Experiment Module 2
Electric Motors

Objective/Introduction
A coil of wire with a current produces a magnetic field. The coil then acts like a small magnet. When the coil is near a stronger magnet, the coil will move to align with the stronger magnet due to the magnetic force of the stronger magnet. In a motor, the current in the coil switches direction over and over again, so the coil keeps spinning as it tries to align with the magnetic field. In this experiment you will build a simple electric motor.

Standards
Benchmarks 2061 Project (see References section to link to the online standards):

- At the end of 8th grade, students should know that
  - Electric currents and magnets can exert a force on each other.

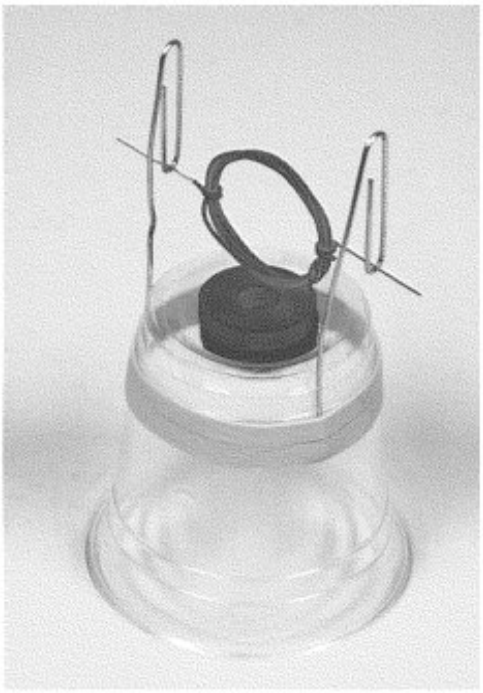
- At the end of 12th grade, students should know that
  - magnetic forces are very closely related to electric forces and are thought of as different aspects of a single electromagnetic force. Moving electrically charged objects produces magnetic forces and moving magnets produces electric forces.
  - the interplay of electric and magnetic forces is the basis for many modern technologies, including electric motors, generators, and devices that produce or receive electromagnetic waves.
  - electric currents in the earth's interior give the earth an extensive magnetic field, which we detect from the orientation of compass needles.

Materials Needed

- 1 meter (3 feet) of 22-gauge or 24-gauge solid-core insulated wire
- 2 disk magnets
- 2 insulated test cables with a clip on each end (2 pieces of above insulated wire can also be used)
- 1 plastic cup
- 2 large rubber bands
- 2 jumbo size (2-inch) paper clips
- 1 D-cell battery
- wire strippers
- waterproof marking pen

Procedure
1. Take the 1-meter piece of insulated wire. Starting about 6 cm from the end of the wire, wrap it seven times around the D-cell battery to form a coil. Wrap the ends of the wire a couple of times around the coil to hold it together.

2. Use the wire strippers to remove the insulation from the two ends of the coil.
3. Straighten the larger loops of two paper clips.
4. Turn the cup upside down and place a magnet on top in the center.
5. Attach another magnet inside the cup, directly beneath the original magnet. This will create a stronger magnetic field as well as hold the top magnet in place.
6. Put two large rubber bands around the base of the cup.
7. Insert the straightened paper clips into the rubber bands, so they stand upright over the bottom of the cup.
8. Rest the ends of the coil in the cradles formed by the paper clips.
9. Adjust the height of the paper clips so that when the coil spins, it just clears the magnets.



10. Adjust the coil and the clips until the coil stays balanced and centered while spinning freely on the clips. Good balance is important in getting the motor to operate well.
11. 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.
12. Attach one of the clip cables to each paper clip just above the rubber bands. You may need to readjust the clips to make sure the coil still spins freely.
13. Hold the other ends of the clip leads against the two poles of the D-cell battery. If the coil is well balanced on the clips, it will rotate to a near horizontal position. The magnetic field created by the electric current in the coil aligns itself with the magnets.
14. The coil may not continue to turn, because the current continues to flow through the coil its magnetic fields stays aligned with the magnets. To get the coil to continue rotating, the current should be turned off when the coil is aligned with the magnets. This can be done by coating part of one of the bare wire ends of the coil.
15. Remove the coil from the paper clips. Hold the coil vertically. Use the permanent marker to paint the TOP HALF of **one** of the two end wires. Allow the ink to dry for a few seconds, and apply a second coat. Allow several seconds again for the ink to dry, and then hang the coil on the paper clips again.
16. Connect the D-cell battery again, and give the coil a gentle spin.

Trouble Shooting

If the motor does not keep spinning on its own

- Check the coil assembly and make sure it is balanced.
- Check that the projecting end has been painted with black pen as described in step #15
- Check that the coil and magnet are close to each other but not touching.
- Try adjusting the distance separating the cradles. There should be constant contact between the coil and cradles as it spins.

Extending the Discussion to Sea Perch:

This very simple motor is related to the motors you have attached to your Sea Perch. If you opened a motor up you would find coils of wire and magnets. When the wires are connected to a power supply the motor would spin.

Take the motor you have built in the experiment and turn your battery around. This runs the current in the opposite direction through the loops of wire. What happens to the direction in which the loop spins? You will want to put your motors in reverse at times. Later you will learn how to build a circuit where you can change the direction of the current.

Additional Resources

There are many resources online for building simple motors. Your might also enjoy another electromagnetic project building speakers out of paper cups, wires, and magnets.

For a very simple introduction to what Oersted observed about the relationship between electric fields and magnetic fields. Place a compass close to a wire. Connect the wire to a power supply and see that the compass needle is deflected. Change the position of the compass. Notice it is deflected in a different direction.

Additional Resources to Share with Students

- **If you would like to learn more about electric motors, please visit the following URL: *http://en.wikipedia.org/wiki/Dc_motor***
- **For some additional information, try the following sites to engage in some interactive simulations http://phet.colorado.edu/en/simulation/faradays-law and http://phet.colorado.edu/en/simulation/magnet-and-compass**

References

- Science Fun. (2010). *Build a Motor.* Retrieved on September 3, 2010 online, from http://www.scifun.org/homeexpts/BuildAMotor.htm
- Science Buddies. (2010). *Building an Electric Motor.* Retrieved on September 3, 2010 online, from http://www.sciencebuddies.org/mentoring/project_ideas/Elec_p009.shtml