Generating Electricity

Outreach Program Lesson Plan

WAAW foundation

Working To Advance STEM Education for African Girls

WAAW Foundation is non-profit organization dedicated to bringing hands-on STEM education to girls all over Africa.

Our Mission: To increase the pipeline of African women in Science, Technology, Engineering and Math (STEM) disciplines and to ensure this talent is engaged in African innovation.

Our Vision: To eradicate poverty in African through female education and science and technology innovation.

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Generating Electricity

Class Description-

In this class, students will explore magnets and their properties. They will build a hand-held generator and use it to run some simple experiments.

Total class time: 1 hour

Class Outcomes-

-Students will be able to describe what magnets do when they encounter different materials.
-Students will understand the effect that a magnetic field has on electrons.
-Students will be able to describe the basics of how a generator works, and know some real-world uses of the technology.

Materials List-

The kit to teach this class should include:
-SimpleGEN Kits from Kidwind
-wire cutter
-rolls of scotch tape (1 per group)
-iron filings
-lid from a plastic container (or flat sheet of plastic)
-electric drill (optional)

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Pre-Class Preparation and Set-Up

Spend some time before teaching this class building your own generator and testing it out. You want to be sure that you understand how the pieces assemble, as well as the tricks to winding wire so you can better guide your students when they do it.

Introduction (5 minutes)

Begin by asking your students: Where have you seen and used magnets today? Have students take a few minutes to brainstorm where they've seen magnets used, or where they suspect magnets might be used (inside certain electronics, for example.) We see magnets everywhere in our everyday lives- Even the earth itself is a giant magnet! We mostly encounter them being used as fasteners, but back in 1831, Michael Faraday discovered an extremely useful, new way to make magnets work to our advantage. Today, we are going to explore the inner workings of an electrical generator.

Magnetic Fields (20 minutes)

Ask your students: Have you ever played with a magnet before? What does a magnet do? Have students carefully take out the magnets from their kits. Before they do anything, be sure to give your students a couple of safety notes:

*These magnets are fairly strong. When you bring them close to each other, they will snap together quickly and forcefully. Be sure to have your fingers clear so that you don't get them caught– it hurts!

**If you have electronics, like a laptop or cellphone, you will want to keep them away from the magnets. Strong magnets can mess up electrical components, and damage these items.

***The magnets supplied in the kits are ceramic magnets, and are breakable. Try not to drop them, or let them smash into each other too many times, as they will chip and not last as long.

Set these guidelines with your students, and make sure they understand consequences of not following the safety rules. They are important!

Magnetic Fields (continued...)

Once the magnets are out and separated from each other, have students make some observations:

- What happens when the magnets are brought close to each other?
- Turn one of the magnets around, and bring the magnets close to each other again. What happens this time? Can you force them together?
- What other things do the magnets stick to, besides each other? What do these items have in common?

It should become clear that some unseen force is acting around a magnet that somehow attracts and sometimes repels other items. Magnets are made of materials that have their electrons arranged in a certain way within each atom. The electrons are grouped in such a way that makes one side of each atom have a high negative charge, while the other side has a high positive charge. Each atom is itself a tiny magnet. When many of these atoms are aligned and brought together, their charges build on each other, creating a magnetic field that attracts and repels other electrons.

The next demonstration should show us how this works. First, have each student bring the magnet close to a non-metallic material, like cardboard, wood, plastic, etc. Is there any magnetic pull? No. The electrons in these items are fixed and can't move, so the magnetic field has no effect.

Next, bring the magnet close to a small metallic object, like a paperclip. What happens this time? Try bringing the paperclip close to each side of the magnet. It should stick to it anywhere. Items like the paperclip are made of materials that have free-flowing electrons. When the paperclip is brought close to the positive end of the magnetic field, the electrons attract and are pulled towards the magnet. When the paperclip is brought close to the negative end of the magnetic field, the electrons are pushed away, leaving a positive charge close to the magnet, which gets pulled by the negative end.

Magnetic Fields (continued...)

Now we are going to introduce a new material: Iron filings. Iron is a ferromagnetic element, and has properties that allow it to line up with an outside magnetic field, just like a needle in a compass.

