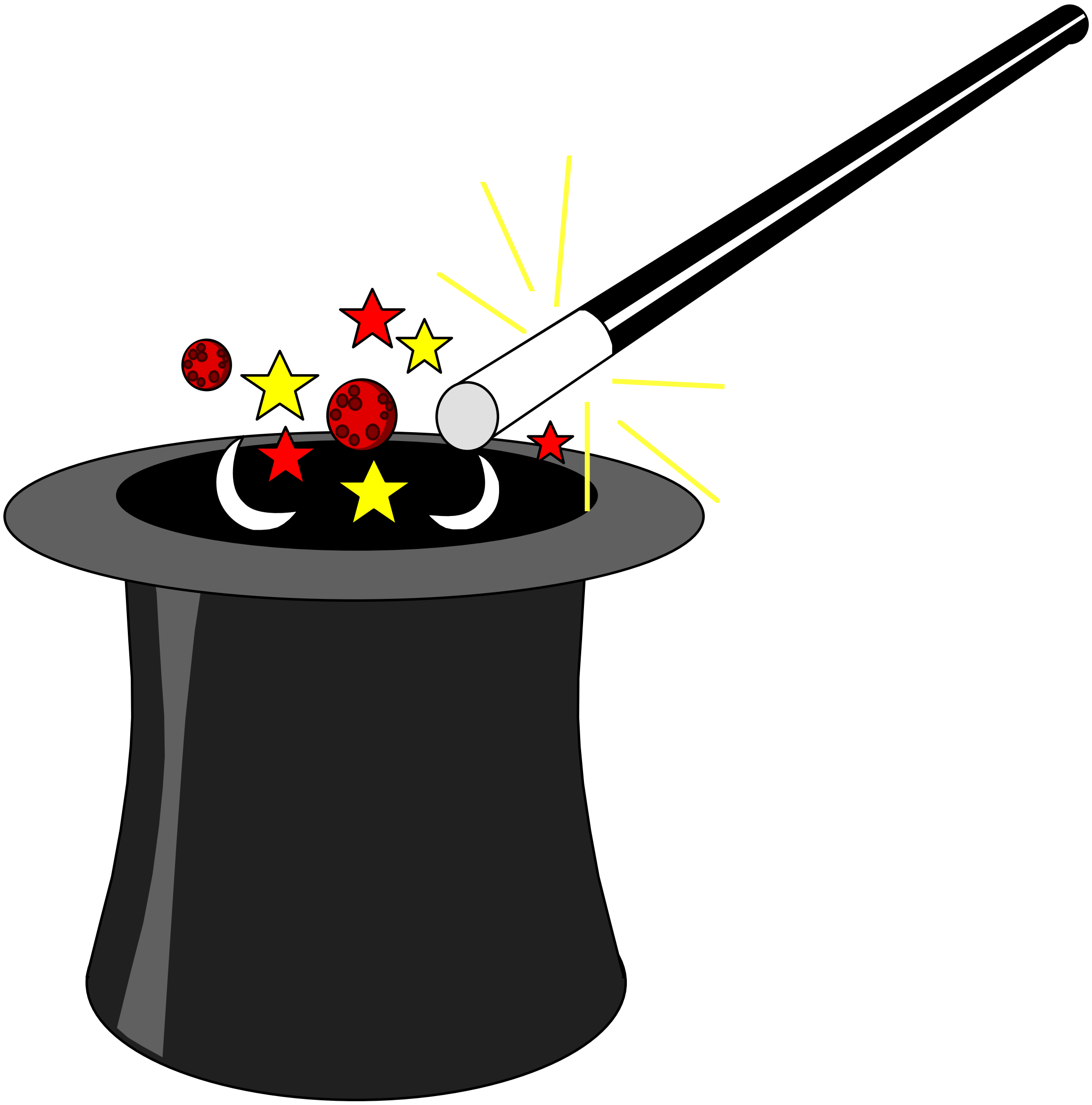
Appendix B

Magnetism Workbook – Teacher Version



IS IT MAGIC OR MAGNETISM?

NAME ________________________________



1. How does the wand work? Does it work by magic, or something else? Write down what you think it is. Also, write about how you think it works.

Answers will vary.

2. What happened when the teacher put the wand over the three rocks on the table?

Rock # 1 Nothing Happens

Rock # 2 Nothing Happens

Rock # 3 The Rock (Lodestone) Sticks to the Magnet Wand

A long, long time ago, the ancient Greeks and the early Chinese knew of rare and strange stones that had the power to attract iron. These rare and strange stones are called **LODESTONES**. It is possible the lodestones were chunks of iron ore that were struck by lightning, giving these rocks the power to attract iron. These stones were discovered in an area near the city of Magnesia, not far from the country of Greece. The word **MAGNET** comes from the city where the rocks were originally discovered.

