Science Unit: *The Electron: Conductivity and Chemistry*
Lesson 7: *Building a Simple Motor*

School Year:	2011/2012
Developed for:	Trafalgar Elementary School, Vancouver School District
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Grade level:	Presented to grades 6 and 7; appropriate for grades 5 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	This lesson is a modification of Lesson 2, Series and Parallel Circuits, in the Electricity with Applications science unit, Scientist in Residence Program. http://scientistinresidence.ca/science-lesson-plans/electricity-with-applications/ This unit assumes that the class has had a lesson on circuits. At the very least, students should have been exposed to the following simulation: http://phet.colorado.edu/en/simulation/faradays-law

Objectives

1. To learn how electromagnets can be used to create a motor.
2. To learn what factors affect the speed of an electric motor.

Background Information

For many jobs in our society, we require things to rotate in order to do work for us. Examples are: in a washing machine, motors pump water by turning a pumping screw, and move the agitator by pushing and pulling a connecting rod. In this lab we use the force created by the electromagnets to cause a rotation. To create a rotation in a motor, two electric magnets are created that are misaligned. Magnetic forces will tend to align the electromagnets. This is what causes rotation in the motor. Once the electromagnets are aligned, however, they stop rotation. In order to have continuous rotation, the movement of the electromagnets causes a switch that once again mis-aligns the electromagnets.

Vocabulary

Electromagnet: A type of magnet in which the magnetic filed is produced by the flow of electric current. The magnetic field disappears when the current is turned off. The simplest electromagnet consists of a coil of insulated wire; such an electromagnet can be made stronger if the coil is wrapped around an iron core. The strength of magnetic field generated is proportional to the amount of current.

Materials

- 22 or 24-gauge wire (to be coiled by the student)
- AAA battery (to form the coil)
- needle nose pliers
- razor blades
- C (or D) battery

- neodymium magnets
- tape (electrical or hockey sock)
- 16-gauge bus wire, shaped (to connect the coil to the battery)

In the Classroom

Introductory Discussion

1. What is a motor? What is an electric motor?
   - Review the connection between electricity and magnetism, and that magnets tend to align themselves. Recall that a circuit is created when charge from an electric power source (*e.g.*, battery or generator) is allowed to flow through conducting elements (such a wire or metal) back to its source.
   - Confirm the understanding of what is an electromagnet.
2. Working in pairs or groups of three, students will be provided with the required materials for making their own electromagnetic motor.

Safety Concerns: Be very careful with the razor blades.

Science Activity

Activity Title: Electromagnet motor

Purpose of Activity: To demonstrate an understanding of how electromagnets and motors work.

Methods and Instructions:
Set-up prior to experiment: Provide each group with: a fully-charged C battery; an uncharged AAA battery, 1m of 22 gauge magnet wire, a neodymium magnet, and two pieces of the shaped 16 gauge bus wire. Students will work in pairs and, using the instructions below, build their own electromagnet motor.

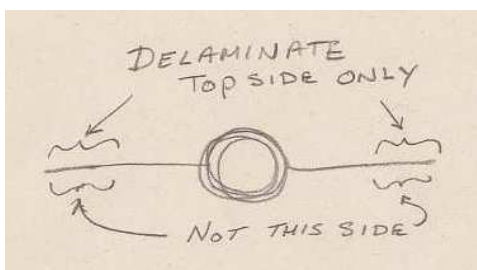
1. Start by winding the armature, the coiled part of the motor that moves. Coil the 22-gauge wire around the AAA battery, leaving 3-5 cm of wire uncoiled on either end. The diameter is not critical, but should be related to the wire size; thin wire requires a small form and thick wire requires a larger form. The length of wire provided should allow for 25-30 turns around the coil form. Don't try to be too neat---a little randomness will help the bundle keep its shape. The coil should end up looking like the picture below.

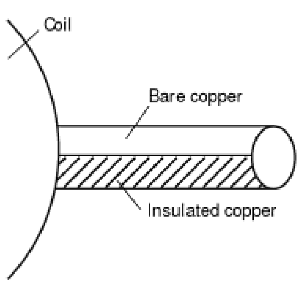
2. Carefully pull the coil off the form, holding the wire so it doesn't spring out of shape. To make the coil hold its shape, wrap each free end of the wire around the coil a couple of times. Make sure the new

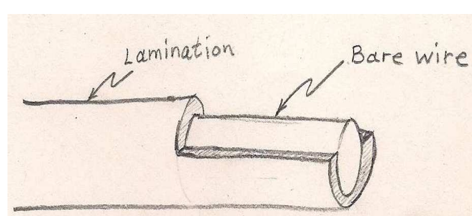
binding turns are exactly opposite each other so the coil can turn easily on the axis formed by the two free ends of wire, as shown below.

