Electromagnetism

Major Topic: Electricity and Magnetism
Science SOL P.S. 11b,c

Length of Unit: 3 - 90 minutes classes

Major Understanding
Student will understand that:

- electricity is related to magnetism.
- magnetic fields can produce electrical current in conductors.
- electricity can produce a magnetic field and cause iron and steel objects to act like magnets.
- electromagnets are temporary magnets that lose their magnetism when the electric current is removed.
- both a motor and a generator have magnets (or electromagnets) and a coil of wire that creates another magnetic field.

Essential Questions

- How can you relate electric and magnetic fields?
- Describe how a magnetic field affects matter.
- What influences do you think origin of a magnetic field came from?
- How can you describe the difference between a permanent magnet and a temporary magnet?

Student Objectives
- The student will be able to create an electromagnet and explain how it works.
- The student will be able to explain the relationship between a magnetic field and an electric current.

Bloom's Taxonomy Skills	21st Century Learning Skills
• Creating • Evaluating • Analyzing • Understanding • Remembering • Applying	• Critical Thinking • Problem Solving • Communication • Creativity & Innovation • Collaboration • Contextual Learning

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Assessment Evidence

Performance Tasks

Students will…

- create an electromagnet, using the materials given, that can lift up to 10 paperclips.

Other Evidence

- laboratory assignments
- notes
- graph
- discussion

Technology computers/laptops, audio/visual equipment for video

Internet Resources:

- Electromagnet site (optional):
- http://www.sciencebob.com/experiments/electromagnet.php
- Electromagnet site (optional): http://education.jlab.org/qa/electromagnet.html
- Electromagnet site (optional): http://outpost1.stellimare.com/scouting/mb/electricity/electromagnet.html
- Electromagnet lab sheet: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=0CF8QFjAJ&url=http%3A%2F%2Fpreparatorya.wikispaces.com%2Ffile%2Fview%2FElectromagnet%2Blab%2Bsheet.doc&ei=bSqHUcefHefYywHnl4G4Aw&usg=AFQjCNHGGhfbbniiDZdXLsSzyOI7lbNKvQ&sig2=QBtBmW27SWQ1jmw_MdOdVw&bvm=bv.45960087,d.aWc
- Electricity and Magnetism Research Questions (attached): www.allaboutcircuits.com

Note: Student may use additional Internet sources in their research group

Supplies/Materials:

- Videos (the appropriate video materials will need to be researched by the teacher previous to the unit)
- Notes (attached)
- Index cards
- Magnets (Circle, Horseshoe, and Bar)
- Plastic Bags (as many as needed – one for each group)
- Iron Filings
- Lab Data Sheet (attached)

- Small Bag with the following for each group:
    - Nails of different thicknesses and lengths
    - Copper wire (Insulated or not)
    - Paper clips
    - Sandpaper
    - Battery (AA)
- Research Questions (attached)

Lesson 1: Attract or Repulse (1-90 minute class)

Engage:

- Show short video on Maglev trains and Junkyard car magnets.
- Ask student to explain what they have just seen and ask them if they know how it works.

Explore:

- Use the Magnetic Fields notes (attached) to explore and pause to explain certain things or have discussions on ways magnets are used.
- Pass around magnets and let students feel and see how the magnetic fields affect the things around them.

Explain:

- Hand out Electromagnetism notes (attached) to students and go over them.

Elaborate:

- Show students magnetic repulsion and attraction as seen in a video using two magnets (use two small circle magnets for this).
- Students can pass these around and see for themselves.
- Show the magnetic field of a magnet by placing a bar magnet near iron filings (these can be placed in a plastic bag to prevent a mess) and students can pass this around as well.

Evaluate:

- Students get a 3x5 index card and write down one thing they learned today.

Lesson 2: Electromagnets (1-90 minute class)

Engage:

- Warm-up on electromagnets.

  Example: What can affect the strength of an electromagnet?

Explain:

- Review electromagnetism.
- Show students a preview of the lab so that they know what to expect.

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- Explain the purpose of the lab.

Explore:

- Hand out the bag of materials for the lab and the lab sheet, "Testing the Strength of an Electromagnet (attached).
- Go over the safety procedures.
- Students are given the materials *without* step by step instructions on how to complete the lab. Very little guidance is needed. Students are encouraged to help each other out.

