Course: Physical Science

I. Grade Level/Unit Number: 9 - 12 Unit 3

II: Unit Title: Electricity and Magnetism

III. Unit Length: 10 days (based on a 90 minute per day schedule)

IV. Major Learning Outcomes:

Static Electricity

- Investigate and analyze the transfer of electrons to charge objects.
- Demonstrate that opposite charges attract and like charges repel.
- Compare and contrast the three methods of charging objects:
  - Conduction
  - Friction
  - Induction

Direct Current Electrical Circuits

- Interpret simple circuit diagrams using symbols.
- Investigate open and closed circuits.
- Apply Ohm's Law and the power equation to simple DC circuits: $V = IR$ and $P = VI$
- Distinguish between series and parallel circuits.
- Conceptually explore the flow of electricity in series and parallel circuits. *(Calculations with series and parallel circuits are reserved as enrichment topics.)*
- Explain how the flow of electricity through series and parallel circuits is affected by voltage and resistance.

Magnetism and Its Practical Applications

- Describe the characteristics and behaviors of magnetic domains.
- Investigate the attraction of unlike poles and the repulsion of like poles.
- Investigate the strength of an electromagnet by varying the number of coils, varying current, or core material.
- Develop an understanding of the relationship between electricity and magnetism in practical applications such as generators and motors.

Inquiry

- Develop questions for investigation from a given topic or problem.
- Distinguish and appropriately graph dependent and independent variables.

- Report and share investigation results with others.
- Discuss the best method of graphing/presenting particular data.
- Use technology resources such as graphing calculators and computers to analyze data.
- Use questions and models to determine the relationships between variables in investigations.
- Read and interpret Material Safety Data Sheets (MSDS).
- Read and analyze newspaper, journal, and on-line articles.

V. Content Objectives Included (with RBT Tags) :

Objective Number	**Objective**	**RBT Tag**
1.01	Identify questions and problems that can be answered through scientific investigations.	B3
1.02	Design and conduct scientific investigations to answer questions about the physical world. • Create testable hypotheses. • Identify variables. • Use a control or comparison group when appropriate. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.	A5 B6
1.03	Formulate and revise scientific explanations and models using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship between evidence and explanation.	C5
1.04	Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment needed for scientific investigations.	C3

1.05	Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of: • Appropriate sample. • Adequacy of experimental controls. • Replication of findings. • Alternative interpretations of the data.	A4
4.01	Investigate and analyze the nature of static electricity and the conservation of electrical charge: • Positive and negative charges. • Opposite charges attract and like charges repel. • Analyze the electrical charging of objects due to the transfer of charge.	B4,C3
4.02	Investigate and analyze direct current electrical circuits: • Ohm's law. • Series circuits. • Parallel circuits.	B4
4.03	Investigate and analyze magnetism and the practical applications of the characteristics of magnets. B4 • Permanent magnets • Electromagnetism • Movement of electrical charges.	B3

VI. English Language Development Objectives (ELD) Included: NC English Language Proficiency (ELP) Standard 4 (2008) for Limited English Proficiency Students (LEP)- English Language learners communicate information, ideas, and concepts necessary for academic success in the content area of science.

Suggestions for modified instruction and scaffolding for LEP students and/or students who need additional support are embedded in the unit plan and/or are added at the end of the corresponding section of the lessons. The amount of scaffolding needed will depend on the level of English proficiency of each LEP student. Therefore, novice level students will need more support with the language needed to understand and demonstrate the acquisition of concepts than intermediate or advanced students.

VII. Materials/Equipment Needed:

Activity	Materials
How Can You Make Water Move?	Balloons Steady stream of water
Why Does the Balloon Stick to the Wall?	Balloons Students with no moussed or conditioned hair (warn them the day before) Natural fiber clothing or cloth
Electric Field Lines of Charges Activity	Balloons Metal part of chair
How Can You Make Paper Jump Without Touching It?	Balloons Students with no moussed or conditioned hair (warn them the day before) Natural fiber clothing or cloth Small paper cups or containers Paper “holes” collected from paper hole punchers
Why Does the Empty Soft Drink Can Move Without an Applied Force?	Balloons (Substitute: rubber combs) Students with no moussed or conditioned hair (warn them the day before) Natural fiber clothing or cloth 12 oz. soft drink cans (empty and clean)
How Can You Detect Static Charge?	Scotch ™ Brand Magic tape (or equivalent---enough for students to work in pairs) Flat surface (such as a table top)
Detecting Electric Charge II	Scotch ™ Brand Magic tape (or equivalent) Balloons Natural fiber clothing or Unmoussed and nonconditioner treated hair
Lightning Video Activity	Video regarding lightning
Activity Hot Fingers- How Does Current Travel in a Battery?	AAA or AA batteries Aluminum foil strips (long enough to

	reach from one end of the battery to the other end) **Optional:** straws, other insulators or non -conducting materials
How are Batteries Constructed?	Various batteries (AA, AAA, C, D, 6 Volt and 9 Volt)
Will it Burn?	AA or AAA batteries Conducting wire Light bulbs or stripped ornamental lights
Bright Lights Activity	3-stripped ornamental lights 9 Volt battery 9-V connector
Build Series and Parallel Circuits	Large sheet of heavy paper Aluminum foil or wire Tape Ornamental lights (3) with sockets (or Cut individual lights from ornamental string lights) Battery (6V=4C or 9V with connectors) Pencil Ammeter Voltmeter
Magnetic Fields- Lab Activity	Permanent bar magnets Small compasses Pencils Horseshoe magnets Notebook paper
Temporary Magnets Activity	Nails Permanent bar magnets Paper clips
Electromagnet Activity	Nails 6 Volt Batteries Copper electrical wire (long enough to wrap several coils around the nail) Paper clips
Motor Lab Activity	**Materials/Group** 5 small disk or rectangular ceramic magnets (available at Radio Shack) 2 large paper clips Plastic or Styrofoam cup

	A solid (not stranded) enameled or insulated 20-gauge copper wire (about 2 feet (60 cm) long- available at Radio Shack) masking tape A battery or power supply (a 6 Volt works very well) 2 electrical lead wires with alligator clips at both ends (available at Radio Shack) Wire strippers (if you are using insulated wire) Sandpaper (if you are using enameled wire) A battery holder (if you are using batteries other than a 6 Volt)

VIII. Detailed Content Description:

Please see the detailed content description for each objective in the Physical Science Support document. The link to this downloadable document is in the Physical Science Standard Course of Study at:

http://www.ncpublicschools.org/curriculum/science/scos/2004/26physical

IX. Unit Notes:

Overview of Unit Three

This unit includes daily lessons and activities for the major topics of electricity and magnetism. Specific topics covered are: static electricity, conservation of static charge, charging by conduction, induction and friction, series circuits, parallel circuits, Ohm's Law, V= IR, power, P= VI, movement of charge with respect to magnetism, magnetic domains, and electromagnetism.

In each unit, Goal 1 objectives which relate to the process of scientific investigation are included. In each of the units, students will be practicing the processes of science: observing, hypothesizing, collecting data, analyzing, and concluding. **Goal 1 objectives are an *integral* part of *each of the other goals*.** In order to measure and investigate scientific phenomena, students must be given the opportunity to design and conduct their own investigations in a safe laboratory. Investigations may also be conducted using simulations.

The unit guide below contains the activities that are suggested to meet the Standard Course of Study (SCOS) Goals for Unit Three. The guide includes activities, teacher notes on how to implement the activities, and resources relating to the activities which include language objectives for LEP (Limited English Proficiency) students. Teachers should also consult the Department of Public Instruction website for English as a Second Language at: http://www.ncpublicschools.org/curriculum/esl/ to find additional resources. If a teacher follows this curriculum (s)he will have addressed the goals and objectives of the SCOS. However, teachers may want to substitute other activities that teach the same concept. Teachers should also provide guided and independent practice from other resources.

Reference Tables:
The North Carolina Physical Science Reference Tables were developed to provide essential information that should be used on a regular basis by students, therefore eliminating the need for memorization. It is suggested that a copy be provided to each student on the first day of instruction. A copy of the reference tables can be downloaded at the following URL:

http://www.ncpublicschools.org/docs/accountability/testing/eoc/PhysicalScience/physicalsciencereferencetable.pdf

Essential Questions:
Essential questions for this unit are included with the activities and embedded throughout the unit. Essential questions are those questions that lead to student understanding. Students should be able to answer these questions at the end of an activity. Teachers are advised to put these questions up in a prominent place in the classroom. The questions can be answered in a journal format as a closure.

Safety: Students should wear chemical splash goggles during any lab activity involving chemicals. This includes household substances. **It is extremely important for the safety and success of your students that you do ALL activities and labs prior to assigning them to students.** At the beginning of each lab, the teacher should address any specific safety concerns relating to the activity.

Modified Activities for LEP Students:
Those activities marked with a ⚐ have a modified version or notes designed to assist teachers in supporting students who are English language learners. Teachers should also consult the Department of Public Instruction website for English as a Second Language at: http://www.ncpublicschools.org/curriculum/esl/ to find additional resources.

Computer Based Activities:
Several of the recommended activities are computer based and require students to visit various internet sites and view animations of various biological processes.

These animations require various players and plug-ins which may or may not already be installed on your computers. Additionally some districts have firewalls that block downloading these types of files. Before assigning these activities to students it is essential for the teacher to try them on the computers that the students will use and to consult with the technology or media specialist if there are issues. These animations also have sound. Teachers may wish to provide headphones if possible.

