Science Docent 4th Grade

Magnetism

Objective: Students will experiment with the natural forces of magnetism. The students will learn all magnets have poles, magnets attract or repel one another, how electromagnets work, and that the Earth is a giant magnet. Next Gen Science Standard: 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

Docent Guidelines:

1. Schedule a date and time with your teacher to have the students come into the lab. Estimated time for this activity: 60-75 minutes.
2. Input the day and time into the Science Lab Master Schedule. Plan on 30 minutes of set up and 30 minutes of clean up time. Plan to arrive early to set up.
3. Start with a 10 minute review of magnetism basics and vocabulary. You may wish to show a video at the beginning or at the end of the experiments, if you have time.
4. The students will rotate between 3 stations, so it is best to have at least 3 docents. Allow 10-15 minutes per station.
    a. Station 1: Ferro Fluid Demonstration and Magnetic Fishing
    b. Station 2: Build and Test an Electromagnet
    c. Sation 3: Using a Compass
5. If you have time at the end of the lab experiments, discuss observations with the students or show one of these videos:

Strongest Magnet in the World (7:08)
https://www.youtube.com/watch?v=QGytW_C6hR8
Homemade Levitating Top (2:30)
https://www.youtube.com/watch?v=VylZJrep1MM

Magnetic Basics: For Docent's Information

What is a magnet?

A magnet is any object that generates its own magnetic force, called a magnetic field. Despite being invisible, a magnet's magnetic field is responsible for producing the force that attracts other objects. The ancient Greeks discovered that some rocks, known as lodestones, produced their own magnetic field. Today magnets are specially made. Magnets come in many shapes and sizes and can be made from different types of materials but only metals are magnetic.

A magnet's magnetic field exists within the space immediately around the magnet; it's here where a magnets magnetic force is strongest. The further you are from the magnet, the weaker the magnetic field is. Permanent magnets continually produce their own magnetic field but normally you can't see it.

How do magnets work?

Magnets can attract other materials. Only metals are attracted to magnets but not all metal are magnetic. Every magnet ever made has two poles – a north and a south pole. Magnets produce lines of magnetic force which leave a magnet from its north pole and re-enters the magnet at the South Pole. When two magnets are placed together one magnet's North Pole will attract the other's South Pole. However, two north poles or two south poles always repel each other.

Why are magnets magnetic?

There are two types of magnets, permanent magnets and electromagnets.

Permanent magnets never lose their magnetism, they are the typical round, bar or horseshoe shaped magnets that you may have seen before. They are made by heating up magnetic material such as iron to really high temperate and then cooling it in the presence of a really strong magnetic field. This makes some of the tiny particles, known as magnetic domains, within the magnet face the same way. The material is then magnetized by placing it within another strong magnetic field which magnetizes all of the tiny particles that are already facing the same way. Each tiny particle now exerts its own magnetic field. You can magnetize everyday objects such as a needle by rubbing in the same direction with a bar magnet.

Electromagnets are created by using electricity and a magnetic material such as iron. When electricity passes through a copper wire it creates a magnetic field around the wire. By winding a coil of wire around an iron core you can increase the strength of the magnetic field produced and create and electromagnet. Unlike permanent magnets, you can turn off an electromagnet's magnetism by removing the electricity.

Is the Earth a big magnet?

Did you know the Earth actually produces its own magnetic field? This is because Earth's core is mainly made up of iron, one of the best materials for making magnets. Part of the Earth's core is continuously spinning really fast, which creates a magnetic field and is the reason why the Earth has a North Pole and a South Pole. This is really helpful for explorers and adventurers as they can use a compass to find out which way is north and which way is south.

Why do magnets have two poles?

The poles of a magnet are the points at which a magnet's magnetic field is strongest, usually either end of a magnet. Lines of magnetic force exit a magnet from its north pole and enter through its south pole finding the easiest route. That's why, if you chop a magnet in two, you get two new separate magnets, each one with a north and a south pole.

Relationship between magnets and electricity

We've seen how the flow of electricity can create a magnetic field. Similarly the movement of a magnet can generate electricity if a wire is placed within the magnetic field in such a way that it cuts through a magnet's magnetic lines of force. You really can't have electricity without magnetism and vice versa. The relationship is known as electromagnetism.

What are electrons and why do they make magnets stick?

An electrical current moving along a wire creates its own field. It is these moving electrical charges that are also responsible for a permanent magnet's magnetic field, more specifically; it is the movement of tiny charged particles called electrons that creates a magnetic field.