Not only did the lodestones have the power to attract iron, they found a steel needle would become **MAGNETIC** when a lodestone was stroked over the needle. Then about the year 1000, the Chinese noticed that when this magnetic needle was freely suspended it would point in a north-south direction.

This magnetic needle, when suspended freely, was used as a **COMPASS** by the European explorers, as they explored the New World. Christopher Columbus used the compass when he crossed the Atlantic Ocean. By using the compass and the nighttime stars, the voyagers were able to know where they were, as well as guide them home again. The compass needle points towards the north but not to the exact north Pole.

Around 1600, a man named William Gilbert of England, proposed an explanation. He suggested the Earth was a giant magnet. This giant magnet's poles were not at the exact place where the Earth turns, as it spins around each day. This place is called the **GEOGRAPHIC NORTH POLE**. Instead, the compass needle points towards the **MAGNETIC NORTH POLE**.

Now, let's go fishing!

3. Predict which items in your bag will stick to the magnet. Place a (X) on the line to show which items you predict to be magnetic or not magnetic.

	What is magnetic?	What is not magnetic?
a. Cotton		X
b. Bolt	X	
c. Toothpick		X
d. Paperclip	X	
e. Penny		X
f. Aluminum		X
g. Staple	X	

4. Now, test these items to determine which are attracted to the magnet. Place a (X) on the line to show which items stick to the magnet.

	Magnetic	Not Magnetic
a. Cotton	___________	______X_____
b. Bolt	_____X_____	____________
c. Toothpick	___________	______X_____
d. Paperclip	_____X___	_____________
e. Penny	___________	______X_____
f. Aluminum	___________	______X_____
g. Staple	______X___	_____________

5. Why do you think the items were attracted to the magnet?

They are made of something that is attracted to a magnet.

6. What do these items have in common?

These items are either iron or steel.

7. Write a definition of magnetism.

The power of a magnet to attract.

Glossary

Attract:	to cause to come near.
Compass:	an instrument for showing direction.
Domains:	any of the small randomly orients regions in a magnetized substance.
Electromagnet:	an iron or steel core with wire wound around it. It becomes magnetic when an electric current passes through the wire.
Elements:	any of the 107 substances that cannot be separated into simpler substances by using chemistry.
Lodestones:	a rock that acts as a magnet and attracts iron.
Magnet:	an object that has the power to pull items made of iron towards itself.
Magnetic:	having to do with magnets and the way they work.
Magnetic Field:	the space around a magnet in which a magnetic force is active.
Magnetic Pole:	either of the two areas on the earth's surface, one near the geographic north pole and one near the south pole, where the earth's magnetic fields are strongest.
Magnetism:	the power of a magnet to attract.
Repel:	to ward off or force back.

Review

1. A Lodestone is a rock with the power to attract iron?

2. Lodestones were first discovered near the country of Greece?

3. When a lodestone is stroked over a steel needle several times, the needle becomes magnetic?

4. Christopher Columbus used a compass when he crossed the Atlantic Ocean?

5. In 1600, William Gilbert thought that Earth was a giant magnet?

6. The needle of a compass points to the magnetic north pole.

7. Name two items from your bag that stuck to the fishing pole magnet. Answers may vary_ and Answers may vary

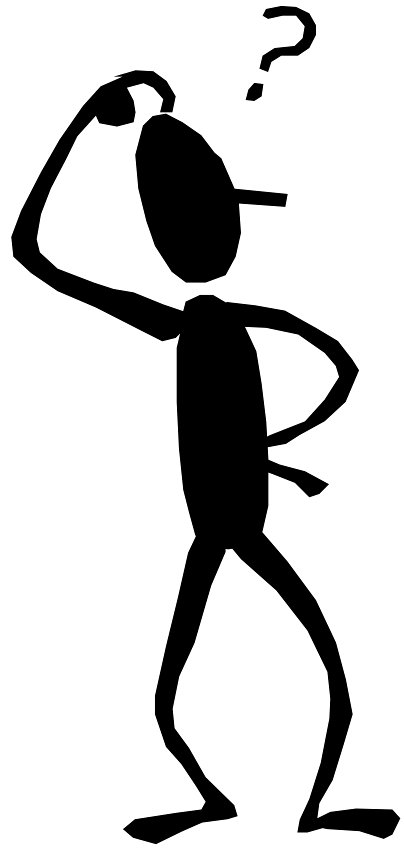
8. What was our definition of magnetism?