X. Global Content: Aligned with 21st Skills:

One of the goals of these Unit Plans is to provide strategies that will enable educators to develop the 21st century skills for their students. As much as students need to master the NCSOS goals and objectives, they need to master the skills that develop problem solving strategies as well as the creativity and innovative thinking skills that have become critical in today's increasingly interconnected workforce and society.
The Partnership for 21st Century Skills website is provided below for more information about the skills and resources related to the 21st Century classroom.

http://www.21stcenturyskills.org/index.php?option=com_content&task=view&id=27&Itemid=120

NC SCS Physical Science	21st Century Skills	Activity
	Communication Skills	
Goal 1	Conveying thought or opinions effectively	• KWL activity • Electric Field Lines of Charges Activity • Why Does the Empty Soft Drink Can Move Without an Applied Force? • Lightning Video Activity • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Electromagnet Activity • Motor Lab Activity
Goal 1	When presenting information, distinguishing between relevant and irrelevant information	• Electric Field Lines of Charges Activity • Why Does the Empty Soft Drink Can Move Without an Applied Force? • Lightning Video Activity • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Electromagnet Activity • Motor Lab Activity
Goals 1-6	Explaining a concept to others	• Electric Field Lines of Charges Activity • Why Does the Empty Soft Drink Can Move Without an Applied Force? • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory

		Activity • Electromagnet Activity • Motor Lab Activity
	Interviewing others or being interviewed	
	Computer Knowledge	
Goals 1-6, esp. Goal 1	Using word-processing and database programs	
Goals 1-6, esp. Goal 1	Developing visual aides for presentations	• Electric Field Lines of Charges Activity • How are batteries constructed? • Magnetic Fields: Laboratory Activity • Motor Lab Activity
Goal 1	Using a computer for communication	
	Learning new software programs	
	Employability Skills	
Goals 1-6	Assuming responsibility for own learning	All activities
Goals 1-6, esp. Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Persisting until job is completed	All activities
Goals 1-6	Working independently	• KWL Activity • Why Does the Empty Soft Drink Can Move Without an Applied Force? • Lightning Video Activity • How are batteries constructed? • Hot fingers activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets
	Developing career interest/goals	
Goal 1	Responding to criticism or questions	
	Information-retrieval Skills	
Goal 1	Searching for information via the computer	• Lightning Video Activity • How are batteries constructed?
Goal 1	Searching for print information	• Lightning Video Activity • How are batteries constructed? • Build Series and Parallel

		Circuits: Lab activity
	Searching for information using community members	
	Language Skills - Reading	
Goal 1-6	Following written directions	Most of the activities can be presented as opportunities for students to follow written directions. The teacher will have to work with most students to develop this skill over time. The following activities are well suited to developing skills in following directions: • How are batteries constructed? • Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets
Goals 1-6	Identifying cause and effect relationships	• How can you make water move? • Electric Field Lines of Charges Activity • How Can You Make Paper Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • Will it burn? • Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets • Electromagnet Activity • Temporary Magnets
Goals 1-6	Summarizing main points after reading	• Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • Lightning Video Activity • How are batteries

		constructed? • Magnetic Fields: Laboratory Activity • Temporary Magnets
Goal 1	Locating and choosing appropriate reference materials	• Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • Lightning Video Activity • How are batteries constructed? • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets
Goals 1-6	Reading for personal learning	
	Language Skill - Writing	
Goals 1-6	Using language accurately	All the activities
Goals 1-6	Organizing and relating ideas when writing	All the activities
Goals 1-6, esp. Goal 1	Proofing and Editing	
Goals 1-6, esp. Goal 1	Synthesizing information from several sources	• Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • Lightning Video Activity • How are batteries constructed? • Temporary Magnets
Goal 1	Documenting sources	
	Developing an outline	
1.04	Writing to persuade or justify a position	• Why Does the Empty Soft Drink Can Move Without an Applied Force?
	Creating memos, letters, other forms of correspondence	
	Teamwork	
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Taking initiative	• How can you make water move? • Electric Field Lines of Charges Activity • How Can You Make Paper

		Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • How are batteries constructed? • Lightning Video Activity • Hot fingers activity • Will it burn? • Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets • Electromagnet Activity • Temporary Magnets
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Working on a team	Most of the activities are designed to be done and discussed in teams. The following activities are well suited to developing team interdependence skills: • Why Does the Balloon Stick to the Wall? • Electric Field Lines of Charges Activity • How Can You Make Paper Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Electromagnet Activity • Temporary Magnets
	Thinking/Problem-Solving Skills	
Goals 1-6	Identifying key problems or questions	• How can you make water move? • Why Does the Balloon Stick

		to the Wall? • How Can You Make Paper Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • How are batteries constructed? • Hot fingers activity • Will it burn? • Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets • Electromagnet Activity • Temporary Magnets
Goals 1-6	Evaluating results	• How can you make water move? • Why Does the Balloon Stick to the Wall? • Electric Field Lines of Charges Activity • How Can You Make Paper Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • How are batteries constructed? • Hot fingers activity • Will it burn? • Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets • Electromagnet Activity • Temporary Magnets
Goals 1-4, 5.02, 5.03, Goal 6	Developing strategies to address problems	• Electric Field Lines of Charges Activity

		• How Can You Make Paper Jump Without Touching It? • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How Can You Detect an Electrical Charge? • How are batteries constructed? • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Temporary Magnets • Electromagnet Activity • Temporary Magnets
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Developing an action plan or timeline	• Electric Field Lines of Charges Activity • Why Does the Empty Soft Drink Can Move Without an Applied Force? • How are batteries constructed? • Hot fingers activity • Will it burn? Bright Lights Activity • Build Series and Parallel Circuits: Lab activity • Magnetic Fields: Laboratory Activity • Electromagnet Activity

Day 1 – Static Charge

Essential Question: What is static charge?

Language (ELP) Objective for LEP students: The learner will:

- *orally explain vocabulary words to a partner.*
- *write facts about electric charge in their notebooks.*
- *read the text in partners and check for understanding.*
- *listen to their partners read the text.*

ENGAGE:

How can you make water move?

As an opener or hook, take a blown up balloon and charge it by rubbing it on your hair or on natural fiber clothing such as cotton or wool. This picks up electrons and transfers them to the balloon. Place the charged balloon close to a steady steam of water. The charge on the balloon will actually "pull" the polar water molecules in the stream towards it. Ask students why the water moved. Ask them why you used a balloon to introduce or reinforce insulators.

Materials: Round shaped rubber or latex balloons, low humidity conditions, steady stream of water

Teacher Notes: It takes a low humidity day for this to work very well, as it does for most of these static electricity lab activities. You will also want to leave conditioner or mousse off your hair if you use your hair to charge the balloon. Ask students to brainstorm about why the water moved. You may include this as an introduction to the polarity of water or as a review of polarity as well as an opener for static charge.

LEP Modifications:

- *When you are charging the balloon. Ask leading questions like: Which subatomic particle is moving when you rub the balloon with your hair? Which direction are the electrons moving? Stress the point that the electrons move from their hair to the balloon.*
- *Complete as a demonstration. Draw and label on the board what the students observe (balloon, water, positive charge, negative charge).*
- *Have students turn to a neighbor and explain vocabulary words (positive charge, negative charge, and insulator).*

KWL Activity Student illustrate concepts about static charges.

At this point, you may want students to fill out a KWL chart with what they already know about electric charge and then what they want to learn about electric charge.

LEP Modifications:

Have students work in pairs/groups to complete the KW of the KWL chart. Have groups share with the class and make a class KWL poster.

EXPLORE:

To investigate the nature of static charge, use blown up balloons to illustrate the movement of charge from a loosely held object (hair or any natural fibers) to an

insulator. Make sure students rub their hair or natural fiber clothing with the balloon so that the electrons are collected in just one area of the balloon. Students then take the charged balloon and place it on the wall or even on a wooden table, if you have one. This helps introduce the concept of separation of charge in a neutral object (induction) and that opposite charges attract while like charges repel. For more visual learners, you can have students draw a diagram of the collection of charges on the balloon. This activity also helps with the concept that charges move on only specific materials called conductors and with the concept that charges are static and do not move on insulators such as the rubber or latex balloons.

Why Does the Balloon Stick to the Wall?

Materials: round shaped rubber or latex balloons, (avoid the long balloons if possible because high school students tend to make remarks regarding their resemblance to condoms), students with no moussed or conditioned hair (warn them the day before) or natural fiber clothing or cloth.

LEP Modifications:

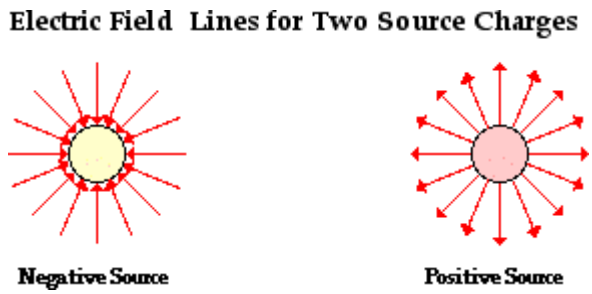
- *Have students draw and label their observations (balloon, wall, positive charge, negative charge, induction, insulators, and conductors) and place in their notebooks.*
- *As a class come up with definitions of the vocabulary words (induction, insulators, and conductors). Have students place these definitions in their notebook.*
- *Have students turn to a neighbor and speak a sentence using the vocabulary words.*

Explain
Electric Field Lines of Charges Activity

Have students work in twos or threes to brainstorm why opposite charges attract and like charges repel. Once they have come to their conclusions, introduce the diagram of like charges.

LEP Modifications:

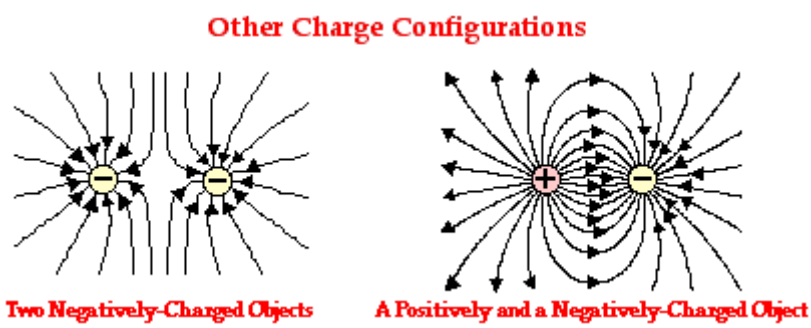
- *Demonstrate and explain the words attract and repel.*
- *Brainstorm (as a class) why do you think opposite charges attract and like charges repel.*



After you show the like charges (positive-positive or negative-negative) diagram, have students predict what a diagram of unlike charges (positive-negative) will look like and have them draw it.