An election is a negatively charged particle found in all atoms. They are found in every atom and are continually moving. While they don't move very far, the movement is enough to create a small magnetic field. Generally, electrons move in pairs and in each pair one electron spins in one direction and the other spins in the opposite direction. Because each spins in a different direction, the magnetic fields created by each cancel each other out. However, materials that we call ferromagnetic, e.g. magnetic materials like iron have several unpaired electrons that are all spinning in the same direction, each creating a magnetic moment and therefore make a material magnetic. The materials that make good magnets are the same materials magnets attract. This is because magnets attract materials that have unpaired electrons that spin in the same direction. In other words, the property that turns a metal into a magnet also attracts metal to magnets.

What is a ferrous metal?

It is rare that metals are used in their raw form. They are often mixed with other metals and elements with different properties to make an alloy. The word ferrous is used to describe a material that contains a lot of iron. Therefore, it means that these materials are commonly magnetic.

What is a ferrofluid?

Ferrofluid is a colloidal suspension of magnetic nanoparticles, typically magnetite , in a liquid medium such as paraffin oil or water It becomes strongly magnetized in the presence of a magnetic field. Ferrofluid was invented in 1963 by NASA's Steve Papell as a liquid rocket fuel that could be drawn toward a pump inlet in a weightless environment by applying a magnetic field.

Ferrofluids are composed of nanoscale particles (diameter usually 10 nanometers or less) of magnetite and hematite or some other compound containing iron. This is small enough for thermal agitation to disperse them evenly within a carrier fluid, and for them to contribute to the overall magnetic response of the fluid.

Ferrofluids consist of two states of matter: a solid metal and liquid it is in. This ability to change phases with the application of a magnetic field allows them to be used as seals, lubricants, and may open up further applications in future nanoelectromechanical systems.

True ferrofluids are stable. This means that the solid particles do not agglomerate or phase separate even in extremely strong magnetic fields. However, the surfactant tends to break down over time (a few years), and eventually the nano-particles will agglomerate, and they will separate out and no longer contribute to the fluid's magnetic response. However, ferrofluids lose their magnetic properties at sufficiently high temperatures.

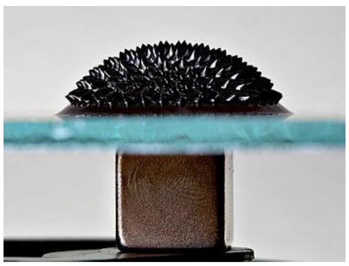
Photo of a ferrofluid over a magnet

What are magnets used for?

Without magnets, thousands of everyday items that we have come to take for granted would never have been possible. Without magnets the world would be without:

- Electric motors
- Loudspeakers
- Smartphone
- Medical equipment like hearing aids and MRI machines
- Wind turbines
- Computer
- Video game systems
- TV’s, toasters
- Circuit breakers
- Brakes on a car
- Superconducting magnetic separators
- Various construction equipment

Vocabulary:

Attract - opposite poles attract. That means they come together.

Compass—instrument that uses the earth’s magnetic field to help people find directions. The needle on a compass points north.

Electromagnet - A metal core that creates a very strong magnet after a current passes through wire that is coiled around it. Electromagnets are used in speakers, phones, generators, doorbells, dishwashers, toys, etc.

Electron - A small particle that carries one unit of negative energy.

Loadstone - naturally magnetic rocks.

Magnet—Any object with magnetic force

Magnetic - Materials that are attracted to magnets are called magnetic. These magnetic materials include iron, cobalt, nickel, and some rare metals. Non-magnetic materials include silver, gold, copper, aluminum, and lead.

Magnetic Field- the area of magnetic force around a magnet

Magnetism- force of attraction or repulsion between various substances, especially those made of iron and certain other metals; ultimately it is due to the motion of electric charges.

Repel - To drive away. Like (north + north) poles repel

Poles- All magnets have two kinds of poles. The poles are located at the ends, on opposite faces, or along the edges of a magnet. The poles are called north or south. They may shift location as the magnet loses strength. The pole is the where the magnetic force is the strongest.

Safety Issues:

When handling neodymium magnets eye protection and gloves must be worn at all times. Neodymium magnets are extremely strong and fingers can be pinched between two attracting. These magnets are also very brittle and can peel, crack or shatter magnets if they are allowed to slam. Neodymium magnets MUST be kept away from credit cards, computers, cellphones and people with pacemakers. Ferrofluid is very messy and will permanently stain clothes as well as fingers. Use gloves and eye protection. Never under any circumstances ingest Ferrofluid.

