Galvanometers

Overview Today is a very important day in your magnetism studies. You will begin to discover how electricity and magnetism cause each other. In the second half of this lab, they'll get to re-enact one of the most important scientific discoveries of all time: how magnetism causes electricity.

What to Learn Galvanometers are coils of wire connected to a battery. When current flows through the wire, it creates a magnetic field. Since the wire is bundled up, it multiplies this electromagnetic effect to create a simple electromagnet that you can detect with your compass.

Materials

- Magnet wire
- Sandpaper
- Scissors
- Compass
- AA battery case
- 2 AA batteries
- 2 alligator clip wires
- Strong magnet
- Toilet paper or paper towel tube

Lab Time

1. Wrap the wire 30-50 times around your fingers, making sure your coil is large enough to slide the compass through. Take one of the ends of the wire and wrap it a couple of times around a section of the circle to keep the wire from unwinding. Do this for both sides.
2. Remove the insulation from about an inch of each end of the wire. Use sandpaper if you're using magnet wire.
3. Connect one end of the wire to the battery case wire.
4. While looking at the compass, repeatedly tap the other end of the wire to the battery. You should see the compass react to the tapping.
5. Switch the wires from one terminal of the battery to the other. Now tap again. Do you see a difference in the way the compass moves? Write it here:

   ____

6. You just made a simple galvanometer. *"Oh boy, that's great! Hey Bob, take a look! I just made a….a what?!?"* I thought you might ask that question. A galvanometer is a device that is used to find and measure electric current. *"But, it made a compass needle move…isn't that a magnetic field, not electricity?"* Ah, yes, but hold on a minute. What is electric current…moving electrons. What do moving electrons create…a magnetic field! By the galvanometer detecting a change in the magnetic field, it is actually measuring electrical current! So, now that you've made one let's use it!

7. Take your new piece of wire and wrap this wire tightly and carefully around the end of the paper towel tube. Do as many wraps as you can while still leaving about 4 inches of wire on both sides of the coil. You may want to put a piece of tape on the coil to keep it from unwinding. Pull the coil from the paper towel tube, keeping the coil tightly wrapped. Take one of the ends of the wire and wrap it a couple of times around a section of the circle to keep the wire from unwinding. Do this for both sides.
8. Remove about an inch of insulation from both ends of the wire using sandpaper.
9. Hook up your new coil with your galvanometer. One wire of the coil should be connected to one wire of the galvanometer and the other wire should be connected to the other end of the galvanometer.
10. Now move your magnet in and out of the coil. Can you see the compass move? Does a stronger or weaker magnet make the compass move more? Does it matter how fast you move the magnet in and out of the coil?
11. Taa Daa!!! Ladies and gentlemen you just made electricity!!!!! You also just re-created one of the most important scientific discoveries of all time.
12. Now, we know that you can't have an electric field without a magnetic field. You also cannot have a moving magnetic field without causing electricity in objects that electrons can move in (like wires). Moving electrons create a magnetic field, and moving magnetic fields can create electric currents.
13. *"So, if I just made electricity, can I power a light bulb by moving a magnet around?"* Yes, if you moved that magnet back and forth fast enough you could power a light bulb. However, by fast enough, I mean like 1,000 times a second or more! If you had a stronger magnet, or many more coils in your wire, then you could make a greater amount of electricity each time you moved the magnet through the wire.
14. Believe it or not, most of the electricity you use comes from moving magnets around coils of wire! Electrical power plants either spin HUGE coils of wire around very powerful magnets or they spin very powerful magnets around HUGE coils of wire. The electricity to power your computer, your lights, your air conditioning, your radio or whatever, comes from spinning magnets or wires!
15. *"But what about all those nuclear and coal power plants I hear about all the time?"* Good question. Do you know what that nuclear and coal stuff does? It gets really hot. When it gets really hot, it boils water. When it boils water, it makes steam and do you know what the steam does? It causes giant wheels to turn. Guess what's on those giant wheels. That's right, a huge coil of wire or very powerful magnets! Coal and nuclear energy basically do little more than boil water. With the exception of solar energy almost all electrical production comes from something huge spinning really fast!