Elaborate:

- Discuss the results of the lab with the students.
- Have a few students discuss their results versus their neighbors, and if there is a marked difference.
- Have them hypothesize why the results were so different.
- Have them graph their results versus their neighbors' results on their lab sheet.

Evaluate:

- The completed lab sheets will be graded.

Lesson 3: Researching Magnets (1-90 minute period)

Engage:

- Warm-up on electromagnetism.

  Example: What did Oersted and Faraday experiment on?

Explore:

- Complete notes on "Generators and Electric Motors" (attached).
- Assign students into pairs and hand out one "Research Questions" paper to each group. Each group may get a laptop.

Explain:

- Tell students that they are to pick three of the five research questions on Electricity and Magnetism (attached) on their paper and find the answers using their textbook, notes, or the Internet.
- Students will cite their resources and answer the questions on their own paper.

Elaborate:

- Have students discuss their answers with each other, expanding their answers throughout their discussion.

Evaluate:

- The participation in the discussion will be graded as well as the completion of the research questions.
- The research questions will be graded for spelling, grammar, accuracy and citation of sources.

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Magnetic Fields, Electromagnets, Motors, Generators NOTES NAME__________________

<u>Magnets and Magnetic Fields</u>

- A _______________ is a material that attracts iron or materials containing iron.
- All magnets have certain properties, such as they all have ______ poles, exert ________, and are surrounded by a ____________________ ______________.
- The parts of a magnet where magnetic effects are strongest are called ________. The magnetic effects are _____________ near the ends of a bar magnet. If left free to rotate, as in a ____________, one pole will always point north. This pole is called the _________ pole. The other pole will always point south. This pole is called the ________ pole. The north pole of a magnet point north because the Earth itself is a _______. The Earth's magnetic poles are near the _________ on which the Earth rotates.
- A magnet can exert a _____ on other magnets. If you place the north pole of one magnet next to the ______ pole of another magnet, the magnets will _______ ________. If you place the north pole of a magnet next to the ______ pole of another magnet, then the magnets will ______ ______. This force of attraction or repulsion between the poles of magnets is known as _____ _____. Like poles _____, whereas opposite poles ______.
- A ________ _______ exists in the region around a magnet in which the magnetic forces can act. The magnetic field is usually represented by _______ drawn around the magnet. The ________ together the lines are drawn, the _________ the magnetic field. Magnetic field lines are closest at the _______, showing that the magnetic force is strongest at these _____ places.
- Examples of materials that a magnet can pick up are _____ ______ and iron nails. These are ______. Examples of materials that a magnet cannot pick up are _________, plastic, pennies, or _________ _______. These are ___________ magnetic.
- If you cut a magnet into pieces, each piece will become a magnet with _______ poles.
- There are _____ types of magnets. Those most common are _______, magnets made of iron, nickel or ______. Another type of magnet is the ________, which is a magnet with an _____ core, produced by an ______ current. Magnets can also be described as ______ or ____. Temporary magnets are made from materials that are ______ to magnetize, but tend to ______ their magnetization easily. Permanent magnets are ______ to magnetize, but retain their ____ properties better.

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<u>Electromagnets</u>

- ______________________ is the interaction between electricity and magnetism. Oersted discovered that a wire carrying an _______________ current produces a magnetic field.
- A ______ is a coil of wire that produces a magnetic field when carrying an ______ current. If a solenoid is given ____ loops or if current is _____, then the strength of the magnetic field ____.
- An ______ is a magnet that consists of a ____ wrapped around an ____ core. The magnetic field for an electromagnet is the field produced by the _____ plus the field produced by the ___ core. The strength of an electromagnet can be ___ by increasing the number of loops in the solenoid, by ____ the size of the iron core, and by increasing the ___ in the wire. Some electromagnets are strong enough to lift a ____ or levitate a ____.

<u>Electric Motors</u>

- An ____ _____ is a device that changes electrical energy into kinetic energy. All electric motors have an _____ (a loop or coil of wire that can rotate). This armature is mounted between the poles of a ______ magnet or _______. A _____ is attached to the armature to reverse the direction of the electric current in the __________.

