EARTH SCIENCE FAX!

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Earth's Magnetic Field

Student Laboratory Kit

Introduction

The Earth's magnetic field is all around us! Investigate and explore magnetic fields created by a bar magnet and a simulated Earth.

Concepts

- Magnetic fields
- Magnets
- Poles

Background

A *magnetic field* is the region around a magnet in which a magnetic force is applied to other magnetic materials. The strength of the magnetic field is not constant, but rather gets weaker as distance from the magnetic poles of the magnet increases. (All magnets have two opposite-polarity poles, a north pole and south pole.) When an object such as iron is placed in a magnetic field, excess unpaired electrons in the metal will "line up" with the direction of magnetic field and cause the iron to become magnetic. An example of this effect is illustrated in Figure 1 for the properties of iron. In the absence of a magnetic field, the electrons point in many different directions—the iron is unmagnetized. In the presence of a magnetic field, all the electrons point in one direction and the iron is magnetized.

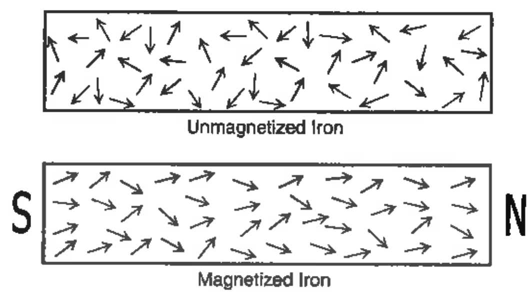


Figure 1.

When the magnetic field is removed, unpaired magnetic electrons will again point in random directions and the material will lose its magnetic property. In order to form a permanent magnet, the potentially magnetic material must be formed or processed in a special way so that the excess magnetic electrons are "locked" into one direction and do not become randomly oriented over time (see Figure 2). The iron in lodestones (the Earth's only naturally occuring magnetic material) became permanently magnetic because the molten iron cooled and hardened while surrounded by the magnetic field of the Earth.

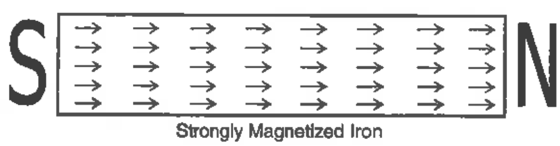


Figure 2.

Scientists believe that Earth's magnetic field is caused by electrical charges that occur deep in the Earth's mantle. The origin of the Earth's magnetic field is not completely understood, but it is thought that the field is formed due to electrical currents caused by the convective rotation of liquid iron and nickel in the Earth's outer core. This process is known as the *dynamo effect.* The magnetic field of the Earth can be compared to that of a bar magnet. The Earth has north and south magnetic poles, just like a bar magnet. If an imaginary line was formed between Earth's north and south poles it would be tilted by 11.5 degrees from Earth's axis of rotation (see Figure 3).

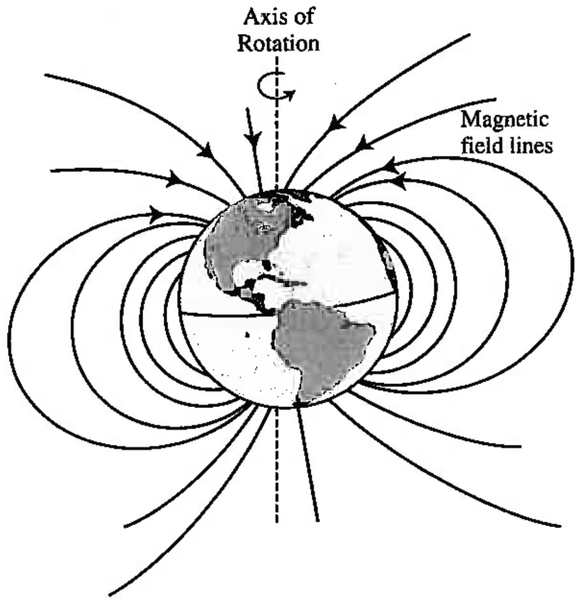


Figure 3.

The actual positions of the Earth's magnetic poles are not always found in the same place. They may wander by as much as 15 km each year! The Earth's magnetic field is constantly changing in size and position. The two poles wander independently from one another and are not directly opposite of each other on the Earth. The Earth's magnetic field can be studied simply by using a compass.

Experiment Overview

The purpose of this activity is to study the interaction of iron filings with a magnetic sphere (as a model for the Earth) and a bar magnet. The magnetic field lines around a bar magnet will also be observed using iron filings.

Materials

- Sphere, magnetic
- Iron filings, 5 g
- Petri dish
- Bar magnet
- Compass
- Index card
- Marker, dry-erase

Safety Precautions

Follow all laboratory safety guidelines. Iron filings can be messy—it is important to neatly collect the iron filings and place them back into the container after the experiment. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Part A. Modeling the Earth's Magnetic Fields

1. Obtain a blue sphere (simulated Earth), a compass, iron filings, and a Petri dish.
2. Add approximately 5 g of iron filings to the bottom of the Petri dish.