ELEP Modifications:

- *Have students turn to their neighbor and tell them their predictions. Have the pair of students draw their predictions.*
- *After students have drawn their predictions, draw the correct drawings on the board and have the students copy them in their notebooks.*



Make sure that students have the field lines correctly drawn for the like and unlike charges. Point out that the field lines represent the force of electricity, a force we see the results of instead of actually seeing the force.

Have students to write on their KWL what they have learned about electric charge. You may want to instruct students to read the pages in their text pertaining to electric charge and static electricity.

ELEP Modifications:

- *Have students read text in pairs. Have groups share five facts about electric charge and static electricity to another group and place in notebook. Make sure you stress that the field lines represent the force of electricity.*
- *Complete the KWL chart as a class together. Discuss the added information, leave up on the wall for future reference.*

Teacher Notes: Again, make sure it is relatively low humidity when you perform these activities. Also make sure that students do not share balloons to prevent any possibility of pests being transferred as well as electrons! As an extension, you can have students predict what types of materials will make good insulators and which materials will make good conductors. Use the charged balloons to test their predictions. Another good activity to illustrate grounding is by placing a charged balloon on the metal part of their chair, if that is the type you have in your classroom. Ask them to explain why the balloon becomes neutrally charged by placing the charged side of the balloon directly to the metal. This can serve to introduce grounding.

PLEP Modifications:

- *Have students draw and label their observations (balloon, wall, positive charge, negative charge, induction, insulators, and conductors) and place in their notebooks.*
- *As a class come up with definitions of the vocabulary words (induction, insulators, and conductors). Have students use these words in a sentence and write them in their notebook.*

Have students draw their own conclusions as to why electric charges attract and repel.

PLEP Modifications:

- *Have students draw and label observations and place in notebook.*
- *Have students come up with a definition of grounding as a class and place in their notebooks.*
- *A word wall is another way to display new vocabulary words. This wall can be used for review and remembering.*

Day 2- Static Charge

Language (ELP) Objective for LEP students: The learner will:

- *read and listen to the text.*
- *write a summary about electric charge.*
- *orally give examples of friction.*

Elaborate:

This opener is simply to use charged balloons and paper to review the attraction and repulsion of electric charges. Use inflated balloons to illustrate the movement of charge from a loosely held object (hair or any natural fibers) to an insulator. Make sure students rub their hair or natural fiber clothing with the balloon so that the electrons are collected in just one area of the balloon. This can serve to introduce charging by friction as well. You will also want to have small pieces of paper. Collect all the punched-out holes in small cups or containers. You may also use puffed rice cereal, but paper holes are cheaper. Once students have charged their balloons, and being careful not to touch them in the charged area, (ask at this point if anyone knows why or remembers grounding from the lesson before) pour out the paper holes on their tables and then have them hold the charged area of the balloon directly over the paper "holes." The paper will literally jump up to the balloon! Warn them to not place the balloon directly in the paper as they then have to wipe them all off and recharge the balloon. Ask them why the paper holes jump up to the balloons (opposite charges attract).

LEP Modifications:

- *Have students draw and label their observations (balloon, paper, positive charge, and negative charge).*
- *Have students write a complete sentence why the paper jumped to the balloon under their drawings.*
- *Have students rub their hands together and discuss what is happening. As a class come up with a definition of friction.*
- *Discuss and brainstorm examples of friction.*

Teacher Notes: Once again, make sure the day is low humidity. Let students explore the charging of the balloon by friction when rubbing it on their hair or natural fibers. Resist the urge to tell students why these phenomena are occurring. Let them explore the process.

How Can You Make Paper Jump Without Touching It?

Materials : round shaped rubber or latex balloons, (avoid the long balloons if possible because high school students tend to make remarks regarding their resemblance to condoms), students with no moussed or conditioned hair (warn them the day before) or natural fiber clothing or cloth, small paper cups or containers, paper "holes" collected from paper hole punchers.

Explore and Explain
This activity (Why Does the Empty Soft Drink Can Move Without an Applied Force?) allows students to explore charging by induction, conduction and friction in various ways without being high tech! Allow students to explore these processes in order to fully grasp some understanding of these processes. It also gives students a chance to explore the process of grounding and how charges move on conductors and do not move on insulators.

Use inflated balloons to illustrate the movement of charge from a loosely held object (hair or any natural fibers) to an insulator. Make sure students rub their hair or natural fiber clothing with the balloon so that the electrons are collected in just one area of the balloon. Have clean empty 12 oz. soft drink cans for each student or group of students. Lay the cans on their sides so that they are able to roll. Make sure the students do not touch the cans once you are ready to "charge" the cans. Place a charged balloon near a drink can. The can will either move away from the balloon (like charges) or towards the can (opposite charges) when the charged balloon is placed near it. Make sure the students do not touch the cans! This allows them to experience the effects of charging through a distance, or induction. It also allows them to see how forces do not have to be physically applied in order to be effective.

LEP Modifications:

- *For Review: Have students create a flow chart explaining electric charge using vocabulary (electric charge, positive charge, negative charge, attract, and repel)*

Teacher Notes: Students love this lab and will roll their cans all around their table! It is also a great place in the lesson to point out the nature of conductors and insulators. The balloon is made of an insulating material and therefore will not allow the free electrons picked up from the hair or natural fibers to move. Making sure the students do not touch the aluminum can, which is a metal and a conducting material, is extremely important because any free electrons on the metal will move to the can. You can try touching the can with the charged area of the balloon in order to show charging by conduction. This can be tricky because if the free electrons on the balloon are not in direct contact with the can, it will not charge. You will have better success with charging by friction by rubbing the charged balloon on the can. Again, too many variables come into play as the students are not always as careful as they need to be and they end up losing the free electrons by grounding. It is a good reinforcement of the nature of like and unlike charges. You may choose to use rubber combs to collect the electrons from their hair or natural fibers. The methods of charging are really abstract but these types of activities give students a visual idea. Also make sure it is a low humidity day for any static electricity labs.

Why Does the Empty Soft Drink Can Move Without an Applied Force?

Materials: round shaped rubber or latex balloons, (avoid the long balloons if possible because high school students tend to make remarks regarding their resemblance to condoms), students with no moussed or conditioned hair (warn them the day before) or natural fiber clothing or cloth, empty and clean 12 oz. soft drink cans. You may use rubber combs instead of balloons.

ELABORATE:

Explanation and Guided Practice of Charges

As follow up, instruct students to write a brief summary of how electric charges repel and attract each other. Once they have completed this summary, lead a short discussion of the practical applications of static electric charge. For example, ask them if they have noticed the warning signs posted at gas pumps about the dangers of pumping gasoline and static electric charge. The warnings simply say to touch the metal part of a vehicle before turning on the gas nozzle. Another good application is asking who has opened up the CPU of their computer to work on it or install new hardware. Let them know the first thing computer technicians do, and tell you to do, is to touch your hand to a metal surface before touching the circuit board because there could be enough static charge buildup on you to harm your CPU. All of these are examples of grounding.

LEP Modifications:

- *Using the words from the concept map from the last activity have the students write a brief summary of how electric charges repel and attract each other.*

Review (guided practice) the charge diagrams for positive and negative charges.

Have students read pages in your text pertaining to grounding and the methods of charging objects. After this reading, have students organize the similarities and differences between the three methods of charging objects. Have them give

LEP Modifications:

- *Have students read text in pairs to each other.*
- *Have students write a sentence using an example of grounding.*
- *Have students create a bubble map using the following words (three methods of charging (the large bubble), friction, conduction, and induction (the smaller bubbles off the large bubble), include examples and definitions coming off each of the smaller bubbles.*

Let students explore and extend their basic understanding of the process of conservation of charges at this point.

Day 3- Electric Charge

Essential Question: How can you detect static charge?

Language (ELP) Objective for LEP students: The learner will:

- *Create and orally present posters about an electroscope to the class.*

ENGAGE:

Make students understand this is an analogy for an electroscope. Again, the humidity of the day is important.

Teacher Notes: An electroscope is used to detect static electrical charge. Most textbooks have a diagram or a picture of an electroscope. While they are available from science suppliers, most are hard to use or even demonstrate as the metal leaves are so delicate. A very good alternative is an analogy adapted from The Science Exploratorium. It is easy to make and a more stripped down version is presented here. This does not serve to replace an electroscope; it merely serves as a great analogy for students to see how the 2 leaves of an actual electroscope will work to detect an electrical charge. Plastic tape can gain or lose negatively charged electrons in some situations. When tape is stuck to a table or other smooth surface then quickly removed, both the table and tape vie to steal negatively charged electrons from each other. Only negatively charged electrons are involved in the transfer because positively charged particles do not move in this situation. When two pieces of tape are ripped from the table, both will have the same charge. Once the tape has been quickly removed from the table, have students put one piece of tape on the end of their index finger and the other piece of tape on their other index finger. The students bring the pieces of tape (non-sticky sides) facing one another. This charge can be positive or negative depending on whether the table or the tape wins the electron tug-of-war. These two pieces of tape will repel one another when brought in close contact because like charges repel.

The same principle applies to two pieces of tape that are stuck together and quickly ripped apart. Place one piece of tape on the table. You then place another piece of tape directly on top of the first to make a “tape sandwich”. Have students quickly pull the first piece of tape up then the second piece of tape. Have them place the pieces of tape on the ends of their index fingers as before, with the non-sticky sides facing one another. In this situation, one piece of tape gains negatively charged electrons while the other piece of tape loses them. As a result, the tape with the sticky side in the center of the tape “sandwich” becomes

positively charged while the tape with the smooth side in the center of the tape sandwich becomes negatively charged. Opposites attract, so these tapes will be drawn to one or another when brought in close contact to one another.

