Real-World Lab

How It Works

Building an Electric Motor

Preparing for Inquiry

Key Concept A motor is a device that converts electrical energy into mechanical energy.

Skills Objectives Students will be able to
- make a model of an electric motor;
- infer how the motor can be used to do useful work.

Time 45 minutes

Advance Planning Construct a motor yourself to make sure the materials you have available are appropriate and functional. Test the batteries to be certain they are strong enough to operate the motor.

Alternative Materials If film canisters are not available, use test tubes, glue sticks, thick markers, or any cylinder that is 1.5–3 cm in diameter as a guide for wrapping the coil.

Guiding Inquiry

Invitation Ask students to give examples of electric motors. *(Samples: Remote control model cars, motors in electric appliances such as refrigerators or vacuum cleaners, electric clocks)* Point out that most electric motors are very similar, even though they may perform very different functions.

Introducing the Procedure

- Show students how to wrap the magnet wire around the film canister.
- Demonstrate sanding the ends of the wire. For best results, hold the coil edgewise while sanding off the lower half of the insulation from one end of the wire.
- The ends of the coil wire are sharp; students must be careful not to poke themselves. If coil is left on the paper clip supports for more than about 10 seconds, it may become very hot.

Troubleshooting the Experiment

If students have difficulty getting their motor to operate, try the following
- Check both ends of the wire to see that one end has all the insulation sanded off and the other has half the insulation sanded off.
- Check the balance of the coil. If it has more weight on one side, it will not spin freely.
- Make sure the paper clips make firm contact with the D cell.
- Try the coil on another group's apparatus.
- Move the paper clips downward so the coil is closer to the permanent magnet.
- Lift the coil, reverse its connections, then set it back on the supports.
- Substitute a stronger permanent magnet.

Analyze and Conclude

1. Current flows when both uninsulated ends of the wire are in contact with the paper clips. Current does not flow when the unsanded hal of the wire is in contact with the paper clip.
2. The current-carrying wire produces a magnetic field. The field is strong because the wire is looped into a coil like a solenoid.
3. When the coil becomes magnetic, it is eithe pulled or pushed by the force of the permanen magnet.

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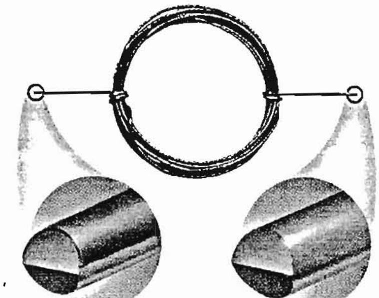
Building an Electric Motor

What does an electric trolley car have in common with a food blender, a computer disk drive, and a garage door opener? At first glance, these things may appear to be unrelated, but each one contains an electric motor. Electric motors are devices that convert electrical energy into motion. In this lab, you will build an operating electric motor.



Bottom half of coating removed *Uncoated wire*

Problem

How does an electric motor operate?

Skills Focus

making models, inferring

Materials

D cell
2 large paper clips
permanent bar magnet
3 balls of clay
empty film canister
pliers
sandpaper
2 insulated wires, approximately 15 cm each
enamel-coated wire, 22–24 gauge, approximately 1 meter

Procedure

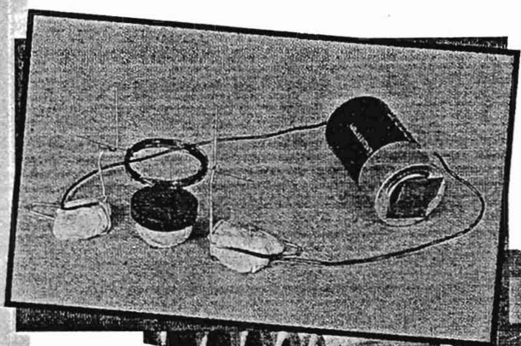
1. Wrap about 1 meter of enamel-coated wire around a film canister. Leave approximately 5 cm free at each end.
2. Remove the film canister and wrap the two free ends three or four times around the wire coil to keep it from unwinding.
3. Use sandpaper to scrape off all the enamel from about 2 or 3 centimeters of one end of the coil of wire.
4. Scrape off *half* of the enamel from about 2 or 3 centimeters of the other end of the wire. To do so, hold the coil edgewise and sand off the bottom half. See the illustration above.
5. Bend two paper clips as shown in the photo at the right. Hold them down with clay.
6. Place the free ends of the wire on the paper clips. Make sure the coil of wire is perfectly balanced. Adjust the paper clips and wire so that the coil can rotate freely.
7. Use clay to hold a permanent magnet in place directly below the coil of wire. The coil needs to be able to rotate without hitting the magnet.
8. Remove the insulation from the ends of two insulated wires. Use these wires to attach the paper clips to a D cell.
9. Give the coil a gentle push to start it turning. If it does not spin or stops spinning after a few seconds, check the following:
   - Are the paper clips in good contact with the D cell?
   - Will the coil spin in the opposite direction?
   - Will the coil work on someone else's apparatus?

Analyze and Conclude

1. How is the flow of current through the coil related to how you sanded the ends of the enamel-coated wire in Steps 3 and 4?
2. A magnetic field is produced when current flows through the circuit. Explain why.
3. Why does the coil of wire rotate?
4. What was the purpose of removing all the insulation from one end of the wire but only half from the other end?
5. Why did the coil have to be balanced in Step 6?
6. What factors did you find that affected the motion of the coil?
7. **Apply** Your motor is capable of producing motion, but it is not capable of doing much useful work. What are some ways you could modify your motor to make it capable of doing useful work?

Design an Experiment

You have demonstrated the principles of a simple electric motor. List three factors that may affect the motion of the coil. Design experiments to test these factors. What will happen to the motor if the connections to the voltage source are reversed? Try it and find out.



Safety

Caution students not to poke themselves with the sharp ends of the coil wire. If coil is left on the paper clip supports for more than about 10 seconds, it may become very hot. Review the safety guidelines in Appendix A.

Program Resources

- **Teaching Resources** Chapter 3 Real-World Lab, pp. 85–87

4. When both uninsulated ends are in contact with the supports, the current flows and the coil rotates. If the current did not change, the coil would only be able to turn half way. The insulated par of the wire turns the current off, so the coil is allowed to continue turning. As i turns, the uninsulated parts again complete the circuit. This allows curren to flow and the coil turns completely around.
5. If the wires are not balanced, the coil will move unsteadily. This causes one o both wires to lose their connection in th circuit.
6. The direction of the current determined which way the coil moved.
7. Students might suggest adding a foar or cork cylinder at the end of the coil wire and attaching a string so that as th motor turns, it lifts a paper clip or other light object. Other attachments would allow the machine to perform other tasks. Students might suggest that the amount of work the motor performs ca be increased by making it more rugged, or larger. Other improvements might include using more cells.

Extending the Inquiry

Design an Experiment Students' plans should identify factors that may affect the rotation of the coil, such as the voltage, whether the coil is balanced, an whether the ends of the wire are insulated. Students should describe experiments to test these variables. Before students perform any work in th lab, check their plans for safety.

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