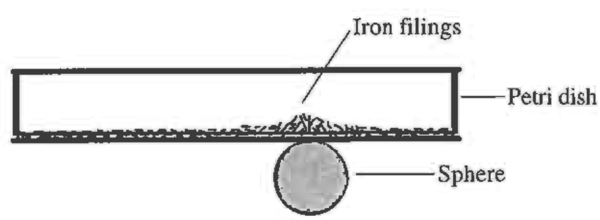


Figure 4.

3. Hold the Petri dish in one hand and the sphere in the other.
4. Place the sphere underneath the Petri dish so that there is direct contact between the sphere and Petri dish. See Figure 4.

5. Rotate the sphere and observe what happens to the iron filings in the Petri dish. Record your observations in the Earth's Magnetic Field Worksheet, Part A.
6. Using a dry-erase marker, mark the locations on the blue sphere where the filings are perpendicular (vertically standing on end) to the sphere. *Note:* The marked locations correspond to the magnetic poles of the sphere.
7. After marking these positions on the sphere, place the sphere under the Petri dish again so that one of the marked spots on the sphere is in direct contact with the Petri dish.
8. Slowly raise the Petri dish above and away from the sphere. Record your observations in the Earth's Magnetic Field Worksheet, Part A.
9. Obtain a compass. Rotate the compass around the sphere. Observe and record the direction of the forces at different points of the sphere in the Earth's Magnetic Field Worksheet, Part A. *Hint:* Pay close attention to the marked poles on the sphere.
10. Using a dry-erase marker, mark "N" for the North Pole and "S" for the South Pole on the sphere. *Note:* The red portion of the compass needle on the compass points North.
11. Answer the *Post-Lab Questions* for Part A.
12. Save the iron filings for use in Part B.

Part B. Bar Magnet and Magnetic Fields

1. Place the bar magnet flat on the table.
2. Following the diagram on the Earth's Magnetic Field Worksheet, Part B, record the direction the red tip of the compass needle points as the compass is moved around the magnet.
3. Obtain an index card, a bar magnet, and the iron filings in a Petri dish from Part A.

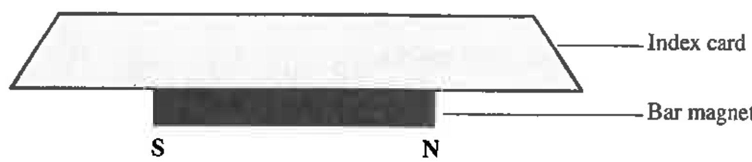


Figure 5.

4. Lay the bar magnet flat on the table and place the index card over the magnet (see Figure 5).
5. Carefully sprinkle the iron filings on the index card. Sprinkle a small amount of iron filings to cover the entire card at first. Then, add more iron filings where lines appear to form. Observe the lines that form as the iron filings line up with the magnetic field of the magnet. Draw the magnetic field lines produced by one magnet in the worksheet.
6. Carefully lift the index card off the magnet, keeping the card horizontal to prevent spilling the iron filings. *Note:* Do not allow the iron filings to contact the bar magnet directly. The iron filings will be difficult to remove once they "stick."
7. Neatly pour the iron filings back into the Petri dish.
8. Answer the questions for Part B.

Name: ______________________________

Earth's Magnetic Field Worksheet

Part A. Modeling the Earth's Magnetic Fields

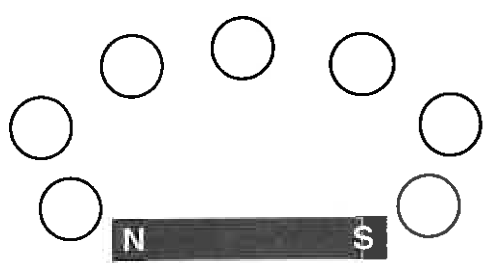
Observations of the interactions of the iron filings and sphere:

Observations when the iron filings are moved away from the poles of the magnetic sphere:

Compass and sphere observations:

Part B. Bar Magnet and Magnetic Fields

Fill in each circle to indicate the direction the red tip of the compass needle points as the compass is moved around the magnet.



Draw the location and appearance of the magnetic field lines around the magnet.

Name: ____________________________

Post-Lab Questions *(Answer on a separate sheet of paper.)*

Part A.

1. Was the magnetic field the same over the entire surface of the sphere?

2. What happened to the iron filings when they were positioned over the poles of the sphere?

3. How were the iron filings arranged in the Petri dish when they were positioned midway between the poles of the sphere?

4. What happened to the iron filings when the Petri dish was moved upwards away from the poles of the sphere? Does this show a change of strength or direction of the magnetic field?

5. What happened to the compass when it was placed directly over the poles of the sphere?

6. Is the magnetic field surrounding the sphere a three dimensional field? Explain your answer.

Part B.

1. How does the direction of the compass needle change as the compass is moved along the magnetic field?

2. How do the iron filings align themselves in relation to the magnetic field? Do the magnetic lines ever cross?

3. Where is the magnetic field the strongest? How can you tell? Compare the strength of the magnetic field to the closeness of the magnetic field lines in that region.