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ACTIVITY : 1 HR

Round and Round with Simple Motors

Students forge a hypothesis about how motors make things move, and then build a simple electric motor using wire, a magnet, and a D cell battery to explore how motors convert electrical energy into mechanical energy.

GRADES

6 - 12+

SUBJECTS

Physics

CONTENTS

5 Images, 2 PDFs

OVERVIEW

Students forge a hypothesis about how motors make things move, and then build a simple electric motor using wire, a magnet, and a D cell battery to explore how motors convert electrical energy into mechanical energy.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/round-and-round-simple-motors/

Program

NATIONAL GEOGRAPHIC PRESENTS ROBOTS 3D

DIRECTIONS

1. Define the term "electric motor."

Tell the class that an electric motor is a device that converts electrical energy into mechanical energy. Magnetism plays an important role in this process. Explain that students are going to build a simple electric motor that they will use in an experiment to test a hypothesis. First, they will participate in some demonstrations about the parts of a motor.

2. Demonstrate that magnets have two poles and that when two magnets are brought together, these poles can cause an object to move.

Show the class two magnets. Ask: *What will happen if these two magnets are brought close together?* (The magnets will be attracted to each other at opposite poles and they will repel each other at like poles.) Demonstrate with the magnets, and have students state their observations. Explain that magnets have two poles, one at either end, north and south. When opposite poles (north and south) are near each other, they are attracted to each other. When like poles are near each other (for example, north and north), they repel each other. To demonstrate, tape one magnet to the back of a small toy car. Use a second magnet to make the car move by holding like poles near one another. Let students try moving the car using the magnets. Ask: *Will the car move if opposite poles are held near one another?* Have a student volunteer demonstrate.

3. Demonstrate the relationship between flowing electricity and magnetism.

Demonstrate that a coil of wire and a nail can act like a magnet when electricity is passed through the wire. Hold up a nail so everyone can see. Ask: *Will I be able to pick up paperclips using this nail? Will it act as a magnet?* Hold the nail to the paperclips to demonstrate that you cannot pick up the paperclips using just the nail. Now, slip the nail into the coil you created before class. Ask: *Will I be able to pick up the paperclips with the nail, now that it is wrapped in a metal coil?* Hold the nail with coil to the paper clips to demonstrate that you still cannot pick up the paperclips. Explain that you are going to turn the nail and the coil into an electromagnet with the help of a battery.

Follow the instructions under Set Up to create the electromagnet before class. In class, place a D cell battery in a D cell battery holder. Tape one end of the wire to each of the terminals on the battery holder. Ask the class to predict what will happen when you hold the nail, wrapped in a coil and connected to the battery, near the paperclips. Hold the nail near the paperclips. Explain it now picks up the paperclips because you created an electromagnet by adding electricity. The nail is magnetized because electrical current is flowing through the coil. Be sure to disconnect the wires from the battery so it does not overheat.

4. Explain that electricity and magnetism can be used to create torque.

Explain that torque is a measure of rotational force. Demonstrate torque for the class. Call a volunteer to the front and instruct the student to hold a rubber band at two ends. Insert a plastic spoon into the center of the rubber band and twist it around and around until the rubber band becomes tight and twisted. Ask the class to predict what will happen when you let the spoon go. Let the spoon go. Explain that by applying torsion, the twisting motion, to the rubber band, a rotational force called torque was created. Torque can be used to power mechanical devices, such as robotic arms and mobility systems, where gears are used to regulate the speed at which this torque is applied. Torque is also the rotational force you use when opening a bottle of soda or using a wrench to loosen or tighten a nut.

Tell the class that torque can be created using the forces of electricity and magnetism—the attraction and repulsion exhibited by magnets, which they witnessed earlier. Explain they will be building a simple motor in class that uses these principles.

5. Students develop a hypothesis about motors, listen to safety instructions, and then construct a simple motor to test their hypothesis.