16. Draw out your experiment, showing how the magnet creates electricity and where/how that electricity creates magnetism. Label all the different parts of your experiment:

Reading

Now we've covered the fact that magnetic fields are caused by electrons moving in the same direction. Up to this point, we've been focusing on magnetism being caused by an unequal number of electrons spinning in the same direction in an atom.

If an atom has more electrons spinning in one direction than in the other direction, that atom will have a magnetic field. When bunches of these atoms get together, we have a permanent magnet. Now we're going to talk about what happens if we force electrons to move.

This is one of the most important scientific discoveries of all time. One story about this discovery goes like this:

A science teacher doing a demonstration for his students (Can you see why I like this story?) noticed that as he moved a magnet, he caused one of his instruments to register the flow of electricity. He experimented a bit further with this and noticed that a moving magnetic field can actually create electrical current, thus tying the magnetism and the electricity together.

Before that, they were seen as two completely different phenomena! Now we know that you can't have an electric field without a magnetic field. You also cannot have a moving magnetic field without causing electricity in objects that electrons can move in (like wires). Moving electrons create a magnetic field and moving magnetic fields can create electric currents.

"So, if I just made electricity, can I power a light bulb by moving a magnet around?"

Yes, if you moved that magnet back and forth fast enough you could power a light bulb. However, by fast enough, I mean like 1000 times a second or more! If you had a stronger magnet, or many more coils in your wire, then you could make a greater amount of electricity each time you moved the magnet through the wire.

Believe it or not, most of the electricity you use comes from moving magnets around coils of wire! Electrical power plants either spin HUGE coils of wire around very powerful magnets or they spin very powerful magnets around HUGE coils of wire. The electricity to power your computer, your lights, your air conditioning, your radio or whatever, comes from spinning magnets or wires!

"But, what about all those nuclear and coal power plants I hear about all the time?"

Good question. Do you know what that nuclear and coal stuff does? It gets really hot. When it gets really hot, it boils water. When it boils water, it makes steam and do you know what the steam does? It causes giant wheels to turn. Guess what's on those giant wheels. That's right, a huge coil of wire or very powerful magnets!

Coal and nuclear energy basically do little more than boil water. With the exception of solar energy almost all electrical production comes from something huge spinning really fast!

Exercises

1. Why didn't the coil of wire work when it wasn't hooked up to a battery? What does the battery do to the coil of wire?
2. How does a moving magnet make electricity?
3. What makes the compass needle deflect in the second coil?
4. Does a stronger or weaker magnet make the compass move more?
5. Does it matter how fast you move the magnet in and out of the coil?

Answers to Exercises: Galvanometers

1. Why didn't the coil of wire work when it wasn't hooked up to a battery? What does the battery do to the coil of wire? (The wire is just wire until you have electricity passing through it. The electricity causes a small magnetic field around the wire. When you bundle and coil the wire up, you multiply this effect to create an electromagnet.)
2. How does a moving magnet make electricity? (If you moved that magnet back and forth along a coil of wire fast enough you could power a light bulb. However, by fast enough, I mean like 1,000 times a second or more!)
3. What makes the compass needle deflect in the second coil? (When a magnet is moved in and out of the first coil quickly, it creates a current in the wire which travels to the second coil of wire, turning the second one into an electromagnet. An electromagnet is a magnet that you can turn on and off with electricity. Since the compass is affected by magnets, this tells us that the compass is near a magnetic field when it deflects, which means that the wire is creating a magnetic field.)
4. Does a stronger or weaker magnet make the compass move more? (Stronger)
5. Does it matter how fast you move the magnet in and out of the coil? (Yes – the faster you move it, the more the needle deflects.)