Teacher's Guide

ACTIVITY 2:

Dancing compasses

Intro

Electricity and magnetism are often thought of as two separate topics but they are actually intertwined. When electric charges move, they create a magnetic field and conversely when a magnetic field changes it can make charges move. This experiment uses compasses to show that current, which is moving electric charges, creates a magnetic field.

Key Question

How do nearby compasses react when current flows through a wire?

Key Terms

Electromagnetism: Electricity and magnetism are not separate. Electro-magnetism is the study of how they are combined.

Current: Current is the flow of positive charges

Magnetic Pole: All magnets have a north and a south pole. Compasses have a small magnet inside them that turns to align with a magnetic field.

Materials

- **12-inch stiff wire**
- **Battery holder**
- **6 AA batteries**
- **8-inch insulated wire**
- **4 small compasses**
- **PhysicsQuest cardboard box**
- **Tape**

Before the activity students should know that …

The earth has a magnetic field.

Compasses are made of tiny magnets that can rotate and align themselves with a magnetic field.

Like electric charges repel; positive repels positive and negative repels negative.

When a wire is connected to a battery a circuit is formed and current flows.

The direction that current flows is the direction of the motion of positive charges.

After the activity students should be able to …

When current flows through a wire, a magnetic field is created around the wire.

Changing the direction of the flow of current changes the direction of the magnetic field that is produced.

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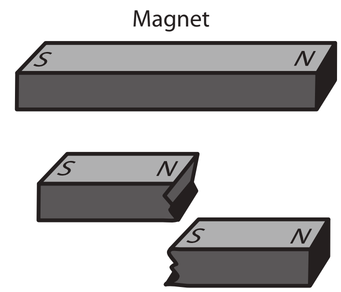
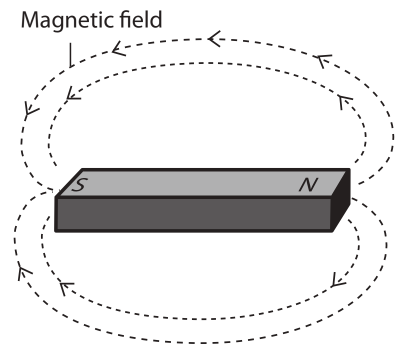
The science behind …

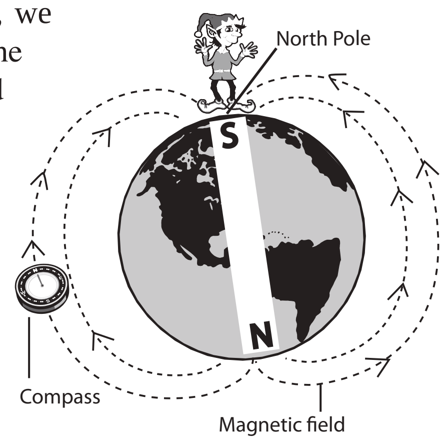
Though often thought of as two separate topics, magnetism and electricity are closely linked. Whenever a charge moves a magnetic field is created. In fact, the only way to create a magnetic field is to have moving charges. Even the magnetic field of permanent magnets is created by the movement of the electrons in the atoms. Magnets have a north pole and a south pole just like electricity which has positive and negative charges.



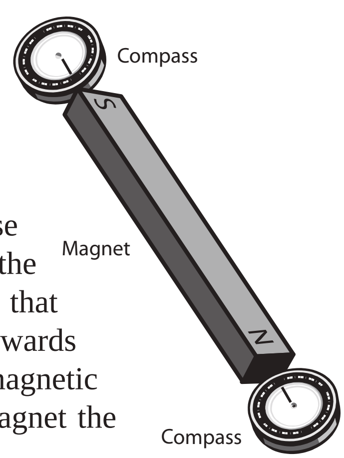
However, with electric charges you can have just a positive charge, like a proton, or just a negative charge, like an electron. You can't do that with magnets, north will always be attached to a south and south will always attached to a north. Even if you break a permanent magnet in half both of the pieces will again have a north and a south. You can keep splitting the magnet, but it will always be a magnet with a north and a south. With electrical charges, like charges repel and opposite charges attract. It is the same with the magnetic poles. The north end of one magnet will be attracted to the south end of another.