<u>Generators</u>

- Faraday discovered that a changing ______ field can create an electric current in a _____. Electromagnetic induction is the process by which an ____ ____ is produced by a changing magnetic field.
- A ___ is a device that uses electromagnetic induction to convert ____ energy into electrical energy. A simple generator contains a ___ of wire, slip ____, brushes, and a ____ ____.
- In nuclear power plants, ____ energy from a nuclear reaction boils water to produce ____, which turns a turbine. The turbine turns the ____ of the generator, inducing an electric current, and generating electrical energy.
- In a hydroelectric power plant, as _______ flows down a chute, it turns a turbine. The turbine spins the _______ of the generator, inducing an electric current.

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Magnetic Fields, Electromagnets, Motors, Generators NAME ANSWER KEY

Magnets and Magnetic Fields

- A **magnet** is a material that attracts iron or materials containing iron.
- All magnets have certain properties, such as they all have **2** poles, exert **forces** and are surrounded by a **magnetic field.**
- The parts of a magnet where magnetic effects are strongest are called **poles.** The magnetic effects are **strongest** near the ends of a bar magnet. If left free to rotate, as in a **compass,** one pole will always point north. This pole is called the **north** pole. The other pole will always point south. This pole is called the **south** pole. The north pole of a magnet point north because the Earth itself is a **magnet.** The Earth's magnetic poles are near the **axis** on which the Earth rotates.
- A magnet can exert a **force** on other magnets. If you place the north pole of one magnet next to the **north** pole of another magnet, the magnets will **push apart.** If you place the north pole of a magnet next to the **south** pole of another magnet, then the magnets will **pull together.** This force of attraction or repulsion between the poles of magnets is known as **magnetic force.** Like poles **repel** whereas opposite poles **attract.**
- A **magnetic field** exists in the region around a magnet in which the magnetic forces can act. The magnetic field is usually represented by **lines** drawn around the magnet. The **closer** together the lines are drawn, the **stronger** the magnetic field. Magnetic field lines are closest at the **poles,** showing that the magnetic force is strongest at these **two** places.
- Examples of materials that a magnet can pick up are **paper clips** and iron nails. These are **magnetic.** Examples of materials that a magnet cannot pick up are **paper,** plastic, pennies, or **aluminum foil**. These are **not** magnetic.
- If you cut a magnet into pieces, each piece will become a magnet with **2** poles.
- There are **2** types of magnets. Those most common are **ferromagnets,** magnets made of iron, nickel or **cobalt.** Another type of magnet is the **electromagnet,** which is a magnet with an **iron** core, produced by an **electric** current. Magnets can also be described as **temporary** or **permanent.** Temporary magnets are made from materials that are **easy** to magnetize, but tend to **lose** their magnetization easily. Permanent magnets are **difficult** to magnetize, but retain their **magnetic** properties better.

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Electromagnets

- **Electromagnetism** is the interaction between electricity and magnetism. Oersted discovered that a wire carrying an **electric** current produces a magnetic field.
- A **solenoid** is a coil of wire that produces a magnetic field when carrying an **electric** current. If a solenoid is given **more** loops or if current is **increased** then the strength of the magnetic field **increases.**
- An **electromagnet** is a magnet that consists of a **solenoid** wrapped around an **iron** core. The magnetic field for an electromagnet is the field produced by the **solenoid** plus the field produced by the **iron** core. The strength of an electromagnet can be **increased** by increasing the number of loops in the solenoid, by **increasing** the size of the iron core, and by increasing the **current** in the wire. Some electromagnets are strong enough to lift a **car** or levitate a **train.**

Electric Motors

- An **electric motor** is a device that changes electrical energy into kinetic energy. All electric motors have an **armature** (a loop or coil of wire that can rotate). This armature is mounted between the poles of a **permanent** magnet or **electromagnet.** A **commutator** is attached to the armature to reverse the direction of the electric current in the **wire.**

Generators

- Faraday discovered that a changing **magnetic** field can create an electric current in a **wire.** Electromagnetic induction is the process by which an **electric current** is produced by a changing magnetic field.
- A **generator** is a device that uses electromagnetic induction to convert **kinetic** energy into electrical energy. A simple generator contains a **coil** of wire, slip **rings** brushes, and a **permanent magnet**.
- In nuclear power plants, **thermal** energy from a nuclear reaction boils water to produce **steam** which turns a turbine. The turbine turns the **magnet** of the generator, inducing an electric current, and generating electrical energy.
- In a hydroelectric power plant, as **water** flows down a chute, it turns a turbine. The turbine spins the **magnet** of the generator, inducing an electric current.