LEP Modifications:

- *Complete this activity as a demonstration with student volunteers. Have students record information on the board.*
- *Discuss as a class their observations.*

Make sure that you use Scotch ™ brand Magic Tape the very first time you perform his lab. Some tables may not charge tape, so test your tables before trying this activity in class. If your table will not charge the tape, try other smooth surfaces before giving up. You can also experiment with other cellophane tapes as you become more familiar with this lab. Some others work just as well and are less expensive. It has been experienced, however, that Scotch ™ brand Magic tape works practically every time.

EXPLORE:

How Can You Detect an Electrical Charge?

Materials: Scotch tm Brand Magic tape (Enough for students to work in pairs)

Like charges: Tear off two 5 cm pieces of Scotch™ Magic Brand tape. Press the tape firmly to a flat surface such as a table. Leave one end of each piece of tape sticking up as a handle. QUICKLY pull the tapes from the surface. Stick one piece of the tape to the end of one of your index fingers. When two pieces of tape are ripped from the table, both will have the same charge. Once the tape has been quickly removed from the table, have students put one piece of tape on the end of their index finger and the other piece of tape on their other index finger. The charge will slowly leak off the tape, so you may need to recharge your tapes by repeating this step after a few minutes of use. Move your fingers so that the non-sticky sides are facing each other BUT not touching. What happens to the pieces of tape as they are brought close to each other? Record what happens. Ask students why the tape behaved as it did.

Opposite charges: Tear off two more 5 cm strips of Scotch™ Brand Magic tape. Place the sticky side of one piece of tape to the table. Then place the second piece of tape directly to the non-sticky side of the second piece of tape, leaving a little folded over piece so that you can quickly pull the individual pieces of tape up from the table, leaving a handle on each. This effectively makes a “tape sandwich” on the table before you pull the tape up. When two pieces of tape are ripped from the table, both will have the same charge. Once the tape has been

quickly removed from the table, have students put one piece of tape on the end of their index finger and the other piece of tape on their other index finger. Move your fingers so that the non-sticky sides are facing each other BUT not touching. What happens to the pieces of tape as they are brought close to each other? Record what happens. Ask students why the tape behaved as it did.

Another use of this electroscope activity (Detecting Electric Charge II) is to use the inflated balloons to collect negative charges from hair or other natural fibers (refer to day 2) and place the charged balloons near the charged tape. Depending upon the charges of the tape, the tape pieces will either attract the balloon or repel away from the balloon. Have students record what happens as they use their "electroscope" leaves and determine what piece of tape is positive and negative. This is possible from the opposite charges part of the electroscope lab.

Teacher Notes: Make sure to point out that this activity is just an analogy to an electroscope. Furthermore, let students know an electroscope is just used to detect an electric charge, it does not measure charge. This does serve as a good point to distinguish between static electricity and current electricity.
Activity Detecting Electric Charge II

EXPLAIN:
Ask students to share their experiences and explain their results.

Detecting Electric Charge II

Materials: Scotch ™ Brand Magic tape, latex or rubber balloons, natural fiber clothing or unmoussed and nonconditioner-treated hair.

Show students an example of a real electroscope and have students sketch an electroscope and the different orientations of the leaves and the knob for the differences between induction and conduction.

Have your students read the parts of your text relating how electroscopes work. If a picture is available in the text, have students draw and label its parts in their

LEP Modifications:

- *Have students get into groups and create posters of an electroscope and how it works.*
- *Have students draw and label the parts of an electroscope, explain in complete sentences the movement of the leaves when unlike charges and like charges are on the electroscope.*
- *Have students present their posters to the class.*

ELABORATE:

Lightning Video Activity

Try to find a video related to lightning and its dangers. Check the internet for videos; students are normally interested in how lightning is generated, so a video clip will serve this purpose. Lead a discussion about the dangers of lightning and the proper safety procedures to follow in an electrical storm, especially if you are caught outside. Have students brainstorm the best places for a person to take shelter in such an event. Also, have students complete KWL chart in notebook about charges.

Suggestions for video clips are listed below.

"How Lightning Works"
http://science.howstuffworks.com/lightning.htm

Lightning Strikes Toronto CN Tower Multiple Times
http://www.youtube.com/watch?v=nCm2UCj6eDU

LEP Modifications:

- *If at all possible try and find a movie that has English subtitles. This increases compression for the LEP students.*
- *Ask students to share what they know about lightning.*

Lead a discussion about the purpose of grounding for safety as well as why the Earth can be used for grounding purposes. Ask students, "Why is it not good to go out in a sailboat in a lightning storm?"

Day 4 – Current Electricity

Essential Question: What is current electricity?

Language (ELP) Objective for LEP students: The learner will:

- *create and present posters on dry and wet cells.*
- *write a sentence comparing an open and closed circuit.*
- *listen to presentations on series circuit.*

ENGAGE:

Teacher Notes: You may use this to review conductors and insulators. Also, you may want to have the students place several batteries together in order to

complete a series circuit. Relate this activity to battery operated devices, such as remote controls, etc.

Let students have the time to explore the different orientations of the conductor aluminum foil to try to complete a series circuit.

Activity Hot Fingers- How Does Current Travel in a Battery?

Materials: AAA or AA batteries, aluminum foil strips (long enough to reach from one end of the battery to the other end). Optional: straws, other insulators or non -conducting materials.

Students will each have (or in pairs) an AA or AAA battery and a strip of aluminum foil. Have students predict what part of the battery provides the electrons. Have them take one end of the aluminum foil and place it on the negative end of the battery. Have them touch the free end of the battery to the sides of the battery. This allows them to see that a battery only works if it is connected positive terminal to negative terminal. You may also use straws and other materials to allow them to see that only metals conduct electricity. **Note that a "short circuit" like this, with a fresh battery, can get very hot very quickly, particularly if students want to see what happens with multiple batteries.**

ELLEP Modifications:

Model the process for the activity. Then have students work in groups. Provide an instruction card for each group.

1. *Collect a battery and piece of foil.*
2. *Put the foil on the end of the battery with the (-) symbol.*
3. *Feel the foil and record observations. (cold or warm)*
4. *Put the foil on the other end of the battery.*
5. *Feel the foil and record observations. (cold or warm)*

Discuss why the foil was warm when it was touching both ends of the battery. As a class come up with a definition for "current".

EXPLORE:

How are Batteries Constructed?

Have the students read the pages pertaining to batteries in your textbook.
You may want them to do a KWL about batteries. You can also have them draw diagrams of wet cell batteries and dry cell batteries in their notebooks. Explain the difference (wet cells use an electrolyte pool while a dry cell uses an electrolyte paste) between the types of batteries. Also have the students list uses of each type of battery. Initiate a discussion on the various sizes of batteries (AA, AAA, C, D, 6 Volt and 9 Volt) and why the shape has nothing to do with the

voltage each battery has in it. Have each size battery on hand for the students to see. Also, introduce the idea of a battery as an electron pump. See diagram below for specific roles of the battery.

ELEP Modifications:

- *Have students work in groups and create a poster comparing wet cell and dry cell batteries. Have students take a large piece of construction and fold in half (put wet cell on one side and put dry cell on the other side). Include drawings with labels, uses, and examples.*
- *Have students orally present their posters to the class. Hang poster around the room.*

Have students brainstorm various orientations of a conductor with a battery and light bulb to predict which arrangement will light the bulb and which ones will not. They can then draw the arrangement they have predicted in their notebook. Make sure students understand that batteries are used in series circuits and that their uses dictate their shapes as AA, AAA, C and D batteries are all 1.5 Volts.

ELEP Modifications:

- ***Show** various orientations of a conductor with a battery and light bulb (use internet and projector or overhead projector).*
- *Have students as a class make predictions.*

EXPLAIN:

Ask students to share their findings with the class or in small groups.

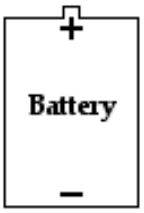
ELABORATE:

Students have the opportunity to further their understanding of conductors, insulators, and series circuits in this activity (Will it Burn?) using batteries.

Will it Burn?

Materials: AA or AAA batteries, a conducting wire, a light bulb, or stripped ornamental lights

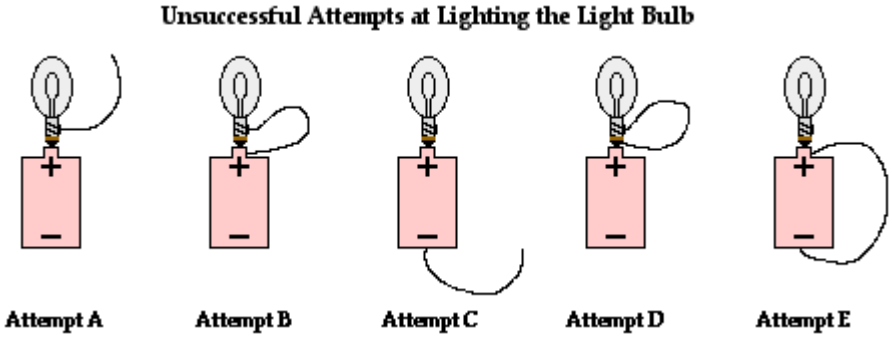
Give each pair of students a battery (AA or AAA) a conducting wire, and a light bulb. Have them test their predictions and record their results in their notebooks. They are amazed, again, that a battery has to be in series with conducting materials in order for the energy to be used.



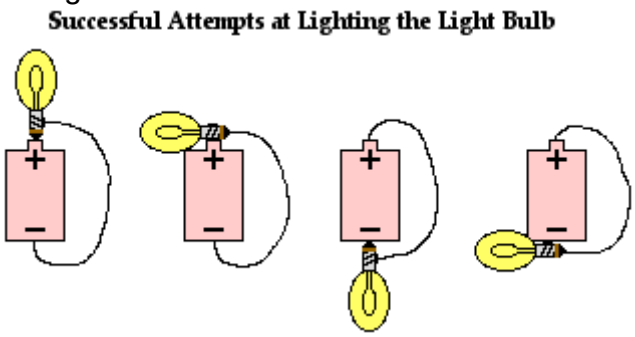
Role of the Battery:

- **Supplies the energy**
- **Pumps the charge from – to + terminal**
- **Maintains a ΔV across the external circuit**

Teacher Notes: See diagrams below for various arrangements



Arrangements that work.