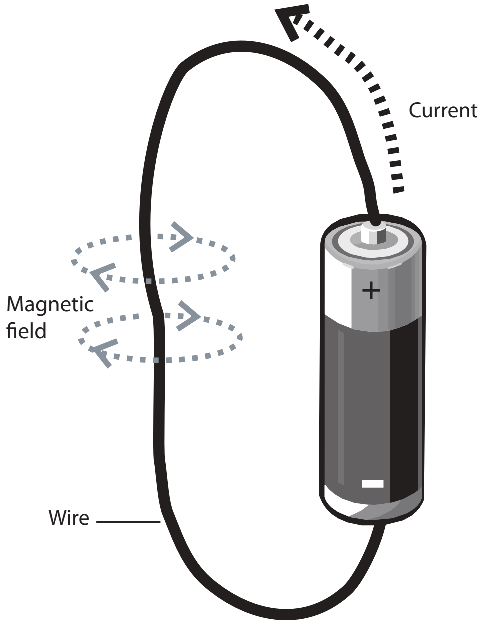
A magnetic field is called a field because at any point it has both a strength and a direction. If it had only a direction, we would know if it would push or pull on another magnet, but not how hard. If it had only a strength, we wouldn't know if it would be pushing or pulling. An electric field has the same properties except it acts on electric charges while a magnetic field only affects magnets. The unit for magnetic field strength is named after our hero, Nikola Tesla. A very strong refrigerator magnet has a magnetic field strength of about 0.1 Tesla. When drawing a magnetic field it is important to include arrows to show the direction of the field. The arrows always point away from the magnet's north pole and towards the magnet's south pole.



In this activity you will use a compass to determine the direction of a magnetic field produced when current flows through a wire. A compass needle is just a tiny magnet that is allowed to move around. It has both a north end and a south end. Normally, when it is not near other magnets, it will align itself along the magnetic field created by the earth. This means that the north pole of the compass needle is attracted to the south pole of the earth's magnet. Now here's where it gets a bit tricky. Earth has a geographic North Pole. This is the place that kids send letters to Santa and elves happily make toys. However the magnetic south pole of the Earth is close to the geographic North Pole. So Santa, his elves, and Rudolph live above the south end of earth's magnet. The compasses used for this activity have a face that spins so the "N" points toward the geographic North Pole, or in other words, towards Santa. In actuality, the end of the compass face marked "N" is attracted to magnetic south. So if you were to bring a compass close to the south end of a bar magnet the magnet would attract the "N" of the compass needle. Opposite poles attract.



ACTIVITY 2: Dancing compasses



Because compass are just small magnets they can be used to do more than find your way in the woods, they can show the direction of any magnetic field. We can use them to show what the field around a current carrying wire looks like. Because of a convention set by Ben Franklin the direction of current is the direction positive charges would move. Later physicists learned that current was actually caused by negative charges flowing, but Ben Franklin's convention stuck and now even physicists pretend that it is the positive charges that flow. If a wire is hooked to a battery, the flow of current is away from the positive end of the battery. If the battery is turned around, the current changes direction. The direction of the magnetic field around the wire depends on the direction of the current. Because moving charges create magnetic fields and current is just moving positive charges, the current will create a magnet field. By placing compasses around the wire and then connecting the wire to the battery, it is possible to see the direction of the magnetic field.

Even though we have said that current will produced a magnetic field, we haven't said which direction the magnetic field will go. This experiment will give you the answer!

Safety

Any time you are working with electricity you must be very careful. If the stiff wire is left connected to the battery the wire will get very hot. Be sure to just quickly touch the battery lead to the wire. The stiff wire is quite sharp. Eye protection should be worn during this activity.

Corresponding extension activities

Galvanometer: Build a super sensitive device to test for current.
3-D compass: Make a compass needle that can move in three directions instead of just two.
Jumping Wire: Make a wire "jump" with just a magnet and a battery.

