Electromagnets

SMUD®
Energy Education & Technology Center

Electromagnet and Compass

Question

- How will electric current passing through a wire affect a compass?

Hypothesis

In your science notebook, write a hypothesis stating how you think electric current passing through a wire will affect a compass.

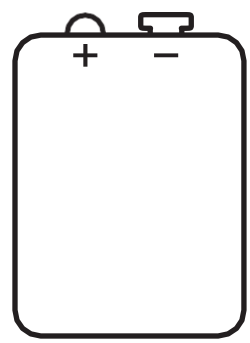
Materials

- 9-volt Battery
- Compass
- Alligator clip
- Nail

Vocabulary

- conduct
- direct current
- electricity
- electromagnet
- energy flow
- magnetic field
- repel

✔Procedure



1. Take the nail and hold it next to the compass. Move the nail around over the compass and observe the interaction. Record your observations in your science notebook.
2. Connect one end of the alligator clip to the negative terminal of the 9 V battery.
3. Wrap the wire of the alligator clip around the nail, starting at the flat end or head of the nail, and moving towards the pointed end. Leave enough wire to reconnect the battery.
4. Connect the other alligator clip to the positive terminal of the 9 V battery.
5. Hold the pointed end of the nail near the compass. Observe the interaction. Record your observations in your science notebook.
6. Hold the flat end or head of the nail near the compass. Observe and record the interaction.

Conclusion

1. What did the electric current create when it passed through the wire around the nail?
2. What are the two poles of a magnet called?
3. Which pole was the flat end of the nail? Which pole was the pointed end of the nail? Support your answer with your observations.
4. How do the parts of an electromagnet work together to create magnetism?
5. Will you accept or reject your hypothesis? Upon what experimental evidence are you basing your conclusion?

Alternative hands-on activity

Don’t have a compass?

Want an extra challenge? Grab a few paperclips and place them near the nail as an alternative method to demonstrate that you have a magnet. If the nail is magnetized it will pick up the paperclips! How many can you lift?

Background Information for adults

This activity takes a non-magnetic object, a nail, and makes it magnetic. Ordinarily, iron is not in and of itself a magnet, but it will respond to a magnetic field. Only three metals are noticeably magnetic: iron, nickel, and cobalt. This is related to the movement of electrons within the atoms.

Electrons don’t just move around the nucleus of an atom; they also spin. Michael Faraday was the first to demonstrate that a moving electrical field creates a magnetic field, and because electrons have an electrical charge, their movement creates tiny magnetic fields. Ordinarily electrons exist in pairs. Each electron in the pair spins in an opposing direction from the other. The magnetic field generated by one electron is canceled by the magnetic field generated by the other electron in the pair. However, in nickel, cobalt, and iron, there are unpaired electrons with magnetic fields that are not canceled. This creates tiny sections in the metal where magnetic fields align, called magnetic domains.

When the wire was wrapped around the nail, and electric current moved through it, a magnetic field was created that moved through the center of the coil of wire, out from one end of the nail, and around, back to the other end of the nail. The way electric and magnetic fields are related is demonstrated with the “right-hand rule.” If you outstretch your right hand, and your thumb indicates the direction of one field, the fingers of your right hand will curl around in the direction of the other field. If the electric current was straight, the magnetic field would curl around the wire. If the electric current was moving in a coil, however, the magnetic field would be straight.

When the wire was connected to the battery and electric current moved through it, the magnetic field induced by the moving electric field in the wire caused the magnetic domains in the nail to align, and the nail became a magnet itself. Even after the wire was disconnected from the battery, the nail may have remained magnetic until dropped on the floor or tapped on the table, which would have caused the magnetic domains to move back into their original configuration. Electromagnetism allows us to transform electrical energy into kinetic energy and make things move. The chemicals in the battery interact to generate electric current, and like the apple electrolytic cell in Station Five, transform chemical energy into electrical energy.