3. It's important that the coil be kept together and symmetric, that you have the two ends of the wire anchored well and aligned in a straight line, to form a good axle.

4. Hold the coil at the edge of a table so that the coil is straight up and down (not flat on the table) and one of the free wire ends is lying flat on the table. Using a razor blade, carefully remove the lamination from ***only the top side of this uncoiled arm***. Be careful to leave the bottom half of the wire with the enamel insulation intact. The top half of the wire will be shiny bare copper, and the bottom half will be the colour of the insulation, as shown in the figures below. Do the same thing to the other free wire end, making sure that the shiny bare copper side is facing up on both wires. *(The idea behind this is that the armature is going to rest on two supports made of bare bus wire. These supports will be attached to either end of a battery, so that electricity can flow from one support to another through the armature. But this will only happen when the bare half of the wire is facing down, touching the supports. When the bare half is facing up, the insulated half is touching the supports, and no current flows. In effect, we have created an electromagnet that is on half of the time and off the other half of the time. When it is on, it will try to align with the permanent magnet; when it is off, it is free to spin.)*







5. Make the axle supports. These are simple loops of wire that hold up the armature and allow it to spin. They are made of bare 16-gauge bus wire so that they can transmit electricity to the armature. These are to be shaped in advance and given to the students to tape to either side of the C battery. Place them

symmetrically on either side of the battery, as shown below, so that they can hold the armature and allow it to spin freely.

6. Carefully place the coil into the 16-gauge bus wire supports. Be careful to keep the arms of the coil symmetric, so that it can spin easily. Make sure that the support arms are positioned so that the bare arms of the coil can make contact with the supports. And leave just enough room between the magnet and the coil to place your magnet so that it will not interfere with the spinning coil. This step, of positioning the supports and the coil, is quite tricky – don't get discouraged if it takes a little while.

7. Place a neodymium magnet onto the C battery and directly under the center of your coil. The setup should look like the image below.

8. Gently give your coil a spin. You may have to try spinning it either direction – the coil will only spin in one direction. If everything is well-aligned, your coil should begin spinning continuously.

9. If the motor still doesn't start, carefully check the electrical connections. Is the battery connected so one support touches the positive end and one support touches the negative end? Is the bare copper half

of the armature wire touching the bare support wires at the bottom, and only at the bottom AND on both sides at the same time? Does the armature spin freely? If all of these things are okay, your little motor should spin at a relatively fast rate.

10. Students should sketch a diagram of the circuit into their logbooks, showing clearly how current flows in the circuit.

Closure Discussion

1. How could we make this kind of motor without a permanent magnet? How could we make the coil spin faster? How could we make the coil spin in the opposite direction? How might we take advantage of this conversion of one type of energy into another (electrical to mechanical or vice versa)?

2. How might this type of motor be used in the real world?

References

1. Filed, Simon Quellen. 2002. Gonzo Gizmos: Projects & Devices to Channel Your Inner Geek. Pp. 35-39. Chicago Review Press, Incorporated: Chicago, USA.

2. <http://scientistinresidence.ca> See Science Lesson Plans, Physical Science, Electricity with Applications, Lesson 2, Series and Parallel Circuits. <http://scientistinresidence.ca/science-lesson-plans/electricity-with-applications/>

3. <http://scientistinresidence.ca> See Science Lesson Plans, Physical Science, Electricity with Applications, Lesson 5, Speakers. <http://scientistinresidence.ca/science-lesson-plans/electricity-with-applications/>

4. <http://www.youtube.com/watch?v=oRSU4FnUSrA> A short youTube video, title “Simple Toy Motor Project” which shows an electrical motor, of the same type built in this lesson, working.

5. <http://www.youtube.com/watch?v=it_Z7NdKgmY> A short youTube video, title “How to build a simple electric motor, plus how it works” which provides a very nice but brief overview of the construction and principle of operation behind the same type of motor described in this lesson.

6. <http://en.wikipedia.org/wiki/Electric_motor> 'Electric motor' entry on Wikipedia [Describes operating principles, use and styles of motors, and performance metrics.]