Build the Simplest Electric Motor

Introduction

Challenge your students to build a simple motor with only three components: a battery, a piece of copper wire and a strong magnet.

Concepts

- Electricity
- Magnetic field
- Energy conversion
- Lorentz force

Materials

Battery, 1.5-V, AA
Copper wire, insulated, 18-gauge, 30 cm
Magnet, neodymium, small cylindrical
Pliers (optional)
Tape (optional)
Washers (optional)
Wire cutter/stripper

Safety Precautions

While 1.5-volt batteries are not harmful, small shocks are possible. Do not allow the wire to spin on the battery for longer than 15 seconds. Since there is very little resistance in the wire, the battery and wire can become very hot if connected for a long duration. Care should be taken when cutting, stripping and shaping the wire. The pointed ends of the wire may be sharp. Use caution when handling the neodymium magnets. These magnets are very strong and may quickly snap together and pinch skin. The magnets are also fragile and may shatter if dropped or if they hit another object too hard. Keep the magnets away from computers and other electronics. Wear safety glasses. Please follow normal laboratory safety guidelines.

Preparation

1. Cut a 30-cm piece of copper wire.
2. Strip 2–3 cm of insulation from each end of the wire.

Procedure

1. Attach the magnet to the negative terminal of the AA battery.
2. Shape the copper wire so a complete circuit is made from the positive terminal of the battery to the magnet at the other end (see Figure 1 for examples). Cut the wire shorter if needed. *Note:* If making a V-shaped or heart-shaped wire, the insulation must also be cut away at the point of the V. See the *Tips* section.

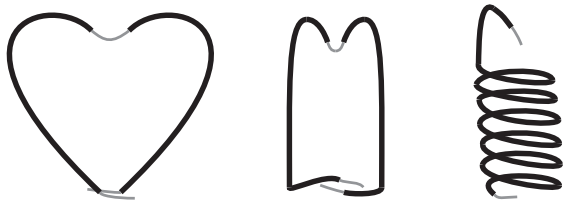

Figure 1.

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3. Set the battery-magnet apparatus vertically on a level surface with the magnet on the bottom and the battery centered over the magnet (see Figure 2).
4. *Optional:* Tape one or 2 small (#10) washers onto the positive end of the battery, leaving the terminal exposed. This will help to keep the wire from rotating off the battery.
5. Carefully lower the shaped copper wire onto the battery-magnet so the wire balances and bare wire makes contact with the positive terminal at the top and the magnet at the bottom (see Figure 3).
6. When the system is balanced, the wire should start to spin. If it doesn't, check the contacts and then gently nudge one side of the wire to begin the rotation.

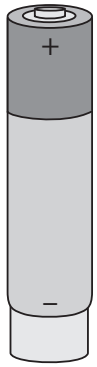

Figure 2.

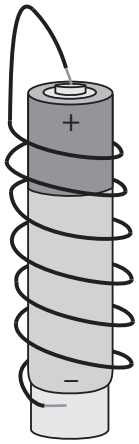

Figure 3.

Disposal

Separate the magnets from the batteries and store at room temperature for future use. Please review all federal, state and local regulations that may apply before disposing of dead batteries.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS2 Motion and Stability: Forces and Interactions
PS2.B: Types of Interactions

Disciplinary Core Ideas: High School
HS-PS2 Motion and Stability: Forces and Interactions
PS2.B: Types of Interactions
HS-PS3 Energy
PS3.A: Definitions of Energy
PS3.C: Relationship between Energy and Forces

Science and Engineering Practices
Asking questions and defining problems
Planning and carrying out investigations
Constructing explanations and designing solutions

Crosscutting Concepts
Cause and effect
Energy and matter
Stability and change

Tips

- Bending the copper wire into the desired shape with the proper contacts is the most challenging part of the activity. Coiling the wire around a thick marking pen or highlighter will help make smooth turns. Pliers may also be used to bend the ends of the wire for good contact with the magnets and battery.
- If making a V-shaped wire, the insulation must be cut away at the point of the V. This should be carefully done by an adult with a sharp utility or craft knife.
- Two neodymium magnets may work better than one for some wire designs.
- Bare copper wire may be used to create the motor in order to save time stripping the insulation or to avoid cutting away the insulation in the middle of a V-shaped wire. Use caution as the wire will get hot if allowed to spin on the battery for longer than 15 seconds at a time. Students should wear heat-resistant gloves to remove the wire from the battery.
- A video of this demonstration, *Build a Simple Motor* is available online at www.flinnsci.com in Teacher Resource Videos, part of the Physical Science Minute Video Series.

Discussion

Hans Christian Oersted (1777–1851), a Danish physicist, was performing an experiment in 1820 when he noticed that whenever an electric current from a battery was switched on or off, a nearby compass needle was deflected. Through additional experiments, Oersted was able to demonstrate the link between electricity and magnetism. The following year, English scientist

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Michael Faraday (1791–1867) created a device that produced "electromagnetic rotation." This device is known as a homopolar motor since the motor requires no commutator to reverse the current.

A motor converts electrical energy to mechanical energy. The simple motor in this activity changes the electrical energy output by the battery to mechanical energy as the copper wire is set into rotational motion. Any current-carrying wire produces an associated magnetic field. The electrons in the wire are subjected to a magnetic field and experience a force—referred to as the *Lorentz force*—that is perpendicular to both the magnetic field and the direction of movement. At some point along the length of the wire, the electrical current is not parallel to the magnetic field. The resulting Lorentz force is tangential and induces a torque on the copper wire. This torque causes the copper wire to spin.

Acknowledgment

Special thanks to Mike Shaw, Stokes Early College High School, Walnut Cove, NC, for providing the idea and the instructions for this activity to Flinn Scientific.

Materials for *Build the Simplest Electric Motor* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP5666	Neodymium Magnet
AP1423	Batteries, AA, Alkaline, 1.5-V
AP4715	PVC-Insulated Copper Wire, Red
AP4716	PVC-Insulated Copper Wire, Black
AP4717	PVC-Insulated Copper Wire, White
C0148	Copper Wire, Bare, 4 oz.
AP5898	Crimping Tool

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