Bibliography/Suggested resources

Exploratorium Science Snacks. *Circles of Magnetism*
http://www.exploratorium.edu/snacks/circles_magnetism_I/index.html

Reuben, Gabriel. Electricity Experiments for Children. London: Sterling Publishing, 1960

Robinson, Tom. *The Everything Kids' Science Experiments Book.* Avon, MA: Adam's Media, 2001

Walter Fendt. *Magnetic Field of a Straight Current-Carrying Wire*
http://www.walter-fendt.de/ph11e/mfwire.htm

Student's Guide

ACTIVITY 2: Dancing compasses

Intro

Now that you have learned about light itself, your next step is to learn about how current and magnetic fields are related. Tesla used the relationship to create his famed AC generator which lit the fair. You are a brave sidekick! Now you must complete this activity to find the next sneaky pigeon and get one step closer to finding all our hero's tools.

When a wire is hooked up to a battery, current flows through the wire. This current can do lots of things like light light bulbs and power your radio. But is that all that is happening? When a battery produces a current, is that all that is produced? In this experiment you will use magnetic compasses to find out what else happens when current flows.

Materials

- **12-inch stiff wire**
- **Battery holder**
- **6 AA batteries**
- **8-inch insulated wire**
- **4 small compasses**
- **PhysicsQuest cardboard box**
- Tape

Key Question

When current flows through a wire, what happens to magnetic compasses placed around the wire?

Getting started

What things around you are magnetic?

What do you think makes them magnetic?

Look at the compasses, why do you think the "N" always points north? Can you think of other uses for compasses besides find your way in the woods?

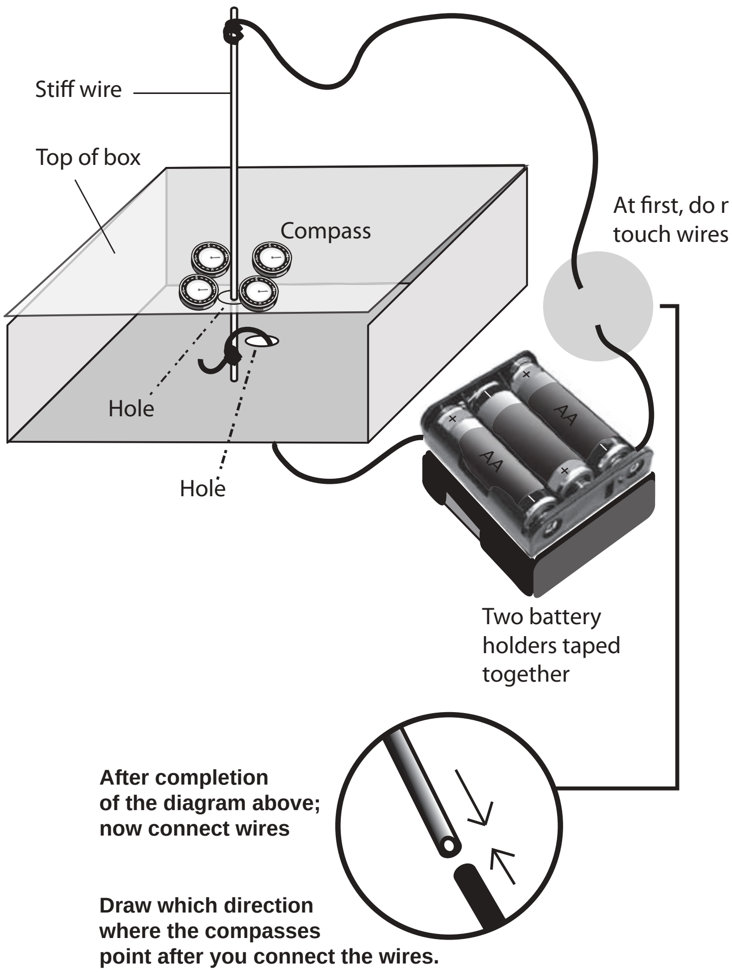
Find items in the room that might be magnetic and bring a compass near them. Does the compass change direction?