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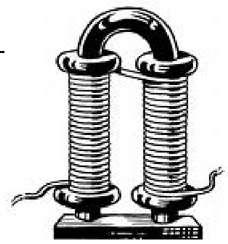
Name ____ Class Period _________



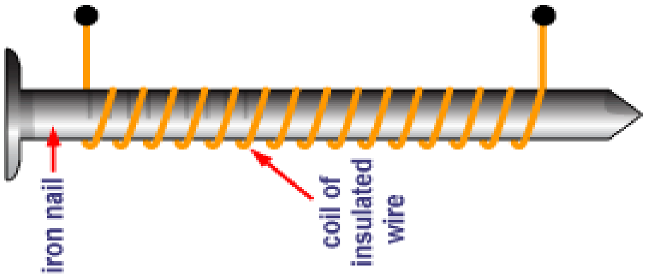
Testing the Strength of an Electromagnet

Objectives: By the end of this practical, you will
- understand that running current through iron creates a magnetic field; removing the current removes the magnetic field
- Create an electromagnet and understand the relationship between voltage and strength of the electromagnet.

Materials:

3 iron nails of different thicknesses
50 cm copper wire
small lab tray
approximately 10 paperclips
2" X 2" piece of sandpaper, medium
1 D battery (dry cell)

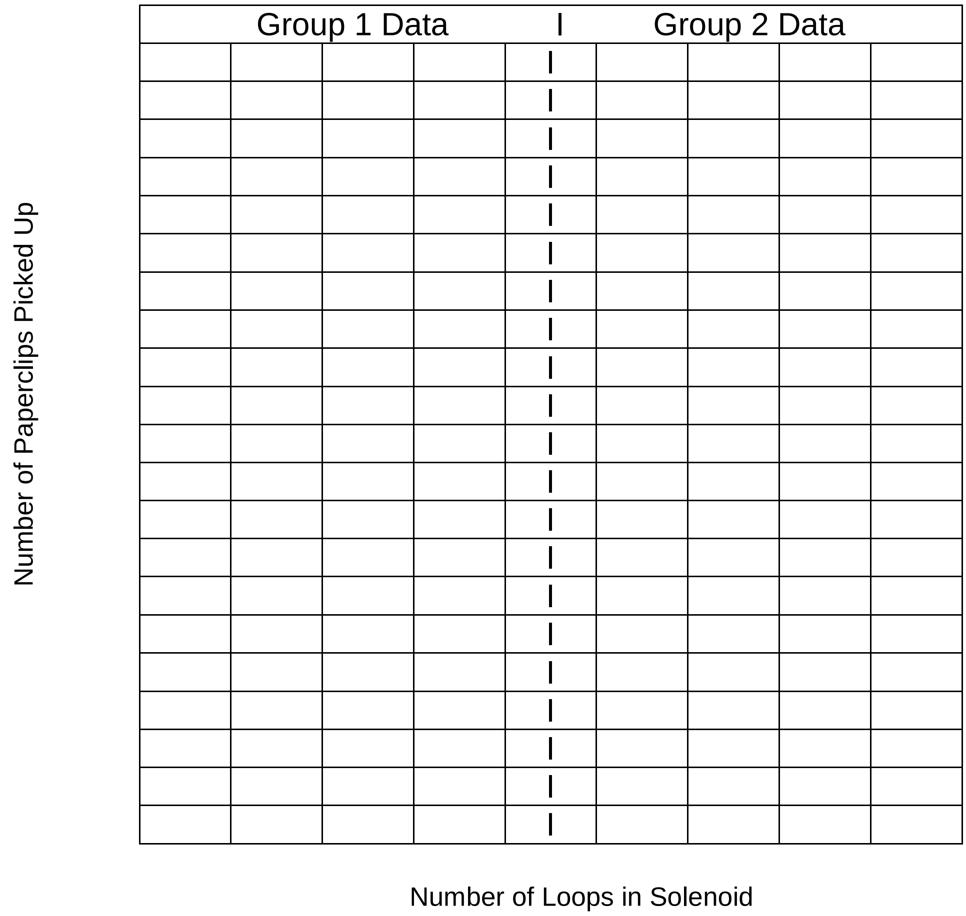
Procedure:
1. If the wire is coated, use the sandpaper to strip the ends of the wire (if necessary). Each end should be a bright copper color.
2. Place 5 coils of wire around the nail. DO NOT overlap the wire.