These arrangements will allow the students to see how the lights can work. You may use a stripped ornamental light bulb instead of purchasing small light bulbs. Additionally, this is a great time to review charges of subatomic particles. Let them explain why the batteries have a positive and negative terminal. These activities also are a great introduction to series circuits.

LEP Modifications:

- *Have each group test a different prediction.*
- *Have them record it in their notebooks.*
- *Have them present their findings to the class.*
- *Have students turn to each other and give a definition of proton, neutron, and electron.*
- *Discuss as a class series circuits (open and closed). Have the students write a definition of open circuit and closed circuit in their notebooks.*

Day 5- Circuits

Essential Question: How do circuits work?

Language (ELP) Objective for LEP students: The learner will:

- orally read the text about series and parallel circuits to the class.
- draw and explain series and parallel circuits.

ENGAGE:
Begin by asking the following question, “Have you ever been trying to decorate with ornamental lights and part of the string worked while the rest did not?” Check for students’ responses by using “thumbs-up” for yes and “thumbs-down” for no.

LEP Modifications:
If at all possible, bring in a string of old Christmas lights as a demonstration. Remove one light and let the students observe what happens.

EXPLORE:
This lab will allow students to explore the science behind this experience along with learning the practical applications of circuit electricity.

Teacher Notes:
Make sure the lights used are able to withstand 9 Volts. Test them before the lab and make sure of this. Some lights will blow, so be sure to check them. Also, make sure all batteries are equally charged. A nearly dead battery will ruin the effects of this activity! Each student or pair of students is given 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector. Twisting the ends of the bare wire together in series, one at a time, makes a simple series circuit. This is done so that students can observe the brightness of the lights as each one is added in series. Students note the dimming of the bulbs as each is added. A discussion is then initiated as students reason through the possible causes for the dimming.

Once the reason for the dimming has been identified, move on and have the students make a parallel circuit with the same 3 lights by twisting three light ends together and then twisting the other 3 ends together so that the lights are “parallel”. It is important to note that students should hypothesize the reason for the dimming effects in this parallel arrangement before they connect the wires to the battery. As they connect the battery, they are surprised to see all three lights equally bright!

Approach this lab in as much of an inquiry manner as possible. Guide them through it but do not tell them what is happening. Let them figure out why the brightness changes. Have them look at the formulas for the potential difference, current and resistance for series and parallel circuits. This also allows them to get used to the math involved in circuits. You can use whatever size batteries you wish, but it works best if you have the connectors/holders for the batteries.

Allow students plenty of time to build series and parallel circuits so that they can see the effects of voltage in series and parallel circuits with the ornamentals lights.

Bright Lights Activity

Materials 3-stripped ornamental lights (Check the voltage. Some ornamental lights use very low voltage.), a 9 Volt battery and a 9-V connector.
Safety: Make sure students do not keep the circuits connected (wires to batteries) as the batteries will overheat and could be a safety issue.

Procedure A

1. Obtain 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector.
2. Twist the ends of the bare wire together in series, one at a time.
3. Note the apparent brightness of each light after it is connected in the circuit.

EXPLAIN:
Questions to Guide Analysis

1. What happens to the brightness of each light as you add one more light to the circuit?
2. Why or why not do you think the brightness changed?
3. Draw a complete circuit diagram of the finished circuit.

Procedure B

1. Obtain 3-stripped ornamental lights, a 9 Volt battery and a 9-V connector.
2. Twist the ends of the bare wire of all three lights so as to make a parallel circuit.
3. Note the apparent brightness of all three lights as they are connected in parallel.
4. Remove each light, one at a time, noting any change in the apparent brightness of each light.

EXPLAIN:
Questions to Guide Analysis

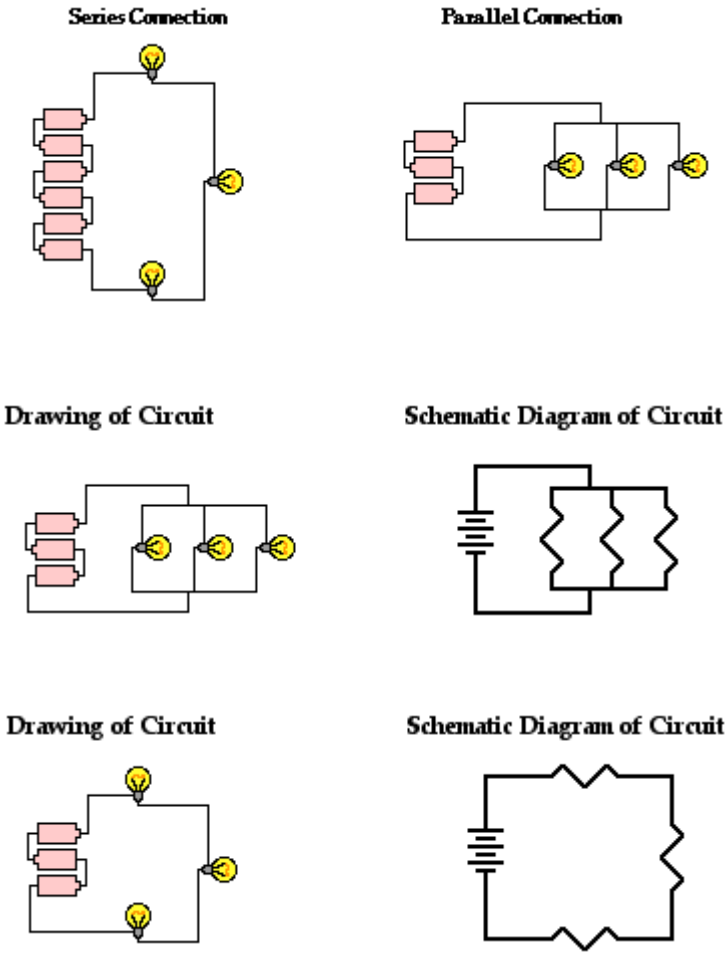
1. What happens to the brightness of each light as you add one more lights to the circuit?
2. Why or why not do you think the brightness changed?
3. Draw a complete circuit diagram of the finished circuit.

ELEP Modifications:

- *Demonstrate and explain the definition of brightness.*
- *Complete Procedure A as a demonstration.*
- *Answer the questions for Procedure A as a class.*
- *Have students work in pairs on the other procedures.*

Below are some examples of circuit diagram symbols.

Some examples of circuit diagrams



When students are finished with this lab, you may want to have them read over the pages pertaining to series and parallel circuits in their textbooks. Have them copy, either from your notes or the textbook, the symbols commonly used in

circuit diagrams. This is also where you can introduce Ohm's law to them. Use the formulas on the reference tables to assist students in the relationships between current, voltage and resistance.

Use an independent practice to familiarize them to circuit diagrams.

LEP Modifications:

- *Have the students take turns reading the text out loud to the class.*
- *Have students make a poster comparing series and parallel circuits. Include definitions, drawings, symbols, and examples of everyday use.*
- *Place the formula for Ohm's Law on the board and call on different students to explain the symbols and their meanings (do not forgot about the units).*
- *Complete several practice problems on the board. Have students come up to the board to check for understanding.*

LEP Modifications:

- *Write the formulas for potential difference, current, and resistance on the board. Go over what all the symbols mean and how to solve for the variables.*
- *Do simple problems together then allow the students to work in pairs to solve problems, and then have them work individually.*

Let students work with various circuit diagrams as an independent practice in order to distinguish between series and parallel circuits and the symbols used in these diagrams.

Day 6- Circuits

Language (ELP) Objective for LEP students: The learner will:

-write answers to the laboratory questions in complete sentences.
-speak circuit vocabulary words and definitions to a neighbor.

ELABORATE:

The purpose of this activity (Build Series and Parallel Circuits: Lab Activity) is to design, build, and test series and parallel circuits. Students will build their own circuits and measure current and voltage.

Teacher Notes: You may want students to draw the circuits so they will learn the circuit symbols. The students could use wire, but the use of aluminum foil reinforces the concept that metal conducts electricity. Students should know the difference between series and parallel circuits.

Build Series and Parallel Circuits: Lab Activity

Materials: Large sheet of heavy paper, Aluminum foil or wire, Tape, Ornamental lights (3) with sockets (or Cut individual lights from ornamental string lights), Battery (6V=4C or 9V with connectors), Pencil, Ammeter, Voltmeter

Safety: Batteries can become hot if left connected for long periods of time. Students should hook up battery only long enough to observe the lights.

Introduction to Students

There are two types of electrical circuits. Series circuits have only one path for electrons to take. Parallel Circuits have two paths for the electrons to take.

ELL/LEP Modifications:

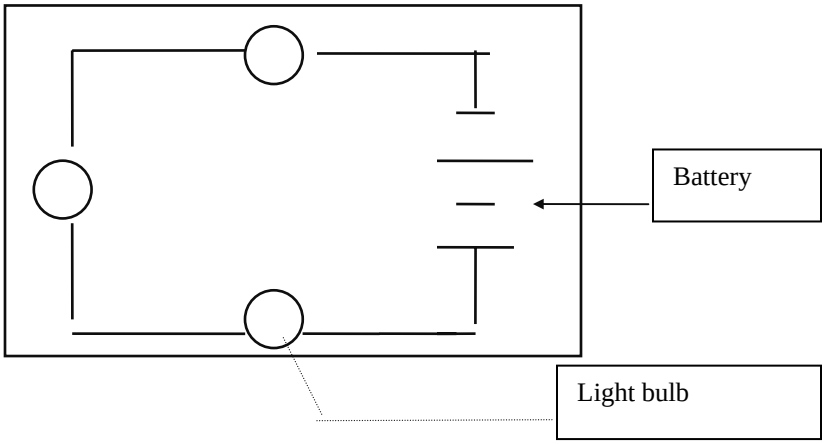
- *Introduce and review vocabulary – Place vocabulary on the board and as a class come with up definitions.*
  - *Parallel Circuit, Series Circuit, ammeter, voltmeter, potential, potential difference, open circuit, closed circuit, and voltage*
- *Have students turn to their neighbor and use a vocabulary word in a sentence.*

Procedure

1. On the large sheet of paper, draw a series circuit that contains three lights and one battery source. USE THE CORRECT SYMBOLS.
2. Construct the series circuit using the light, foil or wire, switch and battery. Test the setup.
3. Test for the amount of current and voltage. An Ammeter measures electric current and should be connected in series with the circuit. A voltmeter measures potential difference across part of a circuit and should be connected in parallel across a part of the circuit.
4. Draw and construct a parallel circuit. Test the setup. Note the brightness of the lights. What happens with one bulb is removed?
5. Test for the amount of current and voltage.

