SUMMARY:
Learners will explore electromagnetism.

GRADE LEVEL:
This activity has been used successfully with 1st to 3rd graders as well as college undergraduates.

TIME:
This activity takes approximately 45 minutes with 1st to 3rd graders. Depending on learners' prior experience this time may need to be extended or shortened.

SUBJECTS:
Physical Science (electromagnetism), Science and Technology

LEARNER BACKGROUND:
Learner should know how to make a simple circuit (Light Me Up activity), what a magnet is (Stuck On Me activity) and how to make an electromagnet (Pick Me Up activity).

LEARNING OBJECTIVES:
Completing this activity will allow learners to:
- ✓ understand how a simple motor works

Discover Question:
What makes this (electric) motor move?

Background:
This activity has learners explore how a to construct a simple motor. This activity is a perfect wrap-up after exploring simple circuits (Light Me Up activity), magnets (Stuck On Me activity) and electromagnets (Pick Me Up activity).

Basically a motor is a simple circuit that contains an electromagnet that interacts with a magnet. A motor works by using magnetic attraction and repulsion between a moving magnet and a stationary magnet. One of these magnets is always an electromagnet which is turned on and off (or has its polarity - magnetic field direction - switched) at just the right moment to keep the motor spinning.

The motor in this activity is a direct current (DC) motor. Learners that are more familiar with electronics can be challenged to find out how alternating current (AC) motors work and possibly try to build one.

The educator needs to facilitate the sharing of observations and ideas. Try to avoid answering questions directly. Instead, ask questions like what have you tried? What do you notice? What else could you try? These types of questions encourage further exploration.

Materials:
- ❑ Each learner should receive
  - Two (2) #3 safety pins (these are the large 2 inch ones)
  - 36 cm of 24 or 25 gauge enamel wire (21 AWG wire is too thick and 28 AWG starts getting too thin)
  - Motor Making Jig - this is basically a ½ inch diameter dowel, an emory board (for sanding the enamel of part of the wire) and a small board with a groove cut in it for the dowel to lay in. I have used markers with good results when I did not have a Jig to use.
- ❑ Each learner should also have
  - A permanent magnet and a battery (C size works well)
  - ✓ If you have already done the Light Me Up and Stuck On Me activities then learners will already have these objects.
- ❑ Each group of four learners should have the following community supplies:
  - Masking tape, Scissors and extra Batteries

Resources and Handouts:
None needed.

Procedure:

1. You can introduce the activity any way that is appropriate for your class. I have had a working motor that I showed to learners to get them excited. (It is also invaluable for the educator to have constructed a motor prior to class to gain an appreciation for how to do so.)

2. Hand out enamel wire, safety pins and motor making jigs. If learners have completed the Light Me Up and Stuck On Me activities they should already have the additional supplies they need.

3. This activity is much more technological in that learners have to follow directions. However, when problems do occur try to ask questions that are open-ended "What have you tried?" "What else could you try?" "What do you notice about your motor?"

4. Use the enamel wire. Leaving a 3 cm tail on either side, wind the wire into a coil with a diameter slightly larger than 1 cm (½ inch works well). Wrap each tail a couple times around the coil to hold the coil together. The tails should be on opposite sides of the coil (180° apart) pointing in opposite directions. The wooden spool allows you to coil and make the finish wrap using the slots cut in its sides.

5. Remove the enamel from the top edge of both tails. If you place the spool with the wire coil on it in the groove of the wooden base you can scrape the enamel off of both sides using the sandpaper board.

6. Secure the safety pins to the battery ends with tape or a rubber band. Place the magnet on top of the battery and position the wire coil through the hinged ends of the safety pins that should be sticking above the magnets.

MODIFICATIONS/ ADAPTATIONS:
Older learners can be given a challenge of trying to design a circuit that would indicate when the motor is on.

NOTE: See the Move Me Baby! explorer instruction page for pictures.

IMPORTANT: Only remove the enamel from ½ of the wire's circumference. Removing the enamel from the edge in-line with the coil allows the coil to switch on and off being an electromagnet at the right position to interact with the permanent magnet. This is the only "tricky" part and is the cause of most motor troubles.

7 Once learners start having success encourage sharing of ideas (if needed). Encourage learners that have discovered one solution to the question to find other solutions.

8 **Troubleshooting**:

- ❑ If your wire just rocks adjust the balance. Balance is crucial so try bending/straightening the coil and tails. You can also add a small piece of tape to the coil to adjust the balance.
- ❑ If your wire coil does not spin, make sure that enough enamel is removed from the tops of both tails. You may have to scrape the wire with the sandpaper some more.
- ❑ If your wire coil does not spin, make sure that the enamel is removed from just one side of each tail and that it is the same side. NOTE: If you took off too much enamel, you can use a permanent marker to replace the missing enamel. Just draw a mark where you want to replace enamel.

Safety Considerations:

- ❑ Drop any thing that gets hot! Then try again when it is cool.

Assessment Ideas:

- ❑ Can the learner make the motor work?
- ❑ Can the learner explain what part of the motor is the electromagnet and what it does?

EXTENSIONS:

- ✓ Can you make the motor spin faster?
- ✓ Can you make the motor spin slower?
- ✓ Build motors with different numbers of coils. What do you notice about how they work?
- ✓ Take apart equipment that has motors in it. Old disk drives are good as well as old VCRs etc.

Internet Resource:

This is part of a NatureShift unit on electricity and magnetism that can culminate in controlling the Mars Rover telerobot.

The following sites are good and will give you more background information.

A good description of how an electric motor works:
http://www.howstuffworks.com/motor.htm
Motorola's tutorial on how an electric motor works:
http://mot-sps.com/motor/mtrtutorial/prin/index.html
Directions for building a very similar simple electric motor:
http://members.tripod.com/simplemotor/simple.htm

You may find that Ask Jeeves (http://www.askjeeves.com) is a good source of additional explanations and diagrams about "how to build an electric motor".

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