The power of a magnet to attract.

9. Draw what you see when the teacher put iron shavings over the overhead. First, make a picture of the magnet. Then draw the iron shavings around the magnet. Student pictures may vary.

10. Do you think that the movement of the iron shavings is MAGIC or MAGNETISM?

Magnetism



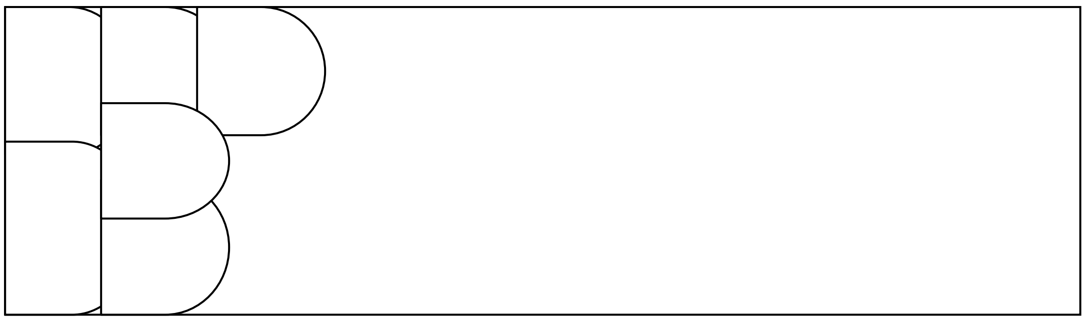
So, let us explore how a magnet works?

Everything on Earth is made of **ELEMENTS**. There are many different kinds of elements, such as hydrogen, oxygen, copper and iron. Magnets are made of the element **IRON**.

Inside the iron, there are regions called **DOMAINS.** When all these domains point in the same direction, the iron material becomes **MAGNETIC**. But, if all the domains are <u>not</u> pointing in the same direction, the iron material is no longer magnetic. Also, when all these domains are pointing in the same direction, a **MAGNETIC FIELD** is created. This magnetic field is all around the magnet.

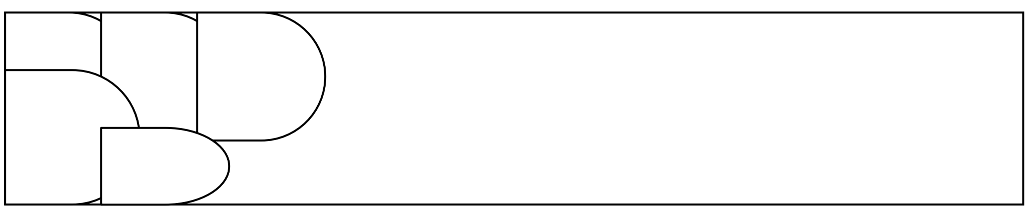
11. Using arrows, draw a picture of the direction all the **DOMAINS** need to be pointing for a magnet to work.

All arrows need to be pointing in the same directions.



12. Using arrows, draw a picture of what the **DOMAINS** will look like when a magnet will not work.

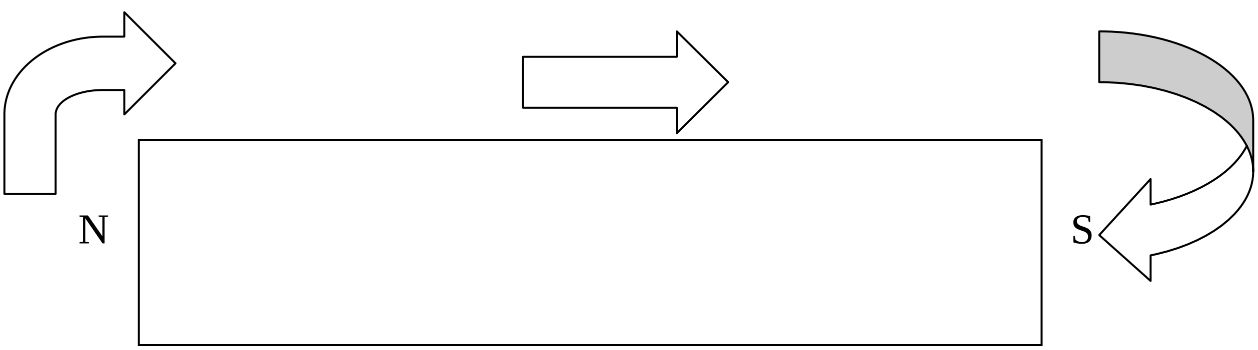
Arrows are not all in the same directions.