Lab Data

Circuit	Current	Brightness	Bulb Removed	Voltage
Series				
Parallel				



Questions to Guide Analysis

1. Is there a difference in the brightness of the bulbs in the parallel and series circuits?

2. What happens when a bulb is removed in the series circuit?

3. What happens when a bulb is removed in the parallel circuit?

EXPLAIN:
Instruct students to complete the following questions regarding Ohm's Law. Allow them the opportunity to explain their answers. This presentation can be done independently or as a group. Make sure students know how to use Ohm's Law to solve various problems and apply it to the circuits conceptually, as well as mathematically.

Ohm's Law Independent Practice

Use Ohm's law to work the following problems related to series and parallel circuits.

1. What is the current in a series circuit with a resistance of 30 Ω and a potential difference of 120 volts?

2. What is the voltage in a series circuit with a resistance of 10 Ω and a current of 20 Amps?

3. What is the potential difference across a 30 Ω resistor that has a current of 10 Amps?

4. What is the total resistance in a series circuit with a 10 Ω resistor, a 30 Ω resistor and a 50 Ω?

5. What is the potential difference of a 60 Ω resistor with a current of 30 Amps?

6. What is the current in a series circuit with a resistance of 40 Ω and a voltage of 220 Volts?

LEP Modifications:

- *Put all formulas on the board and go over the symbols and units.*
  - *Or show and explain how to use the reference tables that will be used on the EOC.*
- *Complete the first question as a class on the board.*
- *Have students turn to their neighbor and explain how the second question should be completed. (Similar to a peer review)*
- *Have students complete the rest of the problems on their own.*

Day 7- Magnetic Fields

Essential Question: What is magnetism?

Language (ELP) Objectives for LEP students: The student will
-write answers to the questions for the magnetic field laboratory activity.
-speak to each other about the forces between the poles of a magnet.
-listen to students read about magnetic domains.

<u>EXPLORE:</u>

The purpose of this activity is to allow students the opportunity to investigate and analyze magnetism and the practical application of the characteristics of magnets. In this activity the students will map the magnetic field around a magnet, two magnets, and a horseshoe magnet.

Teacher Notes:

This is a good introduction to magnetic fields. This activity shows that the magnetic field can be mapped. You may want to use this activity to explain magnetic domains. Also, if your permanent magnets have become weak or

misaligned, you can re-align them using a re-magnetizer. Most science suppliers have these or you may just want to ask in your county or district to borrow one.

Also, point out to students that the magnets should not be placed near a TV or computer screen, watches, credit cards, or floppy disks. This can cause damage to these devices. If you only have bar magnets, that is OK. It serves the purpose to illustrate the lines of the magnetic fields.

Make sure students are careful when handling the magnets. If the permanent magnets are dropped, they will more than likely break.

After completing this lab, introduce students to the field lines around the magnets.

Magnetic Fields: Laboratory Activity

Materials (per group) 2 permanent bar magnets, small compass, pencil, horseshoe magnet, sheet of paper

Purpose

To investigate and analyze magnetism and the practical application of the characteristics of magnets

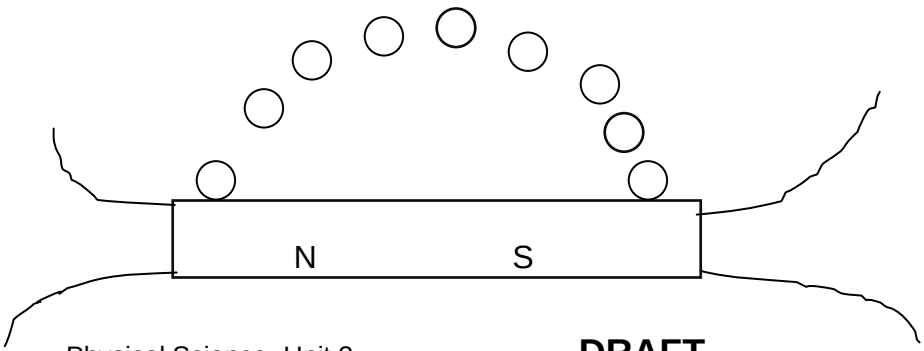
Introduction to Students

A magnet exerts forces. In this activity the students will map the magnetic field around a magnet, two magnets, and a horseshoe magnet.

Procedure

1. Center one bar magnet in the middle of the large sheet of paper. Trace around the magnet. Place the compass near the ends of the bar magnet. Place a dot to show the direction of the needle on the compass. Move the compass and line the compass needle with the dot. Continue until the line returns to the magnet or goes off the page. Connect the dots to show the magnetic field around the magnet. Draw at least 10 lines of magnetic force from each end of the magnet.

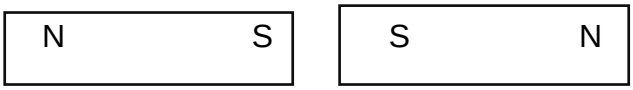
Example



ELLEP Modifications:
Complete as a demonstration using the overhead projector. Make sure you use a clear compass so the students can see the needle spin. Explain how to move the compass and how to draw the lines. You can ask to student volunteers to come up to the over head and draw lines to check for student understanding. Have students copy this in their notebooks.

2. Repeat the procedure with two bar magnets, when the north and south poles are placed about 3 centimeters apart.

3. Repeat the procedure with two bar magnets; place the south (or north) and south (or north) poles about 3 centimeters apart.



4. Repeat the procedure with horseshoe magnet.

ELLEP Modifications:
Have students turn to a neighbor and explain to them what happens when a north and north pole touch. Then explain what happens when a north and south pole touch.

EXPLAIN:

Questions to Guide Analysis

1. Describe the lines of the magnetic field around a bar magnet and horseshoe magnet.

2. How does the magnetic field change when like poles were together? Opposite poles?

3. Where is the magnetic field the strongest? Explain the reasons based on your evidence.

ELABORATE:
This is a good introduction to magnetic fields. This activity shows that the magnetic field can be mapped.

Field lines Independent Practice

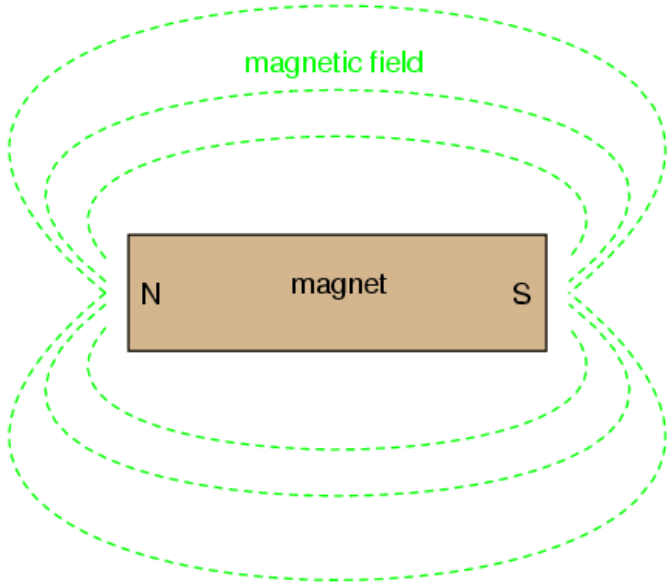
DOMAIN THEORY:
Electrons have a property called 'spin' (not that they are actually spinning). Spin acts like a small loop of electricity and makes a tiny magnetic field with North (N) and South (S) poles. When there are a number of unpaired electrons in an atom, the tiny magnetic fields can add up. Iron, nickel and cobalt are the most common metals that have this effect. They are called "ferromagnetic materials". In ferromagnetic materials the atomic dipoles of neighboring atoms align themselves. A region where the atomic magnetic fields are aligned is called a *domain*.
(Diagram of unmagnetized iron -- random domains that cancel each other out)
(Diagram of magnetized iron with N and S).

A region of a piece of iron where adjacent atoms are magnetically aligned is called a *domain*. Unmagnetized iron consists of many tiny, scrambled domains; a permanent magnet has more aligned atoms and may have one domain the size of the magnet itself.
Magnetic Field Lines indicate the forces which act over a distance (like gravity) with no physical contact. We think of a force field extending from the magnet and getting weaker with distance. (actually $F_{mag} \propto 1/d^2$)
We represent this field with lines.
(i) The lines form complete loops.
(ii) The field lines come out of the N pole and go into the S pole.
(iii) The closer the lines are, the stronger the field is.
(iv) Field lines do not cross.

