Curiosity Guide #904
Electric Generators

Accompanies Curious Crew, Season 9, Episode 4 (#904)

Faraday Fun

Investigation #1

Description

This investigation is electrifying!

Materials

- Iron ring weight
- Insulated wire
- Wire cutters
- Wire stripper
- Galvanometer
- 1.5-volt battery
- A friend

Procedure

1) Wrap a coil of insulated wire repeatedly around one side of the iron ring, leaving two loose ends of wire about 6 to 12" long.
2) Strip the ends of wire to expose the copper so that the ends of the wire can be connected to a battery.
3) Repeat with a second length of wire on the opposite side of the iron ring.
4) Expose the wires and connect them to the poles of the galvanometer.
5) Point out to a friend that the wires on either side of the weight are not connected. Then ask what might happen if the loose wires are connected to a battery.

6) Connect the loose wires to a battery. What do you notice? What happens when the current remains closed?

My Results

Explanation

When there is a change in current, like starting and stopping, the needle on the galvanometer moves or is deflected. When the current is on, the needle moves one way. When the current is off, the needle moves the other way. When the current is steady, there is no reaction in the needle. When the primary wire that is connected to the battery gets charged, electric current flows through that wire, creating a magnetic field and magnetizing the iron ring. Starting and stopping the magnetic field induces an electrical current in the secondary wire. This experiment is like the one that Michael Faraday conducted in 1831. In addition to powering on and off an electromagnet, he also discovered that a moving magnet can also induce electricity. That understanding made it possible for Faraday to make the first electric generator.

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Mystery Generator

Investigation #2

Description

What do generators generate? Let's find out!

Materials

- Single-cylinder kit
- 95% alcohol fuel
- Lighter
- Safety goggles

Procedure

1) Assemble the kit according to directions.
2) Fill the burner with alcohol and light the wick.
3) After 30 seconds, gently rotate the wheel. What do you notice?
4) How does the system work?

My Results

Explanation

As the tube heats up, the material inside gets hot and warms up the air in the tube. This causes the gas particles to begin moving faster and strike the piston with greater force. That movement causes the wheel to rotate, which turns the generator and produces electrical energy that lights the LED light. The energy transfers from chemical energy with the burning fuel; to kinetic energy as the gas molecules move more quickly; to mechanical energy with the moving piston and rotor; and finally, to electrical energy that can light the bulb.

More to think about: Have you ever closely observed a machine running? There is usually an electric motor that uses and converts electrical energy into mechanical energy to get things to spin. A generator does the exact opposite by converting that mechanical energy into electrical energy. There are different ways to supply energy into a generator. One way to supply energy is by burning fuels, but you can also do it with wind, water, steam, or your arm power. Great job!

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Cool Coils

Investigation #3

Description

How do you get electric current to flow? What stops the electric current?

Materials

- Electromagnetic Induction Coil Demonstration Kit
- Galvanometer
- 2 or 3 1.5-volt batteries
- 4 alligator clips

Procedure

1) Use two alligator clips to connect the primary coil to the galvanometer.
2) Use two alligator clips to connect the secondary coil to the battery but leave one contact disconnected.
3) Place the secondary coil slightly inside the primary coil.
4) What do you notice when the final contact leads are tapped together?
5) Try sliding the inner coil further inside and tap the contact leads again. What do you notice this time?
6) Insert the iron rod into the inner coil and tap the contact leads again. What do you notice this time?

My Results

Explanation

When the coils are separated and the contacts touch, there is a slight movement on the needle of the galvanometer when the circuit is closed or opened. When the circuit remains closed, there is no visible change. When the secondary coil is pushed all the way inside, the needle moves a tiny bit more. At this point the space in the center is still empty and has no magnetic material. However, when the iron rod is inserted and the contact leads are tapped, the needle deflection is much higher. When the smaller coil that is connected to the battery gets charged, electric current flows through that wire, creating a magnetic field and magnetizing the iron rod. Starting and stopping that magnetic field induces a greater electrical current in the larger coil that causes the galvanometer to deflect more. This experiment is like the one that Michael Faraday conducted in 1831. In addition to powering on and off an electromagnet, Faraday also discovered that a moving magnet can also induce electricity. That understanding made it possible for Faraday to make the first electric generator.