Docent Resource Information:

http://www.khanacademy.org/science/physics/electricity-and-magnetism/v/introduction-to-magnetism

https://www.youtube.com/watch?v=MZtTVsIOA9c
http://www.explainthatstuff.com/magnetism.html

http://www.sciencekids.co.nz/sciencefacts/magnets.html

Station 1

Part A: Ferrofluid Demonstration (see separate instruction sheet)
Part B. Magnetic Fishing

Materials:
--Magnets tied to "fishing poles"
--various objects placed on the table (found in the supply box)

Set up the Ferro fluid Demo at a separate table. After the demonstration, the students can experiment with "magnetic fishing" at the second table.

Procedure for Magnetic Fishing:

1. Predict which items on the table will be attracted to the magnet? Why?
2. Try to pick up various objects with the magnets to see which items are magnetic. Were your predictions correct?
3. Other things to try: How many objects can your magnet pick up at once?

Station 2

Build and test an Electromagnet

(Source:
h**ttps://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_mag/cub_mag_lesson2_activity1.xml)**

Materials for each group:

- Nail, 3-inch (7.6 cm) or longer (made of zinc, iron or steel, but not aluminum)
- About 2 feet (.6 m) insulated copper wire (AWG 22)
- D-cell battery
- Several metal paper clips, tacks or pins
- Wide rubber band or wires with alligator clips
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Procedure:

1. Make sure each table/group of students has the following materials: one nail, 2 feet (.6 m) of insulated wire, one D-cell battery or lantern battery, several paper clips (or tacks or pins) and a rubber band or wires with alligator clips.
2. Tell the students to tightly wrap the wire around a nail at least 20 times (see Figure 4). Take turns.
3. Give the students a few minutes to see if they can create an electromagnet on their own before giving them the rest of the instructions.
4. To continue making the electromagnet, connect the ends of the coiled wire to each end of the battery using the rubber band or to hold the wires in place (see Figure 4). Alternately, they may use wires with alligator clips to connect the wire to a lantern battery.

Figure 4. Set-up to make an electromagnet using a battery, wire and nail.

5.Test the strength of the electromagnet by seeing how many paperclips it can pick up.

6..Disconnect the wire from the battery after testing the electromagnet. Can the electromagnet pick up paperclips when the current is disconnected? (Answer: No.)

8.Test how varying the design of the electromagnet affects its strength. The two variables to modify are the number of coils around the nail and the current in the coiled wire by using a different size or number of batteries. To conserve the battery's power, remember to disconnect the wire from the battery after each test.

Docent note: Please uncoil the wire for the next group to use.

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Station 3

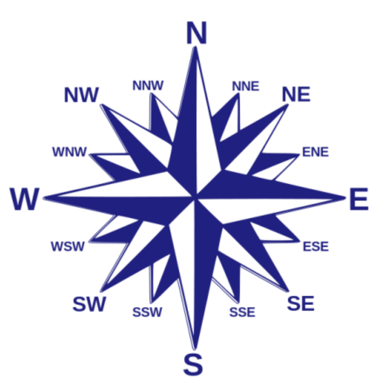
Using a Compass

Materials needed:

--Compass for each group of students (groups of 2-3)
--Course markers (coins or cones) placed outside spread apart from each other on the blacktop or lawn
--Set of course instructions (next page)

Procedure:

1. Begin by explaining how a compass works. A compass is an instrument that uses Earth's magnetic field to help people find directions. The magnetic material inside the compass causes the needle to point north (towards the north pole of the earth.)
2. Teach the kids how to find direction using the compass. Remind them to hold it flat, parallel to the ground. Explain how to determine which direction is East/South/West by lining the red needle up with North on the compass. Practice walking a few steps East together, then West, while looking at their compasses.
3. Tell them they are going to use their compass to follow directions to get to a certain place, using the compass. Each group should start at a different coin/marker. Give each group a different piece of paper with their set of instructions. (Each set of instructions is different, but they should all end up at their beginning point—but don't tell them that at first!)



Course 1
Go Southeast for 10 steps
Go West for 10 steps
Go Northeast for 10 steps
How many steps are you away from your beginning point?

Course 2
Go Northwest for 8 steps
Go Northeast for 8 steps
Go South for 12 steps
How many steps are you away from your beginning point?

Course 3
Go East for 12 steps
Go South for 12 steps
Go West for 12 steps
Go North for 12 steps
How many steps are you away from your beginning point?

Course 4
Go East for 6 steps
Go South for 8 steps
Go Northwest for 10 steps
How many steps are you away from your beginning point?

Course 5
Go Southeast for 6 steps
Go Southwest for 8 steps
Go East for 12 steps
Go West for 10 steps
How many steps are you away from your beginning point?

Course 6
Go East 6 steps
Go South 8 steps
Go West 12 steps
Go Northeast 10 steps
How many steps are you away from your beginning point?