How do you think electricity and magnetism are related?

Setting up the experiment

1. Poke a hole in the PhysicsQuest box top and one right under it in the PhysicsQuest box bottom.
2. Place the 6 batteries in the battery holder.
3. Put the box on its side and put the black lead of the battery holder through the hole in the bottom of the box. This lead is connected to the negative end of the battery.
4. Open your PhysicsQuest box and put the stiff wire through the hole in the top.
5. Carefully wrap the black battery lead around the end of the stiff wire. Make sure it is secure; the metal of the lead should be in good contact with the wire. Tape them together if necessary.

ACTIVITY 2:: Dancing compasses



6. Close the box and tape the stiff wire so that it is sticking straight up out of the box. Be sure that the black lead is still securely wrapped around the bottom of the wire.
7. Wrap one end of the 8" insulated wire around the top of the stiff wire making sure the two are in good contact.
8. Place the four compasses on top of the box surrounding the wire.

Collecting data

Draw a picture of your compasses. Make sure you indicate which direction they are pointing.

Touch the free end of the insulated wire to the red battery lead and hold it for 1 second. Notice what happens to the compasses.

Describe what happened to the compasses when the wires were connected and draw a picture. Make sure you indicated the direction the compasses were pointing.

Now you will flip the battery leads, which will change the direction of the current flow.

Detach the black lead from the bottom of the stiff wire and attach the red lead in its place.

Touch the black lead to the insulated wire for 1 second and again draw your results. What was different?

Troubleshooting

If the compasses did not move it is because current is not flowing through the stiff wire. For current to flow there must be good connections and good batteries. First, make sure that all the wires are securely connected. Second, make sure the batteries are not dead.

Write your answers below:

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Analyzing your results

When both leads of the battery were connected to the stiff wire, current is flowing. Current flows from the red lead of the battery to the black lead. On each of the pictures you have drawn draw and arrow on the wire to show which direction current is flowing.

When the wire was connected to the battery what happened to the compasses?

What makes the compasses move? Is it the electricity in the wire or is the electricity producing something else to make the compasses move?

As you found out as you were exploring your room with the compasses, the compass needle will align itself along a magnetic field. Magnetic fields go in a specific direction. The direction of the field is shown by the direction of the compass needles. Does the direction of the current affect the direction of the magnetic field?

If you had a wire that had a current and a compass, could you tell which way current was flowing, even if you couldn't see a battery? How?

When current is flowing through a wire, is the space around the wire empty? There is no right or wrong answer to this question. Discuss and then decided on an answer as a group and justify your answer to the class.

Write your answers:

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Using your results to help Tesla light the fair.

You caught your first pigeon and found the first tool stolen from Tesla. Yet again, you must be on the move and chase away. When the red lead from the battery was connected to the top of the stiff wire, which direction did your compasses point?

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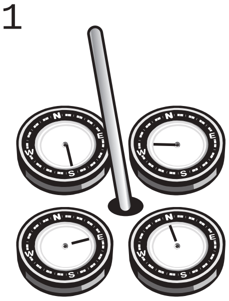

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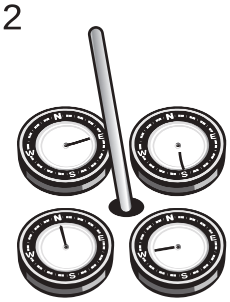

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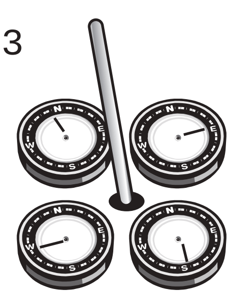

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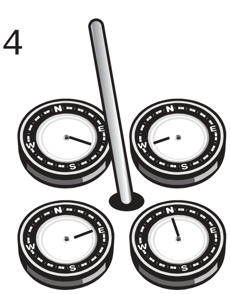

Picture 1	Chase the white pigeon
Picture 2	Chase the gray pigeon
Picture 3	Chase the pigeon with stripes
Picture 4	Chase the pigeon with a gray head and white body