3. Connect one end of the wire to the positive terminal of a dry cell. Connect the other to the negative terminal.
4. Place the head of the nail into the paperclips and carefully remove it. Release the wires from the dry cell and drop the paperclips on the lab table.
5. Count and record the number of paperclips in the data table.
6. Add another 5 loops and repeat the process until the data table is complete.
7. Make a ***line graph*** on the back of the page.
8. Answer the lab questions on the back.
9. If time allows, try another nail thickness to see how the strength of the electromagnet is affected.

Data:

Loops	Number of Paperclips
5	
10	
15	
20	



Conclusions:

1. What causes the nail to be come magnetic?

____

____

2. Predict how many Paperclips would be picked up with 30 loops_______________

3. Predict how many Paperclips would be picked up with 50 loops______________

4. Besides number of loops in the solenoid, list two other factors that might affect the strength of an electromagnet. ____
____

5. If we use smaller nails, would that affect the results? Why or why not?

____

____

____

Basic electromagnetism and electromagnetic induction – Pick 3 of the following topics to answer.

Question 1:

When lightning strikes, nearby magnetic compass needles may be seen to jerk in response to the electrical discharge. No compass needle deflection results during the accumulation of electrostatic charge preceding the lightning bolt, but only when the bolt actually strikes. What does this phenomenon indicate about voltage, current, and magnetism?

Question 2:

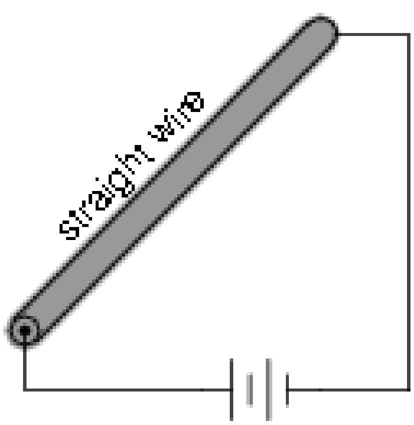
Just as electricity may be harnessed to produce magnetism, magnetism may also be harnessed to produce electricity. The latter process is known as *electromagnetic induction*. Design a simple experiment to explore the phenomenon of electromagnetic induction.

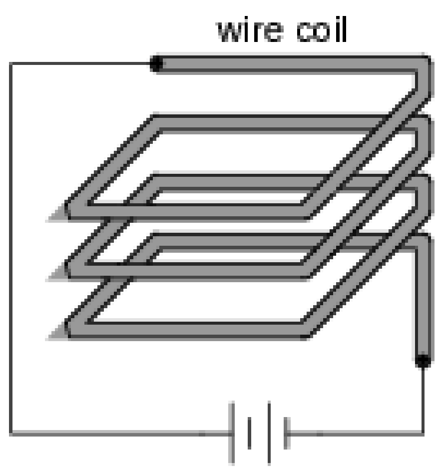
Question 3:

A large audio speaker may serve to demonstrate both the principles of *electromagnetism* and of *electromagnetic induction*. Explain how this may be done.

Question 4:

Draw the pattern of the magnetic field produced by electric current through a straight wire and through a wire coil:





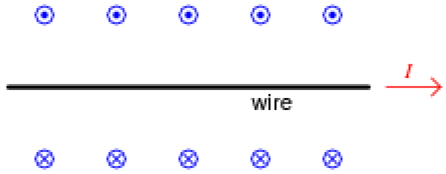
Explain your answer using either the *right-hand rule* (conventional flow) or the *left-hand rule* (electron flow).

Question 5:

A *permanent magnet* is a device that retains a magnetic field without need for a power source. Though many of us have experienced the effects of magnetism from a permanent magnet, very few people can describe what *causes* permanent magnetism. Explain the cause of permanent magnetism, in your own words.

Question 6:

When engineers and physicists draw pictures illustrating the magnetic field produced by a straight current-carrying wire, they usually do so using this notation:



Explain what the circle-and-dot and circle-and-cross symbols mean, with reference to the *right-hand rule*.