Have the whole class gather around for the demonstration. Place one magnet inside the plastic ziplock bag, and seal it. (If iron filings stick directly to the magnet, they are very hard to remove.) Place the magnet on the table, and the plastic lid over the magnet. While students watch, slowly scatter the iron filings onto the lid, and make observations. You should begin to see the filings line up into curves running from the bottom of the magnet to the top. Point out how the filings with the shape of the magnetic field. You might even see some of the filings seeming to stand off the face of the lid– the magnetic field is three dimensional, and is pulling in the iron from every angle.

This magnetic field that the Iron is allowing us to "see" is the key. It is constantly pulling electrons towards its positive end, and pushing them away from its negative end.

Building the Generator (30 minutes)

Now it's time to build our generators! Follow the directions found at http://learn.kidwind.org/files/manuals/SIMPLEGEN_MANUAL.pdf to have students assemble their generators.

Groups should each build their generators with a different number of turns of wire. For example, for 6 groups, each group should do 20 more coils than the previous group (140, 160, 180, 200, 220, 240.) This will allow you to explore what difference is made by having different numbers of coils later on in class.

If you do not have a plastic container lid, a sheet of paper works too… the plastic just works well because the lip on the lid helps you to easily contain the filings.

Be sure to sprinkle filings all over the lid, not just right on top of the magnet. Filings further out can be more helpful to show the field lines.

Allow students to assemble their generators before giving an explanation of how they work. This will give students a chance to deduce on their own (with the help of guiding questions) how the generator works.

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How does it work? (10 minutes)

Once the generators are all assembled, allow students some time to play with them. They can attach one of the LED light bulbs provided, test the voltage with the multi-meter, and try to get the generator spinning as fast as possible!

Now it's time to think about how this is working:
Let's think back to what magnets do. We know there is this magnetic field that pushes and pulls electrons in metal. When we spin the generator, we move the magnet, which pulls electrons through the wire. We have electrons MOVING THROUGH WIRE– that's electricity!

Ok, but… why is the light blinking? Why doesn't it just stay on?
Remember that one end of the magnet is pulling electrons towards it, the other end is pushing electrons away. As the magnet spins, the wire comes into contact with opposite ends of the magnetic field. So half of the time, electrons are being pulled forward through the wire, and the other half of the time, they are being pushed backwards. Since our LEDs only work in one direction, the light only comes on when the electrons are being pushed forwards.

Experiments (20 minutes)

Ask students– did anyone notice differences in the generators? It seems that the more coils a generator has, the easier it is to get the light to come on… Let's do an experiment to find out if the number of coils really makes a difference. Have student set up their generators with the multi-meters attached and the switch set to read AC voltage. If you have an electric drill, use it to run each generator at the same speed. If you don't have a drill, have the same student spin each of the generators (hopefully, she or he can run each generator at the same speed.) Record the maximum voltage achieved for each generator.

Have the students plot the data points on the board, and compare the results. What effect does the number of coils have on the voltage generated? Why do you think this is?

Refer to the Simple-GEN manual again if you need instructions on how to hook up an LED or the multi-meter. http://learn.kidwind.org/files/manuals/SIMPLE-GEN_MANUAL.pdf

If you have more time, there are more experiments that can be done with these generators. Again, see the SimpleGEN manual for more ideas.

Conclusion (10 minutes)

So now it's time to gather your students: What can we do with this knowledge? We know that if we can get something to spin, we can generate electricity– so how can we get things spinning? Have students spend a few minutes brainstorming how they might generate spinning motion, or where they've seen this used in real life. Some prime examples:

- Bicycle dynamo
- Wind Turbine
- Steam Turbine (this is how most electricity is generated!)

This technology is used all over the world– It's a relatively simple way to generate electricity, so we use it all the time! Even huge coal or natural gas power plants use this technology– the turbines and generators may be bigger and more complicated, but they use the same principles as our little generators.

As a bonus activity, look up what your country uses to supply electricity to the national grid. Then explore how that fuel is used with a generator to create electricity.

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References-

KidWind– SimpleGEN Manual http://learn.kidwind.org/files/manuals/SIMPLEGEN_MANUAL.pdf