In a magnet, there are two poles at each end. The NORTH POLE is at one end, and the SOUTH POLE at the other end. For the magnet to work, the magnetic field must be working in a very specific way. **MAGNETIC FIELD LINES** leave from the north pole and enter back into the south pole. The magnetic field lines travel through the magnet. And again, the magnetic field lines leave the north pole and go back to the south pole, passing through the magnet.

It is like a hot dog! The magnetic field lines pass through one end of the hot dog (the north pole of the magnet) and go around the hot dog bun, then back into the hot dog (the south pole of the magnet) at the other end. It forms a closed curve that goes around and around.

13. In the picture below, draw a magnet showing the **MAGNETIC FIELD LINES** traveling around the magnet. Use arrows to show the correct direction the lines are traveling. Label this magnet, with a (N) or a (S), at the north and south poles.



If two magnets are put together, the north pole of one magnet will stick to the south pole of the other magnet. They **ATTRACT** each other. But, if you put the north pole to another north pole, they push each other away, or **REPEL**.
Opposite poles attract, like poles repel.

REVIEW

1. Everything on Earth is made of elements?

2. A magnet is made of the element iron?

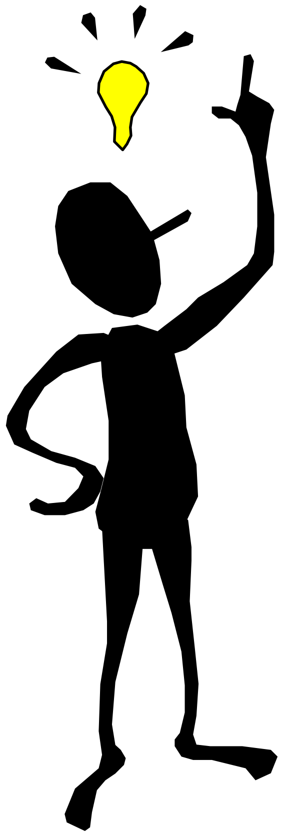
3. Domains are regions inside the iron material?

4. The iron material becomes magnetic when all the domains are pointing in the same direction.

5. Magnetic field lines leave the north pole and enter back onto the south pole of a magnet.

6. Opposites poles attract and like poles repel.

7. The iron shavings were attracted to the magnet.



Here is a question for you!

14. What can you build with only a long piece of copper wire, an iron nail and a small battery? Do you have any ideas?
(Here is a clue. It has something to do with **MAGNETISM** and **ELECTRICITY**).

Write down your ideas.

An Electromagnet.

A simple **ELECTROMAGNET** can be built with a few common household items.

<u>Materials For An Electromagnet</u>

A large iron nail (about 3 inches)
About 3 feet of <u>thin</u> insulated copper wire
A new 6 volt battery
Paper clips or other light items that are attracted to magnets.

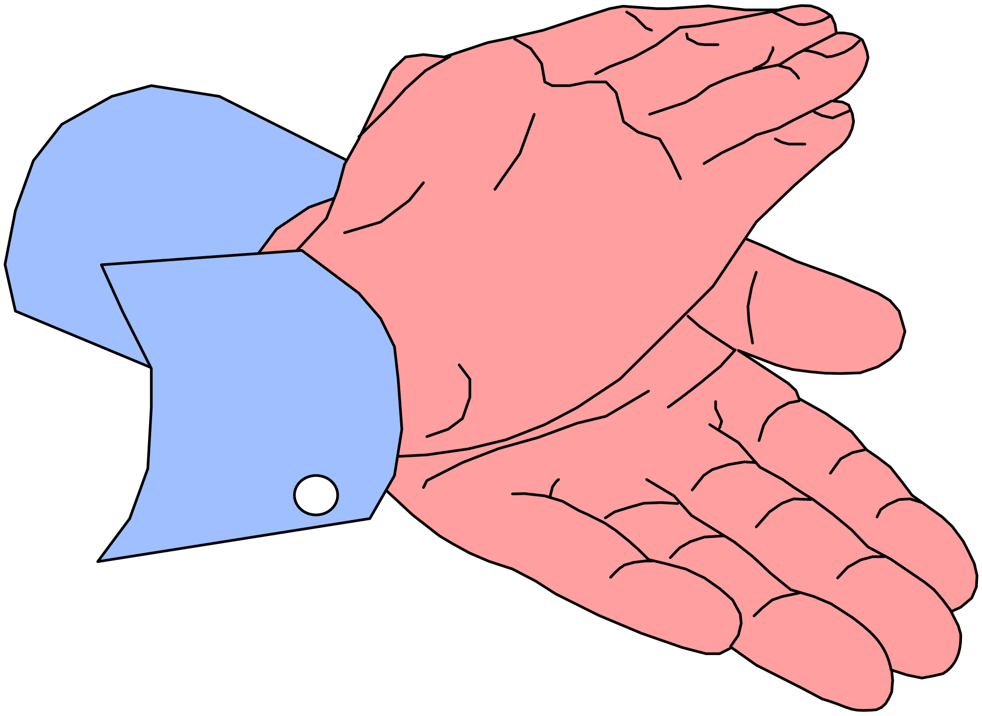
<u>Directions To Build An Electromagnet</u>

