IMHOTEP'S
LEGACY ACADEMY

Making an Electric Motor

Grade 9 Activity Plan

Reviews and Updates

9.5 Electric Motor

Objectives:

1. To know more about force fields and be able to outline the difference between field and contact forces.
2. To have a basic understanding of the features of magnets.
3. To have a basic understanding of Ohm's law
4. To understand the right-hand rule.

Key words/concepts: motors, magnetism, right-hand rule, electricity, electromagnetism, friction, commutator, static electricity, permanent and temporary magnets, magnetic poles.

Curriculum outcomes: 109-14, 210-7, 308-15, 308-16.

Take-home product: electric motor

Segment	Details
African Proverb and Cultural Relevance *(5mins)*	Around a flowering tree, one finds many insects. **Ethiopia**
Pre-test/ background *(10mins)*	Ask probing questions on students' knowledge of energy. Discuss kinetic to potential energy conversion; electric charges; static electricity and electric current.
Activity 1 *(10mins)*	Demonstrate static electricity using balloons and wool.
Activity 2 *(10mins)*	Demonstrate the Lorentz force (force on a current carrying wire) using a piece of foil, batteries, wires and a large horseshoe magnet.
Concept *(10mins)*	Explain right hand rule ensuring everyone follows along with their hands.
Activity 3 *(25mins)*	Introduce the concept of magnetic field lines, using a magnet and iron filings to demonstrate.
Activity 4 *(25mins)*	Encourage students to apply acquired knowledge in making their own motors
Summary and post-test *(10mins)*	Explain how forces in the wire cause it to spin

Suggested interpretation of proverb: when one is successful, people are happy with them and as a result, would like to be associated with them.
In this activity it is discovered that charged and magnetized bodies attract other bodies of opposite charge and pole respectively.

Related Facts
http://www.lifescientist.com.au/article/355365/inside_nature_most_efficient_motor_flagellar/

To explain energy conservation, follow this link and download the "energy state park" simulation on the page.
http://phet.colorado.edu/en/contributions/view/3186

BACKGROUND INFORMATION

See activity 8.5 for background information on static electricity

Magnets: Properties that all magnets have in common. They all exert a magnetic force on each other. They all have a south pole and a north pole (just like the Earth, which itself is a magnet); opposite poles attract, like poles repel. In all magnets, the magnetic field lines run from south to north, and these fields are what produce forces on other magnets that follow specific physical laws.

There are two basic kinds of magnets – permanent and temporary. Unlike temporary magnets, the permanent ones (such as those on your fridge) stick around for. While they may not last forever, you often have to go to some effort to demagnetize them. Permanent magnets all belong to a class of materials referred to as ferromagnetic. The other major difference between permanent and temporary magnets is what the magnetic fields look like on an atomic level. These are two different phenomena entirely. All magnetism comes down to electrons. In the electromagnets magnetic fields result from electron flow through a conductor. In the case of permanent magnets, it's the *spinning* of the electrons that creates magnetism, not their movement through a conducting material.

Lorentz Force: A charged particle moving through a magnetic field experiences a force that is at right angles to both the direction in which the particle is moving and the direction of the applied field. This force, known as the Lorentz force, develops due to the interaction of the applied magnetic field and the magnetic field generated by the particle in motion. The phenomenon is named for Dutch physicist Hendrik Lorentz, who developed an equation that mathematically relates the force to the velocity and charge of the particle and the strength of the applied magnetic field. The Lorentz force is experienced by an electric current, which is composed of moving charged particles. The individual magnetic fields of these particles combine to generate a magnetic field around the wire through which the current travels, which may repel or attract an external magnetic field.

Right hand rule: Point the thumb of the right hand in the direction of the current and the rest of the fingers in the direction of the magnetic field, which extends from the north pole of a magnet to its south pole. The direction that the palm is facing when the hand is in this position is the direction of the force exerted on current (charged particles), called the Lorentz force.

Source: http://www.magnet.fsu.edu/education/tutorials

Activity 1: Static electricity

Follow this link to simulate this activity graphically: http://phet.colorado.edu/en/simulation/balloons
This activity was culled from: http://www.mos.org/sln/toe/admirer.html

Suggested format: hand two balloons to every student, and lead them through the activity.

Purpose: to refresh knowledge on static electricity and understand magnetic repulsion.

Items	**Quantity (for mentor and 10 students)**
Balloons	22
String	1spool
Masking Tape	1
Wool Cloth	1 piece

Tip!

