Simple Iron Nail Motor

Introduction

Build the "simplest" motor from only four components: a battery, a magnet, a piece of wire, and an ordinary iron nail.

Science Concepts

- Electricity
- Magnetic field
- DC Motors
- Torque

Materials

Battery, D, AA or C-cell
Knife or wire strippers (to strip wire sheath)
Magnet, Neodymium, small cylindrical
Nail, iron, 9 cm (3″) with flat head
Tape, transparent or electrical
Wire, insulated copper, 25 cm

Safety Precautions

The materials in this activity are considered safe. Use caution when handling a knife to strip the insulation off the wire. Wear safety glasses and follow all normal laboratory safety guidelines.

Preparation

1. Obtain 25 cm of insulated copper wire.
2. Use a knife or wire strippers to carefully remove about 1 cm of insulation from each end of the insulated wire to expose the bare copper wire.
3. Tape one end of the wire to the *negative* terminal (flat bottom) of a D-cell battery. Make sure the exposed metal wire makes solid contact with the terminal of the battery.

Procedure

1. Obtain the battery with wire taped to the negative terminal, a Neodymium magnet, and an iron nail.
2. Place the head of the nail on the Neodymium magnet. Make sure the nail is centered on the cylindrical magnet so the nail–magnet unit will be balanced when it spins (see Figure 1).
3. Hold the battery with the *positive* terminal (knob side) pointing towards the ground. Touch the tip of the nail to the positive terminal. The magnetized iron nail will "stick" to the terminal of the battery and hang vertically (see Figure 2).

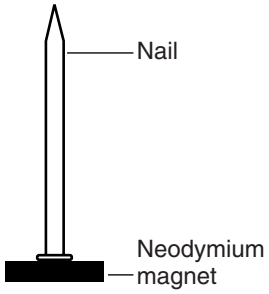

Figure 1.

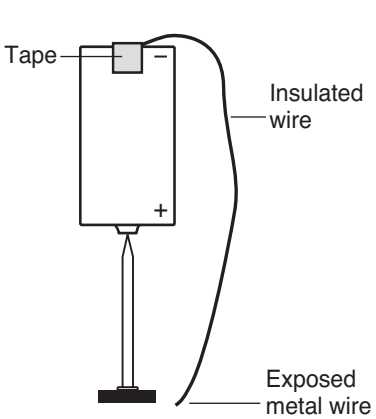

Figure 2.

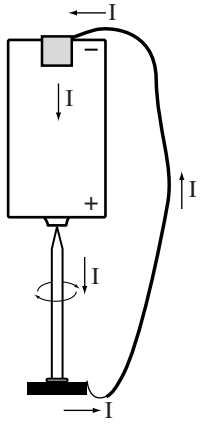

Figure 3.

4. Keeping the battery and nail vertical, lightly touch the exposed metal wire to the side of the magnet (see Figure 3). The magnet and nail should begin to spin. If the magnet does not spin right away, it may need a small initial twist to "activate" it. *Note:* Lightly touching the magnet with the side of the metal wire instead of the pointed tip provides more surface contact and a smoother surface which limits the amount of friction that may slow down the motor.
5. Continue to lightly touch the side of the magnet as it bounces and spins, and observe the "simplest" motor pick up speed! *Caution:* Prolonged use will cause the wire to get very warm and the increased speed may cause the nail and magnet to "fly off" the battery. Lightly touching the wire to the magnet until the nail begins to spin and then removing

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the wire will minimize this risk. As the nail slows it spin, the wire can briefly be applied to the magnet again.

Tips

- Insulated wire is also known as annunciator wire, or bell wire. Any insulated wire will work for this demonstration. Using wire with alligator connector cord ends will also work, but the alligator clip ends may be too large or rigid to maintain a smoothly operating motor. The magnetized nail may bounce off the battery terminal too far and prevent the motor from spinning continuously.
- Flip the magnet and the motor will spin in the opposite direction.
- Using a flat head ferromagnetic screw (such as a drywall screw) may allow easier detection of the spinning motion.
- Use Flinn's small Neodymium Magnet, Catalog No. AP5666, for best results.

Discussion

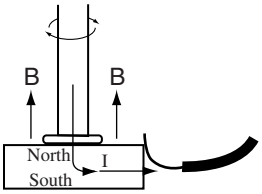

Figure 4.

For this simple (homopolar) motor, direct electric current (DC*)* travels through and over the surface of the permanent magnet when the wire makes contact with the side of the magnet (Figure 3). Electric current travels horizontally through the magnet and the magnetic field of the magnet is vertical. The interaction between the electric current (*I*) and the magnetic field (*B*) yields a force that is perpendicular to both the electric current and the magnetic field. The direction of the force can be determined by applying the "Right-Hand Rule." The "Right-Hand Rule" states that when the fingers on the right hand point in the direction of the current, and the palm of the right hand points in the direction of the magnetic field, then the thumb on the right hand will be pointing in the direction of the force. Therefore, the force produced by the interaction between the magnetic field and the electric current represented in Figure 4 is horizontal and perpendicular to the plane of the page. Since this horizontal force is off-center from the axis of rotation of the magnet–nail combination, a *torque* is produced. A torque is a "rotational" force that is the result of a force acting at some distance away from an axis of rotation. The force produced by the interacting electric current and magnetic field "pushes" on one side of the magnet, near the edge, and causes the magnet and nail to spin in a clockwise direction (when observed from above). The sharp point of the nail and the smooth surface of the battery terminal minimize frictional forces that might otherwise prevent the nail from spinning.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Process: Grades K–12
Evidence, models, and exploration
Content Standards: Grades 5–8
Content Standard B: Physical Science, understanding of motions and forces, transfer of energy
Content Standards: Grades 9–12
Content Standard B: Physical Science, motions and forces, conservation of energy

Reference

Chiaverina, C. *The Physics Teacher.* 2004, Vol. 42, p 553.

Materials for the *Simple Iron Nail Motor* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1425	Battery, D
AP5417	Annunciator Wire (Bell Wire)
AP5666	Neodymium Magnet
I0032	Nails, Iron

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.