1. Leave about 8 inches of wire at one end and wrap the wire around the nail about 10-20 turns, trying not to overlap the wires.

2. Cut the wire (if not already cut) so that there is about another 8 inches loose at the other end. You should be able to see the top of the nail and the tip of the nail.

3. Now remove about an inch of the wire's insulation coating from both ends of the wire and attach the one end of the battery and the other wire to the other end of the battery. Tape the ends of the wires to the battery. The wire could get very **HOT-**so be careful.

Be safe and have fun!



Congratulations! You have just built an **ELECTROMAGNET**. If you put the point of the nail near a few paper clips it should pick them up! But how does it really work? Let's explore.   Is it MAGIC or MAGNETISM?

Most magnets, like the ones we looked at earlier, which cannot be turned off, are called permanent magnets. The kind of magnet that you built is called an **ELECTROMAGNET**. They are only magnetic when a current of electricity, from the battery, is flowing. They do not work when the electricity from the battery is turned off. It is the current of electricity flowing through the wire that arranges the **DOMAINS** regions of the iron nail. When these domains are all in the same direction the nail becomes magnetic and can attracted some metals.

When the battery is on, an electric current travels through the wire. A **MAGNETIC FIELD** is created.   The magnetic field becomes stronger when a wire is coiled around a piece of iron. **LINES OF FORCE** form around the wire. When the wire is coiled around the nail, these lines of force link up with each other. The more the wire is coiled around the nail, the stronger the electromagnet. The iron nail concentrates the lines of force increasing the power of the electromagnet.
Electromagnets obey the same rules as permanent magnets; they have a north pole and south pole and like poles **REPEL** each other while unlike poles **ATTRACT** each other.

Electromagnets were developed from a series of observations. In 1820, Hans Christian Oersted discovered that a current-carrying wire set up a magnetic field. **William Strugeon** invented the first practical electromagnet early in the **19th century**. He found that leaving the iron inside the coil greatly increased the magnetic field. He also found by bending the iron core into a U-shape, brings the poles closer together, and concentrated the magnetic field lines. Joseph Henry used insulating wire, and his largest electromagnet was built in 1832. This electromagnet could lift 3,600 pounds. One of his original electromagnets is in the Smithsonian Institute collection.

ELECTROMAGNETISM is the foundation for all **electrical engineering**. We use and depend on electromagnets in much of our everyday lives. Electromagnets are in many of our household appliances, moving vehicles and used in many different industries. Can you think of any uses for electromagnets?

15. List some appliances, machines or industries you think uses an electromagnets. There are many.

Examples are on the following page.

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Electromagnets are used in many useful things. Electromagnets are in doorbells, loud speakers and circuit breaker. We use electromagnets to generate electricity, store memory in computers, generate a picture on our televisions, and they can be found in some automobile brakes and clutches.

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g.	Staple	X	X

Review

1. List three things needed to build an electromagnet?
   copper wire, iron nail, battery.

2. When the battery is on, an electric current travels through the wire, creating a magnetic field.

3. If the wire is coiled, the lines of force link with each other, making a stronger electromagnet.

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REVIEW

1. Under the Earth's surface is the outer core.

2. Magnetic field lines around the Earth form the magnetosphere.

3. An area in the magnetosphere where charged particles can get trapped is called the Van Allen Belt.

4. The charged particles come from the Sun's solar winds.

5. **Auroras** are lights that can be seen in the northern and southern hemispheres.

6. Name four other objects in the solar system that have a magnetic field.

   Answers may vary   Answers may vary

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