NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 55 MINS

Magnetic Fields Lab

Students create and observe ferrofluids to understand magnetic field lines and how they can affect planets.

GRADES

6 - 8

SUBJECTS

Astronomy, Experiential Learning

CONTENTS

1 Video, 1 Image, 2 PDFs, 1 Link

OVERVIEW

Students create and observe ferrofluids to understand magnetic field lines and how they can affect planets.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/magnetic-fields-lab/

Program

WILDEST WEATHER IN THE SOLAR SYSTEM

DIRECTIONS

1. Activate students' prior knowledge about magnetic fields.

Ask: *What do you already know about magnetic fields? What everyday object can you think of that measures magnetic fields?* Elicit from students that a compass uses Earth's magnetic field to give information about direction. Then show students the NASA video "Magnetometry 101." Ask them to restate in their own words how magnetic fields can be measured and drawn. Tell students that, in this activity, they will create and observe ferrofluids to understand magnetic field lines and how the field lines can affect planets.

2. Have students investigate magnetic field direction.

Have pairs of students place a bar magnet on a white sheet of paper. Pour a very small amount of filings onto the paper. The filings should form lines. Have students determine the direction of the lines by placing a compass on the lines and drawing an arrow to show which direction is north on the compass. After drawing a few of the arrows, ask students to label which end of the magnet represents north and which represents south. If they are not sure, have them label a few more of the lines created by the filings. Provide support, as needed.

3. Build background about ferrofluids.

Explain to students that one way we can observe magnetic fields is through the use of a material called *ferrofluid*. A ferrofluid is a liquid that becomes strongly magnetized in the presence of a magnetic field. Display the photo of magnetized ferrofluids for students and allow them to ask questions. Ask: *Why do you think something with these properties might be useful on Earth or in space?* Explain to students that, on Earth, ferrofluids are used to form liquid seals in electronic devices. In space, ferrofluids are used to control the flow of liquid fuels and the rotation of spacecraft.

4. Introduce the activity.

Tell students that, in this activity, they are going to investigate magnetic fields and use that information to analyze how ferrofluids work. Provide each pair of students with a set of materials and room to work. Distribute one set of worksheets Ferrofluid Investigation and Ferrofluid Observations to each pair. Tell students they will fill in Part 1 of Ferrofluid Observations as they move through the steps of the investigation.

5. Have students complete and discuss the first part of the lab experiment.

Ask students to complete Step 1 in handout Ferrofluid Investigation and then stop. Ask: *What do you observe about the filings?* Students should notice that the filings form spikes similar in appearance to a porcupine. Explain that this is due to the magnetic field, as well as the fluid suspension. Each spiky point is a subdued representation of the magnetic lines. If the fluid didn't hold the filings back, the spikes would continue to grow into lines like those seen when a bar magnet is placed under a dish of metal filings not suspended in fluid. Ask: *What does this tell you about the magnetic field?* Students should be able to confirm that the magnetic field shows itself as a series of lines gathered at the top and bottom of the bar magnet.

6. Have students complete and discuss the remaining parts of the lab experiment.
Have students continue with Steps 2-5, filling in Ferrofluid Observations, and then stop. Ask:

- *What do you notice when you move the magnet?* (The spikes move with the magnet. As the magnet is pulled away, the spikes are less prominent and smaller. Eventually they are nonexistent and the ferrofluid falls to the bottom of the preform.)
- *What are some possible explanations for that behavior?* (The ferrofluid is metallic and is affected by the magnetic attraction of the magnet. The spikes form and reflect the magnetic field, trying to form magnetic circles similar to what is observed with the magnetic field of the Earth and other planets.)
- *What do you think would happen if you repeated the lab, but only used toner or filings and no oil?* (Students should understand that they would see the filings or toner flow from the positive to the negative polarity of the magnet.)

7. Have students compare and contrast their observations and USGS data.
Display the USGS: National Geomagnetism Program web page for students. Ask:

- *What do you notice about Earth's magnetic field?* (Earth's magnetic field flows from near the north magnetic pole to near the south magnetic pole.)
- *How is it similar to or different from what you saw in your experiment?* (The spikes appear to have equal distances and look like they would continue around to the opposite end of the magnet from one pole to the other.)
- *Why do you think your ferrofluid experiment looked more like a porcupine than lines?*

Make sure students understand that the section they observed with the ferrofluid would continue to travel around to the opposite side of the magnet, demonstrating the same “lines” as observed with the filings due to the polarity of the magnets. The liquid suspension holds the filings back. The filings not suspended in a liquid will form magnetic lines from one pole of the magnet to the other. We observe this same phenomenon here on Earth. Help students make the connection to magnetic fields on Earth and other planets. Explain that many of the planets have magnetic fields, but some do not have a magnetic field or have a weak magnetic field. Magnetic fields serve as a shield that protects planets from solar radiation. The solar particles are deflected to the polar regions along the magnetic field lines. If a planet has very little or no magnetic field, there is not enough protection for people or vehicles exploring that planet.