Wool cloth readily gives up electrons to other materials it touches. Rubbing a balloon with a wool cloth allows the balloon to accumulate an excess of electrons, and it will become negatively charged. The rubbed portion of the balloon will then be attracted to positively or neutrally charged objects (by induction), and repelled by other negatively charged objects. If the balloon is permitted to touch an object that is not negatively charged, some of the excess electrons will be transferred and the degree of attraction will decrease.

Procedure:

Although this activity is an excellent demonstration, students will gain more from the opportunity to make and experiment with their own "admirers."

1. Inflate a balloon and draw a face on it with a pen or permanent marker.
2. Tie off the balloon and suspend it from a doorway or ceiling using tape and string. The balloon should hang at the level of your head when you stand on the floor.
3. Rub the face of the balloon with a wool cloth. The balloon will now face you and move toward you whenever you approach it. You now have an admirer!
4. Try to determine how far away the attractive force is able to act. Is the balloon still attracted toward you if you position a piece of cardboard between the balloon and your face? Can you wind up the string without touching it by making the balloon follow you round and round in a circle?
5. How do you think your admirer will react if you create another admirer? Draw a face on a second balloon, rub its face with wool, and suspend it near the first admirer. Describe the way they react to each other.

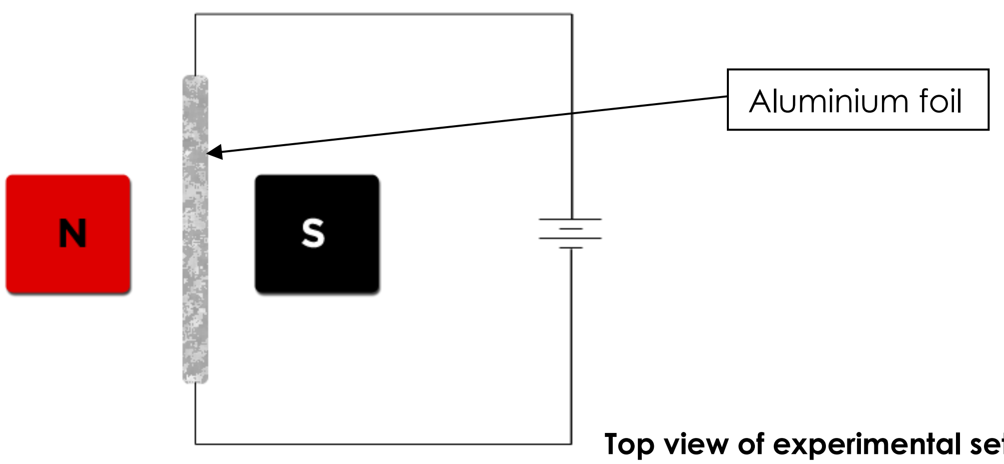
Activity 2: Lorentz Force

Suggested format: mentor should assemble students and encourage them to participate while conducting demo.

Purpose: to understand of Lorentz force.

For additional resources, follow the link below:
http://www.youtube.com/watch?v=-USn7ilxp-Q&NR=1
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfor.html

Items	**Quantity (for mentor only)**
Alligator clip	4
Short alligator connector wire	2
Aluminium foil	15cmx10cm (a small piece)
Large horse-shoe magnet	1
9v battery	1



Top view of experimental set up.

Procedure:

1. Support the foil such that it is suspended in-between the poles of the magnet.
2. Connect aluminium foil to both terminals of a 9v battery, using alligator clips as shown in the diagram above.

Allow students to watch the foil deflect upwards or downwards depending on the direction of flow of current as the set-up conforms to the right hand rule.

Activity 3: Tracing Magnetic Field Lines

Suggested format: mentor should conduct this activity with the help of the students.

Purpose: to understand magnetic poles and be able to draw magnetic field lines

Items	Quantity (for mentor)
Sheet of paper	1
Iron filings	25g
Bar magnet	1
Compasses	12

Procedure

1. Place the paper on top of the bar magnet.
2. Trace the outline of the bar magnet and mark the North and South poles.
3. Lightly sprinkle the iron filings uniformly over the paper and gently tap the paper to make the filings align with the magnetic field.
4. Trace the lines and explain.

Note: compasses can be used to determine the direction of the fields.

Explanation: the magnetic field flows from the north pole to the south pole and the intensity of the field is higher at the poles.

Activity 4: Making a Motor

For tips on this activity, follow the link below.
http://www.exploratorium.edu/afterschool/activities/index.php?activity=138&program=594

Suggested format: hand everyone enough materials to make their motors, but encourage team work.