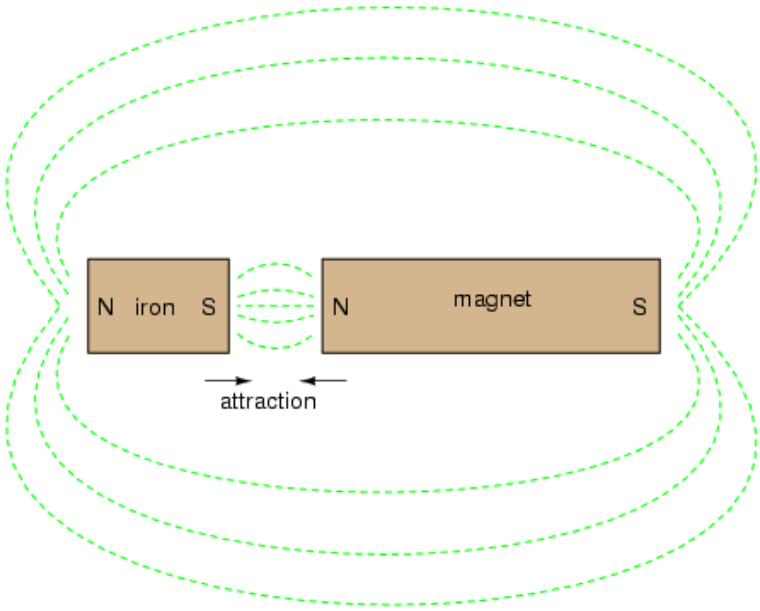
Have students draw various orientations of field lines representing attraction and repulsion.

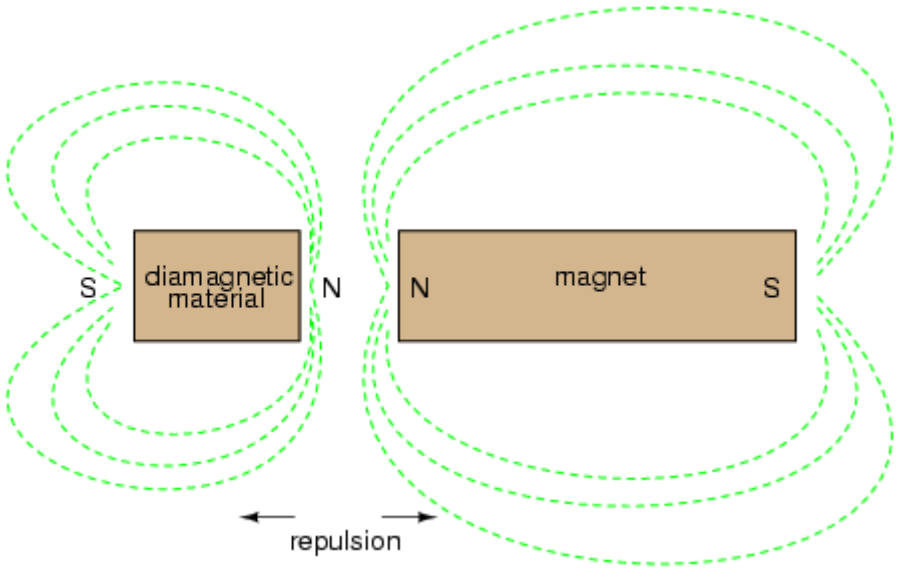
ELEP Modifications:
Draw an example of the field lines of a magnet on the board. Then allow the students to work independently and draw two more examples on their own. Walk around the room and check for understanding.

Below are examples of field lines of magnets.



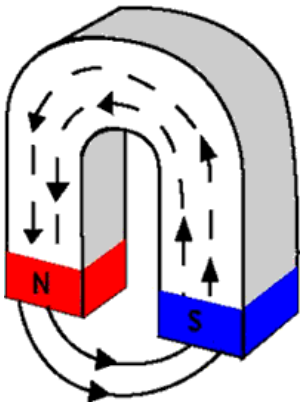
Orientations of magnets field lines and attractive and repulsive forces.





Independent Practice

Have students read the pages pertaining to permanent magnets in your textbooks. Make sure they have the correct diagrams of the filed lines with the lines coming out of the north pole and entering the south pole. Have an independent practice with students selecting the varying arrangements of poles to indicate attractive and repulsive forces. For example, the horseshoe magnet is one of the more common shapes. The horseshoe magnet has north and south poles just like a bar magnet but the magnet is curved so the poles lie in the same plane. The magnetic lines of force flow from pole to pole just like in the bar magnet. However, since the poles are located closer together and a more direct path exists for the lines of flux to travel between the poles, the magnetic field is concentrated between the poles.



Allow students to use the magnets if needed to reinforce the attraction and repulsion using the field lines.

Day 8 – Permanent Magnets vs. Temporary Magnets

Language (ELP) Objective for LEP students: The learner will:
-design a pamphlet using vocabulary words about magnets.

ENGAGE:

As an introduction, have students to make a temporary magnet out of a nail. You may use any metal object but nails work well. Rub one end of a permanent bar (or horseshoe) magnet on the nail approximately 40 times in only one direction. After each stroke, lift the magnet away from the nail before returning to the top to stroke it again. Test the nail's magnetism by holding it above a pile of paper clips. (If magnetism has been induced, some paper clips will cling to it.) Have you noticed that only certain objects can be magnetized? Which ones?

Teacher Notes: Students will be able to magnetize their nails if they rub the nail in the same direction enough times. You may want to have several examples of magnets on hand for students to examine after they complete this lab.

LEP Modifications:

- *Make a chart for the students to fill out. Write and read orally the instructions for the activity. Some ideas for the top row of a chart*
  - *Stroke a nail 10 times and try to pick up a paper clip and record what happens.*
  - *Stroke a nail 20 times and try to pick up a paper clip and record what happens.*
  - *Stroke a nail 30 times and try to pick up a paper clip and record what happens.*
  - *Stroke a nail 40 times and try to pick up a paper clip and record what happens.*
  - *Time how long the magnetize nail will hold the paper clip.*
  - *Stroke the nail back and forth and try to pick up the paper clip and record what happens.*

Temporary Magnets

Materials: nails, permanent bar magnets, paper clips

Questions for Analysis

1. How long will the objects you turned into magnets remain magnetized? Does the number of times an object was stroked with the magnet influence how long it retains its magnetic effect?

2. What would happen if you stroked the object in both directions with the magnet?

3. What factors can interfere with a magnet's power?

EXPLORE:

This (Electromagnet Activity) is a great inquiry activity for students. Give students the materials listed below and have them figure out how to make a magnet out of the materials given to them. Tell them they have to use all the given materials, except the paper clips, to construct a magnet. The paper clips are used to test the strength of the magnet.

Electromagnet Activity

Materials: nail, 6 Volt Battery, copper electrical wire long enough to wrap several coils around the nail, paper clips

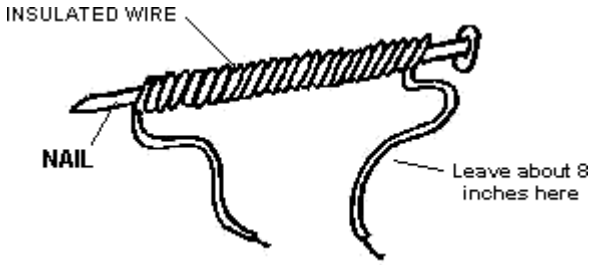
Safety: As always, when working with batteries and wire, these conductors can become very hot. Caution students about this. Also, be aware that students also like to keep the conductors connected, so batteries can be run down very quickly. Make sure students disconnect the wire (open the circuit) to keep this from happening.

Teacher Notes:

If you have not made an electromagnet, here are the specific directions.

1. Leave about 8 inches of wire loose at one end and wrap most of the rest of the wire around the nail. Try not to overlap the wires.

2. Cut the wire (if needed) so that there is about another 8 inches loose at the other end too. It should look like this:



3.Now remove about an inch of the plastic coating from both ends of the wire and attach the one wire to one end of a battery and the other wire to the other end of the battery.

Make sure students understand that several factors can influence the strength of an electromagnet: voltage, number coils, use of an iron core.

EXPLAIN:

Have students read and complete an independent practice about magnets and their uses in their textbook to further their understanding or instruct students to answer the following questions.

Independent Practice- Magnets

1. What does a magnet repel?
    a) The opposite pole of another magnet
    b) Iron, nickel and cobalt
    c) The same pole of another magnet

2. What happens if you cut a magnet in half?
    a) It destroys its magnetism
    b) You get a North Pole magnet and a South Pole magnet
    c) You get two magnets, each with a N and S pole

3. Why does a compass point north?
    a) The shape of the Earth causes it
    b) There is a large deposit of iron right at the North Pole
    c) The Earth is a large magnet with a magnetic pole near the North Pole

4. Draw a diagram to illustrate what happens when you move two unlike magnetic poles closer together.

5. Why are only certain materials magnetic?

6. How would the properties of a bar magnet change if it were broken in half.

LEP Modifications:

- *Have students get into groups and read the text to each other.*
- *Have students construct a pamphlet about magnets.*
  - *Pamphlets must include:*
    - *Definition*
    - *Vocabulary words related to magnets*
      - *North pole*
      - *South pole*
      - *Domains*
      - *Repel*
      - *Attract*
    - *Pictures – at least three*
    - *Every day uses – at least three*

Day 9- Movement of Electric Charges and Practical Applications

Essential Question: How does magnetism relate to electricity?

Language (ELP) Objective for LEP students: The learner will:
-write answer about motors in complete sentences.

EXPLORE:

The purpose of this lab (Motor Lab Activity) is to investigate and analyze magnetism and the practical applications of the characteristics of magnets.

Teacher Notes:

A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin. You have created an electric motor.

You can successfully run motors on one 1.5 volt D battery; additional batteries seem to make it easier to get the motor to run. You may want to try 6-volt lantern batteries. We have also had excellent results using a power supply (battery eliminator) set to about 4 volts. The advantage of the power supply is that it will supply a substantial current over a period of time. Unlike batteries, it doesn't have to be replaced. Experiment with what you have, and use whatever works. A current flow through the wire coil and creates an *electromagnet*. One face of the coil becomes a north pole, the other a south pole. The permanent magnet attracts its opposite pole on the coil and repels its like pole, causing the coil to spin.

Another way to describe the operation of the motor is to say that the permanent magnets exert forces on the electrical currents flowing through the loop of wire. When the loop of wire is in a vertical plane, the forces on the top and bottom wires of the loop will be in opposite directions. These oppositely directed forces produce a twisting force, or *torque*, on the loop of wire that will make it turn.