TipSafety

Make sure students know that laser toner will stain clothing and cannot be removed.

TipSafety

Make sure students wear safety goggles during the entire lab experiment.

Informal Assessment

Check students' completed worksheets to make sure they followed directions and made relevant observations.

Extending the Learning

Have students read the NASA: Science News article “Sickening Solar Flares.” Then have students compare and contrast the planets in our solar system with magnetic fields and what that might mean for the planets and anyone who might explore those planets:

- Earth—30,000-60,000 Nanotesla (nT)
- Mercury—100 times weaker than Earth
- Venus—25,000 times weaker than Earth
- Mars—5,000 times weaker than Earth
- Jupiter—20,000 times greater than Earth
- Saturn—540 times greater than Earth
- Uranus—40 times greater than Earth
- Neptune—a quarter that of Earth

Ask: *Given what you know about how magnetic fields protect planets from solar radiation, which planets would you rather visit?*

OBJECTIVES

Subjects & Disciplines

- **Earth Science**
  - Astronomy
- Experiential Learning

Learning Objectives

Students will:

- make observations about the properties of ferrofluids
- describe magnetic properties using ferrofluids
- make connections to magnetic fields on Earth and other planets

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Hands-on learning
- Lab procedures

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills
    - Productivity and Accountability
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard B-3:**
Transfer of energy

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 2:**
Communication and Collaboration

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- 2-liter bottle preforms (optional)
- Bar or earth magnets
- Beaker
- Fine metal filings or magnetic laser printer toner
- Magnetic compasses
- Mineral oil
- Paper towels
- Pencils
- Plastic petri dishes
- Safety goggles
- Sealable plastic sandwich bags
- Stirrers
- Tablespoons or graduated cylinders
- White paper

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per classroom, Projector, Speakers
- Plug-Ins: Flash

PHYSICAL SPACE

- Classroom
- Laboratory space

GROUPING

- Large-group instruction
- Small-group instruction

OTHER NOTES

As you set up for the activity, and as students complete it, make sure to keep iron filings away from the bar magnet.

BACKGROUND & VOCABULARY

Background Information

Magnetic poles are assigned the labels of north or south. Magnetic fields can be described via the concept of magnetic lines of force; the lines form closed loops originating at the North Pole and ending at the South Pole and also passing through the material. The space where the lines of force are crowded represents a region of strong magnetic field compared to the region where the lines are farther apart. Magnetic field lines are an important tool for describing the nature of magnetic interactions. A rule for describing interactions between magnetic poles is that like poles repel and unlike poles attract. Hard magnetic materials are permanent magnets and they either attract (south-north) or repel (south-south). Ferrofluid is soft magnetic material. A soft magnetic material, versus a hard magnetic material, is always attracted to a permanent magnet independent of its polarity. Magnetic fields help protect planets and their inhabitants from solar radiation.

Prior Knowledge

["basic understanding of magnets", "basic understanding of solar activity"]

Recommended Prior Activities

- Build a Magnetometer
- Our Active Sun

Vocabulary

Term	Part of Speech	Definition
cardinal direction	*noun*	one of the four main points of a compass: north, east, south, west.
ferrofluid	*noun*	fluid that becomes magnetized in the presence of a magnetic field.
magnetic field	*noun*	area around and affected by a magnet or charged particle.
nanotesla	*noun*	(nT) unit of measurement for magnetic flux density (magnetic field B), which is magnetic force on a moving charge.
north magnetic pole	*noun*	constantly moving area where compass needles point from all over the Earth.
polarity	*noun*	property of having or being attracted to poles, such as positive and negative electrical charges.
solar radiation	*noun*	light and heat from the sun.
solar storm	*noun*	sudden change in the Earth's magnetosphere, caused by the solar wind interacting with the Earth's magnetic field. Also called a geomagnetic storm.
south magnetic pole	*noun*	constantly moving area where south compass needles point from all over the Earth.
space weather	*noun*	changes in the environment outside the Earth's atmosphere, usually influenced by the sun.

For Further Exploration

Websites

- USGS: Geomagnetism—FAQ
- Nat Geo Movies: Wildest Weather in the Solar System

FUNDER