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Power Loops

Investigation #4

Description

Magnetic fields are invisible but very powerful!

Materials

- Wire
- D-cell battery
- Galvanometer
- Wire cutter
- Bar magnet
- Alligator clips

Procedure

1) Wrap three different coils of wire around the battery, leaving a 2-inch leading wire on both ends. One coil will be a single loop, the second will have ten loops, and the third has one hundred loops.
2) Connect the single-loop coil to the galvanometer, using alligator clips.
3) What happens when the bar magnet is quickly thrust in and out of the loop?
4) Repeat the experiment with the ten-loop coil and then the hundred-loop coil. What do you notice?
5) What do you notice if the movement is done slowly versus quickly?

My Results

Explanation

When the magnet moves in a single coil, there is a slight movement of the galvanometer needle. The needle movement is greater with the ten-loop coil and greater still with the one hundred-loop coil. The needle moves one way as the magnet enters and moves the opposite way as the magnet is pulled out. The current is either flowing positively or negatively. The faster the magnet moves, the greater the needle is deflected. The greater the number of turns in the coil, the greater the current that is induced. You can also move the magnet beside the coil or across the top and see a slight deflection of the needle from the smaller amount of electrical current. These investigations show that a magnetic field generates electrical current.

More information for you! In the early 1830s, Michael Faraday in London, and Joseph Henry in New York, independently discovered electromagnetic induction. We saw how the galvanometer reacted when the magnet moved into the coil of wire, but what if we moved a wire through a magnetic field? If we had a large horseshoe magnet and moved a straight wire connected to a galvanometer into the magnet, we could also see a reaction. Generators need wires, magnets, and motion to make electricity.

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Mechanical Lights

Investigation #5

Description

You gotta have some pep to do this fun investigation!

Materials

- Hand-crank flashlight
- Hand-crank generator with attached bulb
- Shakable flashlight

Procedure

1) Challenge a friend to use each of the devices to get the lights to work.
2) What is happening to produce electricity for the lights to work?

My Results

Explanation
In each device, human energy converts mechanical energy into electrical energy. The hand-crank devices each have larger gears that tend with a smaller gear to increase the rotation of the generator. The generator is made of wire coils and permanent magnets to produce an electric current. When the light is connected, you can feel how much harder it is to crank the handle as you feel the resistance in the system. In the shakable flashlight, the magnet slides through a coil of wire. That movement of the magnet sends out pulses of electricity that can charge a capacitor to store the energy and light the bulb. Without the capacitor, the flashlight would have to move continuously in order to work.

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Handy Power

Investigation #6

Description

Let's get an up-close look at a generator!

Materials

- AC/DC Model Generator

Procedure

1) What parts do you notice in the system?
2) Turn the switch to DC and crank the handle. What do you notice?
3) Try the AC switch and crank the handle. What do you notice this time?
4) What will happen if you remove the bar magnet from the top and crank the handle?

My Results

Explanation

Moving a wire next to a magnet can produce electricity. The bar magnet across the top magnetizes the iron sides that surround the coil of wire. When the crank is turned, the wire rotor spins in the magnets and creates an electrical current that travels to the light. The process is converting mechanical energy into electrical energy. The DC current runs across brushes and a split ring to provide positive or negative direct current. The AC current uses brushes with a slip ring and can light up the AC contact. If the magnet is removed from the top, nothing happens when the crank is spun. There has to be both a magnet and a wire in a generator.

Think about this! In the previous investigation, you discovered that you could convert mechanical energy into electrical energy in a generator, and you used arm power to get the rotor to spin. There are other ways to get the rotor to spin, too. These include water wheels, windmills, or steam that blows against vanes and causes a turbine to rotate. When you can connect wires, magnets, and motion, you've got a generator. What a dynamo!

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V-Twin Piston Engine

Investigation #7

Description

Steam can power things? Let's find out!