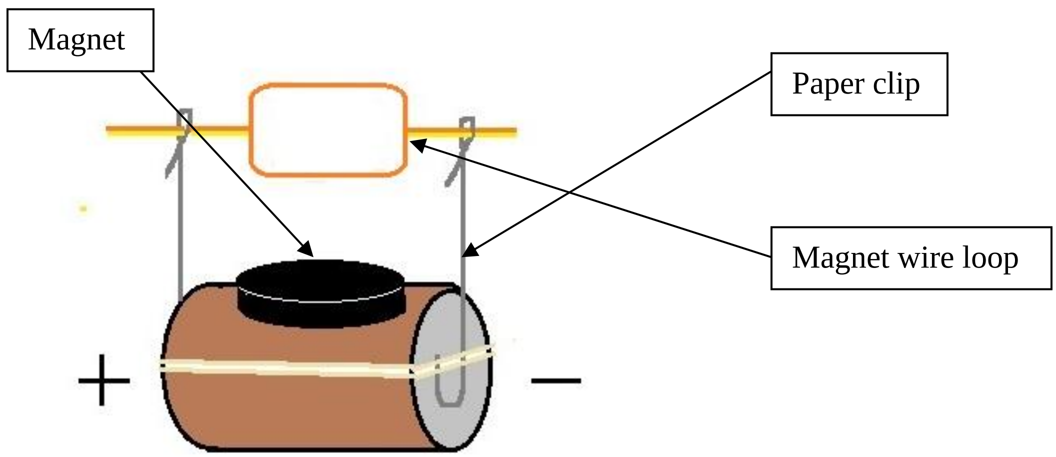
Purpose: to know how to make simple motors and know the basic principles upon which motors work.

Items	**Quantity (for mentor and 10 students)**
D-cell battery	11
Large trombone paper clip	22
Disc magnet (about 3cm diameter)	11
Magnet wire	22 feet
Medium grit sand paper	6 sheets (2 students share a sheet)
Scotch tape	2
Rubber band	11

Procedure

1. Cut about two feet of magnet wire.
2. Form a loop with the wire (this can be done by wrapping the wire around the battery)
3. Pull back about an inch of wire from the loop to make leads (whiskers) to connect to the supports(these leads should be located at 180 degrees apart).
4. **Use the sandpaper to scrape** away about an inch (2 cm) of the coating on either end of the wire. This can be done carefully by placing the loop on a flat surface and sanding the part of the two ends facing up.
5. Place a rubber band around the long side of the battery so that it is touching the positive and negative side
6. Take a paper clip and bend the outside wire down, so that you have a loop with post. Repeat with the other paper clip.
7. Tape a good disk magnet to the top of the battery, ensuring that is doesn't interfere with the path of the loop.
8. Set the loop leads on the paperclips and give the motor a small push start. Enjoy!

NOTE: If the copper loop doesn't spin, try using a stronger magnet


Magnet
Paper clip
Magnet wire loop
+
–

Post-Test

Answer the questions below and write your answers in the blocks. Once you answer the questions, use the numbers underneath the block to encode the answer to the bonus question.

1. ____________________ is the movement of electrons through a conductor from a region of high electron concentration to one of lower electron concentration.
2. A battery converts **a.**______________ energy into **b.**_______________ energy.
3. An electric charge can be either **a.** ______________ or **b.** ______________
4. When talking about electricity, we are concerned only with the _________charges.
5. Particles with a negative charge are called _______________.
6. Electricity where the charges are not moving is called ______________ electricity.
7. Electricity where the electrons are moving is called _____________ electricity.
8. A __________________ magnet is always magnetic and the magnetism never turns off.
9. In power engineering, an electrical _________ is a length of metal, usually surrounded by insolating sheath that is used to conduct electricity.
10. Point your thumb in the direction of the electric current. Curl your fingers in the direction of the magnetic field. You are following the _________ _______ rule.
11. Nature's most efficient motor known to man is found at the base of each __________.

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3a.	P	O	S	I	T	I	V	E				
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Bonus Question: What did the baby light bulb say to the mommy light bulb?

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3a. 2b 5 3b. 2a. 1 5 2b. 9 4 7 7 6 4 8 10 9
4 7 7 6

Item	**Quantity (10 students)**
Batteries	10
Magnet wire	1.5 ft per student
Disk magnets	10
Aluminum foil	1 roll
Alligator clips with appropriate wires	20
Magnet compass	10
Iron filings	1 jar full
Large paper clips	20
Bar magnets	20
Fine grit sand paper	2 square inch sheet
Plain sheets of white paper	10
Masking tape	1 roll
Wire cutters/needle pliers 1	1
scissors	1