Why is it so important to paint half of one projecting wire black? Suppose that the permanent magnets are mounted with their north poles facing upward. The north pole of the permanent magnet will repel the north pole of the loop electromagnet and attract the south pole. However, once the south pole of the loop electromagnet was next to the north pole of the permanent magnet, it would stay there. Any push on the loop would merely set it rocking about this equilibrium position.

By painting half of one end black, you prevent current from flowing for half of each spin. The magnetic field of the loop electromagnet is turned off for that half-spin. As the south pole of the loop electromagnet comes closest to the permanent magnet, the paint turns off the electric current. The inertia of the rotating coil carries it through half of a turn, past the insulating paint. When the electric current starts to flow again, the twisting force is in the same direction as it was before. The coil continues to rotate in the same direction.

In this motor, the sliding electrical contact between the ends of the coil of wire and the paper clips turns off the current for half of each cycle. Such sliding contacts are known as *commutators*. Most direct current electric motors use more complicated commutators that reverse the direction of current flow through the loop every half cycle. The more complicated motors are twice as powerful as the motor described here.

This motor can also be used to demonstrate how a generator works. Try hooking up the ends of the paper clips to a sensitive galvanometer instead of the battery. Spin the coil and see if any current registers on the meter.

Motor Lab Activity

Materials: 5 small disk or rectangular ceramic magnets (available at Radio Shack), 2 large paper clips, a plastic or Styrofoam cup , a solid (not stranded) enameled or insulated 20-gauge copper wire, about 2 feet (60 cm) long (available at Radio Shack), masking tape, a battery or power supply (a 6 Volt works very well) , 2 electrical lead wires with alligator clips at both ends (available at Radio Shack) , wire strippers (if you are using insulated wire), sandpaper (if you are using enameled wire), a battery holder (if you are using batteries other than a 6 Volt)

Purpose
To investigate and analyze magnetism and the practical applications of the characteristics of magnets.

Materials

- 5 small disk or rectangular ceramic magnets (available at Radio Shack)
- 2 large paper clips

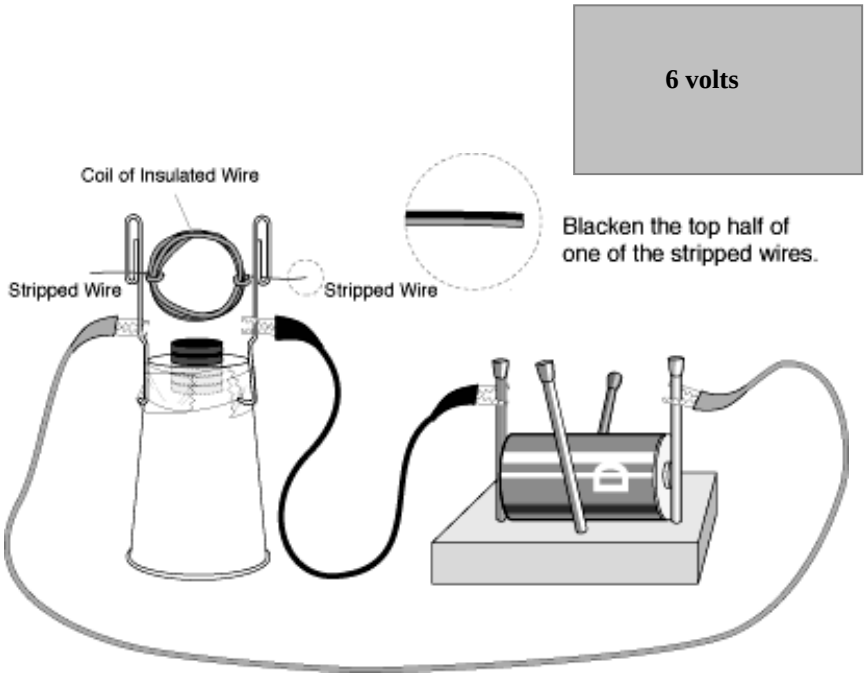
- A plastic or Styrofoam cup
- A solid (not stranded) enameled or insulated 20-gauge copper wire, about 2 feet (60 cm) long (available at Radio Shack)
- Masking tape
- A battery or power supply (a 6 Volt works very well)
- 2 electrical lead wires with alligator clips at both ends (available at Radio Shack)
- Wire strippers (if you are using insulated wire)
- Sandpaper (if you are using enameled wire)
- A battery holder (if you are using batteries other than a 6 Volt)

Introduction to Student

A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin. You have created an electric motor. Follow the directions of your teacher carefully in order to successfully make an electric motor.

Procedure

Obtain the materials listed above from your teacher. Wind the copper wire into a coil about 1 inch (2.5 cm) in diameter. Make four or five loops. Wrap the ends of the wire around the coil a couple of times on opposite sides to hold the coil together. Leave about 2 inches (5 cm) projecting from each side of the coil, and cut off any extra. (See diagram below)



If you are using insulated wire, strip the insulation off the ends of the wire projecting from the coil. If you are using enameled wire, use the sandpaper to remove the enamel.

Turn the cup upside down and place two magnets on top in the center. Attach three more magnets inside the cup, directly beneath the original two magnets. This will create a stronger magnetic field as well as hold the top magnets in place.

Unfold one end of each paper clip and tape them to opposite sides of the cup, with their unfolded ends down. (See diagram above.) Sandpaper the entire paper clip to make sure good connections are made when completing the circuit. Rest the ends of the coil in the cradles formed by the paper clips. Adjust the height of the paper clips so that when the coil spins, it clears the magnets by about l/l6 inch (1.5 mm). Adjust the coil and the clips until the coil stays balanced and centered while spinning freely on the clips.

Once you have determined how long the projecting ends of the coil must be to rest in the paper-clip cradles, you may trim off any excess wire. (The length of the projecting ends depends on the separation of the paper-clip cradles, which in turn depends on the width of the base of the cup you are using. See diagram above.). Use the clip leads to connect the battery or power supply to the paper clips, connecting one terminal of the battery to one paper clip and the other terminal to the other paper clip.

Give the coil a spin to start it turning. If it doesn't keep spinning on its own, check to make sure that the coil assembly is well balanced when spinning, that the enamel has been thoroughly scraped off if enameled wire has been used, that the projecting end has been painted with black pen as noted, and that the coil and the magnet are close to each other but do not hit each other. You might also try adjusting the distance separating the paper clip cradles: This may affect the quality of the contact between the coil and the cradles.

Keep making adjustments until the motor works. Have patience! The success rate with this design has been quite good.

ELLEP Modifications:

- *Build this motor as a demonstration.*
- *Answer the questions as a class. Have students write answers in complete sentences.*

Questions to Guide Analysis

1. How do the magnets affect the flow of the electrical current?

2. Why is it important to sand off the paint and plastic from the enameled wire and paper clips?

3. What forces are present in this motor?

4. Does it make the coil turn faster by placing more voltage into the circuit? Why or why not?

5. Can you increase the spin by using more magnets? Why or why not?

EVALUATE:

Instruct students to make a booklet illustrating the vocabulary terms in this unit.

LEP Modifications:

- *Students have been working on these vocabulary words throughout the unit.*
- *Review and reinforce vocabulary.*
  - *Flashcards*
  - *Games*
  - *Word wall*
  - *Create flow charts, bubble maps, or concepts maps using vocabulary words.*

Vocabulary List

Electric charge

Magnetic fields

Static; static discharge

Grounding

Conduction

Induction

Radiation

Electroscope

Conductor

Insulator

Electric current

Ampere

Circuit; closed, open; series, parallel

Resistance

Ohm

Voltage

Magnet; permanent, temporary

Electromagnet

Domain

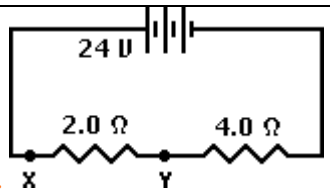
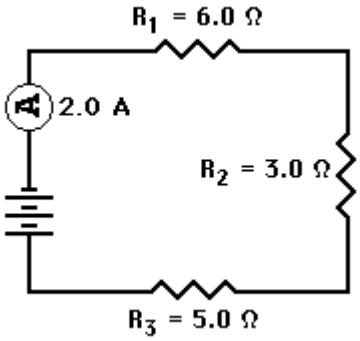
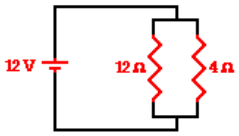
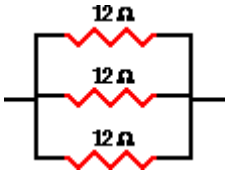
Motor

Generator

SUMMATIVE EVALUATION:

Sample Assessment Questions for Unit 3

Unit	Goal/ RBT Tag	Questions
3	4.01 B4 B4	**1. A student took their clothes from the clothes dryer to help their mom. The student noticed that her woolen sweater was clinging to their silk scarf. Why would these pieces of clothing be clinging together?** a. The static charge of both pieces of clothing is the same b. The static charge of both pieces is positive. c. The static charge of both pieces is negative. d. The static charge of one piece of clothing is positive and the static charge of the other piece of clothing is negative. **2. An electroscope has an overall negative charge. A student touches the metal base of the electroscope and grounds the electroscope. Why is the electroscope is no longer charged?** a. Protons flowed through the student's body into the ground. b. Electrons flowed through the student's body into the ground. c. Electrons flowed through the student's body into the electroscope. d. The student must have been negatively charged prior to touching the electroscope.
3	4.02 B4 B4	**1. What is the current in a parallel circuit that has a potential voltage difference of 120 Volts and a resistance of 2 Ohms?** a. 240 Amps b. 60 Amps c. 40 Amps d. 0 Amps **Which circuit is a series circuit with a total resistance of 6 Ohms?**

		 a. b.   c.  d.

3	4.03 B4	**1. How can an electromagnet's strength be increased?** a. decrease the number of coils b. decrease the voltage c. use a plastic core d. increase the number of coils
	C3	**2. What is the direction of the field lines in a permanent magnet?** a. north lines are directed out and south lines are directed out b. north lines are directed out and south lines are directed in c. north lines are directed in and south lines are directed out d. north lines are directed in and south lines are directed in