Materials

- Steam Engine kit
- 95% alcohol fuel
- Lighter
- Safety goggles
- Water

Procedure

1) Assemble the kit according to directions.
2) Fill the boiler 2/3 full of water, as the rest of the volume will hold the generated steam.
3) Fill the burner with alcohol and light the wick.
4) Wait 1 to 2 minutes. What do you notice?

My Results

Explanation

As the burner heats up the water in the boiler, the water begins to turn into steam, just like a tea kettle. However, unlike a tea kettle, there is no open spout for steam to escape. Instead, the steam is captured by the tubing, which sends the steam through the engine. The moving steam strikes the vanes in the pistons and causes the pistons to move back and forth. This movement rotates an axle and turns the rotor, converting the mechanical energy into electrical energy. We know this is happening from the blinking LED bulb. The energy transfers from chemical energy with the burning fuel; to kinetic energy as the water molecules turn into vapor; to mechanical energy with the moving pistons and rotor; and, finally, to electrical energy that can light the bulb.

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Wind Turbine

Investigation #8

Description

Breeze on in and find out about wind power!

Materials

- Thames & Kosmos Wind Power 2.0 Kit with blue sails
- Alligator clips
- LED light

Procedure

1) Build the turbine according to the kit directions.
2) Connect the LED light to the output of the generator.
3) Rotate the sails of the turbine by hand. What do you notice?
4) What happens if you change the gear ratio?

My Results

Explanation
Wind turbines are designed to convert wind energy into electrical energy. As the wind moves toward the sails, the particles deflect off the sails and cause the shaft of the wind turbine to spin, which rotates a large gear in the gearbox. The large gear rotates a smaller gear on a high-speed shaft that produces electrical energy in the attached generator. The output electricity causes the light to light up. Depending on the gear ratio, the bulb will light up quickly and brightly when the sails move or more slowly with the sail rotation. Although the model uses mechanical energy from you moving the sails, a large wind turbine uses energy from the wind to convert mechanical energy into electrical energy.

Think about this! We've explored how generators convert different kinds of energy into electrical energy. Did you know engineers are even creating wearable generators? I'm telling the truth! These small devices can be worn as a ring, bracelet, or other jewelry that directly contacts your skin. The thermoelectric generators in the jewelry convert the heat from your body into small amounts of electricity! Some day we will personally be providing the power to charge our watches and phones. Perhaps you will help develop these technologies. Here's to the power generation!

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Making a Simple Generator

STEM Challenge

Description

You can make your own generator. You've got the power!

Materials

- Spool of 28 AWG wire
- Carboard boxes
- Strong neodymium magnets
- 6-inch iron nail
- Sandpaper
- Alligator clips
- 2 1.5-volt incandescent bulbs
- Scissors
- Electric drill

Procedure

1) Use the point of the nail to pierce a hole through both sides of the box, then widen out the hole from each side with the nail.
2) Cut the ends off one end of the box so you can look down inside the compartment.
3) Slide the nail back through the hole of one part of the box.
4) Position the magnets on opposite sides of the nail so that one end is north, and the other outside end is south.
5) Slide the other half of the box onto the nail.

6) Leaving a three-inch tail, wrap a coil of wire 250 times to one side of the nail. Then, move the wire to the other side of the nail with another 250 wraps. Be careful not to crush the box or bind up the nail.
7) Sand the end of each wire pigtail to fully expose the copper under the insulation.
8) Use alligator clips to connect the pigtails and the LED.
9) Can you get the LED to light by spinning the nail?
10) Can you light more than one bulb?

My Results

Explanation

Wind turbines are designed to convert wind energy into electrical energy. As the wind moves toward the sails, the particles deflect off the sails and cause the shaft of the wind turbine to spin, which rotates a large gear in the gearbox. The large gear rotates a smaller gear on a high-speed shaft that produces electrical energy in the attached generator. The output electricity causes the light to light up. Depending on the gear ratio, the bulb will light up quickly and brightly when the sails move or more slowly with the sail rotation. Although the model uses mechanical energy from you moving the sails, a large wind turbine uses energy from the wind to convert mechanical energy into electrical energy.

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