Ask: *How could the motion created by a simple motor be used to provide motion in another object?* Write student suggestions on the board. Continue lines of questioning until the suggestions are boiled down to one testable hypothesis developed as a class. (A hypothesis is provided in the Tips section if you need one.) Explain that students will build a simple motor to use in an experiment to test this hypothesis.

Before handing out materials, tell students they should never connect the positive and negative side of the battery directly to each other using a wire, or anything else that is conductive, as it will create a short circuit and will cause the battery to get very hot and may lead to a painful shock. Also, instruct students to immediately disassemble their project should any part get hot, and then inform the instructor.

Separate students into groups of 2-4. Distribute the How to Build a Simple Motor handout and Scientific Method worksheet to each group. Review the steps on the How to Build a Simple Motor handout with the class, then ask each group to send up one member to collect the items the group will need to build a motor. Have each group fill out the problem/question and hypothesis sections on their Scientific Method worksheet. Students will also record information about building their motor in the process section. Monitor each group's progress as they build. Project the Build a Simple Motor photo gallery, which documents each step on the How to Build a Simple Motor handout, if necessary. Ask questions of each group and assist as needed.

6. Students design an experiment to test their hypothesis using the simple motor.

When all the groups have successfully built their motors, invite them to share their experiences with the rest of the class. Then, working in their groups, have students design an experiment using their motor to test the hypothesis the class developed earlier. Have students draw an experiment setup in their groups, label their drawings, and write a full description of the steps they would take in the procedure part of the Scientific Method worksheet.

7. Have groups share their experiment descriptions, and have a class discussion about the similarities and differences between all the experiments to test the same hypothesis.

Ask: *What did the experiments have in common? What was different about the experiments?* If time allows, set up a show-and-tell where groups can examine the other groups' experiment setup drawings. Invite students to imagine how a motor might power bigger objects, like a robot. (Motors are commonly used to provide motion to the mechanical structures of a robot; wheels to move the robot or an arm to interact with the environment are examples.)

Tip

Familiarize yourself with the activity by doing it yourself beforehand, as it might require a bit of trial and error to get the motor working.

Tip

In some cases, it might be better to provide a hypothesis for students to test. A good example hypothesis is: The more loops in the coil, the faster the coil will spin.

Tip

Project the Build a Simple Motor photo gallery as students build their motors. These photos reflect each step of the process.

Modification

Students can use an iPad/iPhone to digitally document the steps in building the motor and the steps in testing their hypothesis. The photos can then be annotated using a drawing app like Skitch. The finished projects could be published on a blog or used as a multimedia presentation in comparing class results.

Modification

This activity can be done with younger students by shifting the emphasis onto magnetic properties and how they can be used to produce movement. Only do Steps 1-3 of the activity and allow time for students to experiment with magnets afterwards.

Modification

To complete Steps 5-7 with younger students, show the class a pre-built simple motor and how it works. Give them a simplified explanation: The coil rotates because the opposite poles on the electromagnet and the permanent magnet are attracted to each other. Compare this motion to how the car moved when the opposite sides of the magnets were held close to each other. Work as a class to complete Steps 5-7.

Modification

To do this activity in 45 minutes, provide students with the following hypothesis to design an experiment for: The more loops in the coil, the faster the coil will spin.

Informal Assessment

Collect students' Scientific Method worksheet and experiment diagram and description, and evaluate for completeness.

Extending the Learning

Secure any additional materials necessary to conduct one or more of the student experiments, and have students carry out the experiment and complete the rest of the Scientific Method worksheet.

OBJECTIVES

Subjects & Disciplines

- Physics

Learning Objectives

Students will:

- Develop a scientific hypothesis in a collaborative setting
- Build a working model of a simple motor
- Explain how a motor works using electromagnetic forces
- Design an experiment to test a hypothesis

Teaching Approach

- Learning-for-use

Teaching Methods

- Experimental learning

- Hands-on learning

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Analyzing
  - Applying
  - Creating
  - Evaluating
  - Remembering
  - Understanding
- Science and Engineering Practices
  - Asking questions (for science) and defining problems (for engineering)
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Developing and using models
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-3:**
Transfer of energy

NEXT GENERATION SCIENCE STANDARDS

• **Energy:**
HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

• **Energy**:
HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
• **Engineering Design**:
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
• **Engineering Design**:
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
• **Engineering Design**:
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
• **Engineering Design**:
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
• **Motion and Stability: Forces and Interactions**:
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
• **Motion and Stability: Forces and Interactions**:
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
• **Motion and Stability: Forces and Interactions**:
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- 1 1 ¼″ donut magnet per group
- 1 D cell battery holder per group
- 1 D cell battery per group

- 1 Pencil per group
- 1 Rubber band per group
- 1 Sheet of sandpaper per group
- 1 small toy car
- 2 Safety pins per group
- 45-60 cm (18-24 in) of 20-gauge insulated magnetic wire (20-gauge copper enameled wire) per group
- Pencils
- Masking tape
- Nails
- Paper
- Plastic spoon

REQUIRED TECHNOLOGY

- Internet Access: Required

PHYSICAL SPACE

- Classroom

SETUP

Room should be set up so that students can easily work in groups.

Build and test the electromagnet before class. Coil 40 cm (15 in) of insulated magnet wire around a steel nail, leaving two 10 cm (4 in) ends coming off of the nail at either end. Using sandpaper, remove 2.5 cm (1 in) of insulation from each end of the wire coming off of the nail. The nail should be able to easily slip in and out of the coil, while still making good contact with the wire. Test the electromagnet. Place a D cell battery in a battery holder. Tape one end of the wire to each of the terminals, making a circuit. Try to use the nail to pick up small paper clips. When finished testing, disconnect the wires from the battery and slide the nail out of the coil. Drop the nail on the ground to demagnetize it before the class demonstration.

GROUPING

- Large-group instruction

Background Information

Motors turn electrical energy into rotational motion called torque. Many robots use the torque provided by motors to make their wheels spin or to move the jointed parts in their arms or legs. These motors are known as actuators. The simple motor built in class uses a coil that is a temporary electromagnet. This coil gets the force to help create torque from the electrical current supplied by the battery. The donut magnet used in the motor is a permanent magnet, which means it has a north and a south pole that are permanently in place. The forces of magnetism and electricity work in concert to make the coil of the motor spin. The poles of the permanent magnet repel the like poles of the temporary magnet, causing the coil to make a half rotation. After this first half rotation, the insulated portion of the wire (the part that wasn't sanded off) comes in contact with the safety pins, and the flow of electricity stops and allows gravity to pull the coil around until the sanded portion of the wire is again in contact with the safety pins. Electricity again flows, and the process starts again. The strength of the motor or the amount of torque is determined by voltage of the battery and the length of the wire in the coil; the more coils, the stronger the magnetic field, the greater the torque.

Prior Knowledge

["Knowledge of basic circuits", "Knowledge of basic properties of magnets "]

Recommended Prior Activities

- Building Circuits
- Circuits with Friends

Vocabulary

Term	Part of Speech	Definition
inertia	*noun*	property of matter by which it remains at rest or in uniform motion unless acted upon by some external force.

Term	Part of Speech	Definition
insulation	*noun*	any of various substances that block or slow the flow of electrical or thermal currents.
magnet	*noun*	material that has the ability to physically attract other substances.
magnetic field	*noun*	area around and affected by a magnet or charged particle.
magnetism	*noun*	force by which objects attract or repel one another.
motor	*noun*	engine used to create motion.
polarity	*noun*	property of having or being attracted to poles, such as positive and negative electrical charges.
rotation	*noun*	object's complete turn around its own axis.
torque	*noun*	moment of a force or system of forces tending to cause rotation.

For Further Exploration

Interactives

- Interactive Magnet Game

FUNDER

Symantec

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