Lab 23 Earth's Magnetic Field

Name: ______________________ Lab Partner(s): ______________________

Driving Question

How can models be used to visualize the magnetic field lines surrounding Earth?

- How does the magnetic field strength vary with different locations on Earth?
- What creates Earth's magnetic field?
- How does Earth's magnetic field help navigators stay on course during their travels?

Background

All magnetic objects produce invisible lines of force connecting their poles. Although Earth's magnetic field might suggest the presence of a powerful bar magnet at its center, no such magnet exists. Instead, Earth's magnetic field arises from complex interactions between convection currents in the molten outer core and the solid inner core, both of which contain large quantities of ferromagnetic metals such as iron, nickel, and cobalt.

The north magnetic pole and the geographic North Pole are distinct. The north magnetic pole is the location where Earth's geomagnetic field points vertically downward, meaning the magnetic dip is 90°. Compass needles generally align with Earth's magnetic poles, but the magnetic and geographic poles are not coincident. In 2025, the north magnetic pole is located at 85.76°N latitude and 139.30°E longitude, whereas the geographic North Pole is defined as 90°N latitude and 0°W longitude (longitude is arbitrary at the poles). Moreover, the north magnetic pole is not fixed—it has wandered roughly 600 miles northward over the past century to its current position in the Canadian Arctic.

Magnetic reversals further illustrate the dynamic nature of Earth's field. Although navigation relies heavily on Earth's magnetism, it is not entirely stable. Lava flows in Oregon indicate that about 16 million years ago, magnetic north shifted as much as 6 degrees per day. Within just over a week, a compass in the United States would have pointed toward Mexico City. Over approximately 1,000 years, the magnetic field fully reversed, with the magnetic north becoming south. Geological evidence, preserved in the paleomagnetic record, shows that such reversals have occurred many times throughout Earth's history. Today, seafloor spreading provides a detailed record of these reversals: by mapping the magnetic polarity of crustal rocks on either side of the Mid-Atlantic Ridge, scientists can determine both the age of the rocks and the rate at which tectonic plates have moved.

Materials

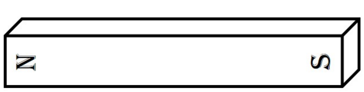
- Magnetic field sensor
- Bar magnet
- Small cork
- Sewing needle
- Pin
- Water, 500 mL
- Clear plastic cup
- Magnetic field demonstrator plate (4), 3D
- Degree wheel template
- Map of Earth template

Safety

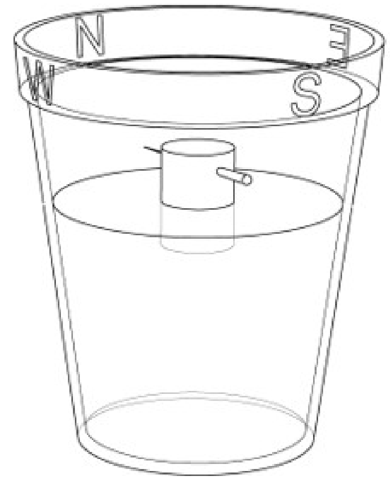
Keep magnets away from electronic equipment.

Part I: Constructing a Simple Compass

1. Magnetize the needle:
   (a) Hold the needle by its eye.
   (b) Hold the bar magnet horizontally by its north end.
   (c) Stroke the needle from the south end of the magnet, moving from the needle's eye to its point. Repeat 40-50 times.
2. Test the needle's magnetism by bringing it near a pin.
3. How can you tell whether the needle has been magnetized?
4. In general, describe how two magnetized objects interact with each other.
5. Determine which end of the needle is north and which is south by placing it next to the bar magnet.
6. Draw a diagram of your needle near the south end of the bar magnet (as pictured below). Label the north (N) and south (S) ends of the needle.



7. Cut a small piece of cork and push the magnetized needle through it.
8. Label a clear plastic cup with the directions N, E, S, and W.
9. Fill the cup with water.

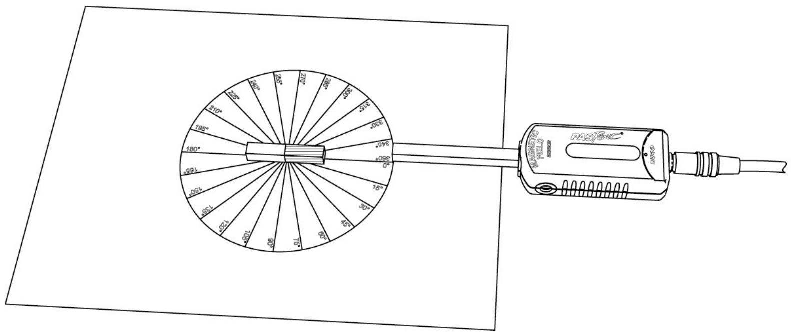


10. Float the cork with the needle in the water.
11. Rotate the cup so that the needle points to N to complete your simple compass.
12. Which end of the needle points toward the north magnetic pole?
13. What does this indicate about the polarity of Earth's north magnetic pole?
14. Is the north magnetic pole the same as the geographic North Pole?
15. How do navigators account for the difference between magnetic north and geographic north?

Part II: Measuring the Magnetic Field of a Bar Magnet

1. Open *SPARKvue* and build a page with a Graph display.
2. Connect the magnetic field sensor.
3. Display the |Resultant| Magnetic Field Strength (mT) on the y-axis of the graph.
4. Place the bar magnet on the degree wheel template so that the north pole on the magnet points to the 0 degree line on the template.

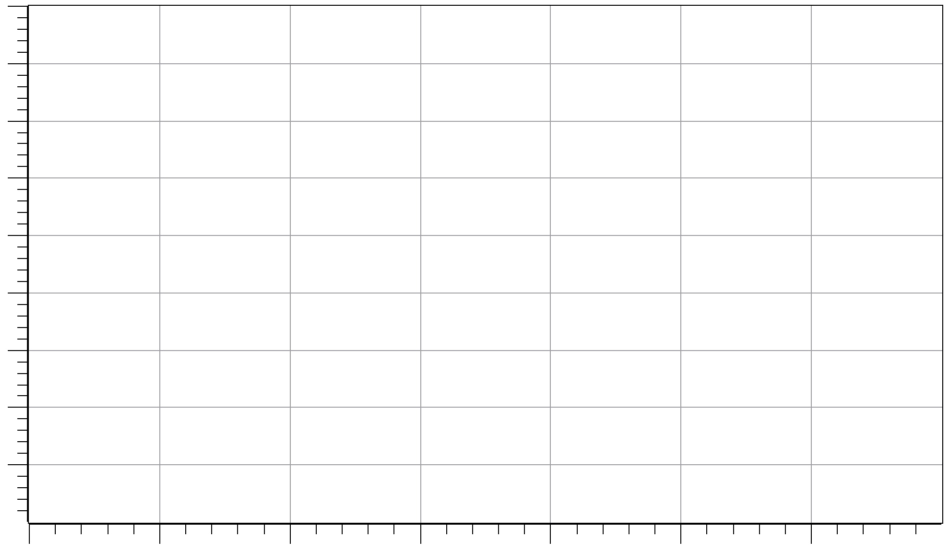
5. Position the magnetic field sensor's tip at the 0 degree line on the template as shown in the diagram. The closer you place it, the stronger the field will be; keep the sensor the same distance from the magnet and in line with the circle.



6. Record the magnetic field strength every 15 degrees starting at the 0 degree mark on the template.

Angle (Degrees)	Magnetic Field (mT)	Angle (Degrees)	Magnetic Field (mT)
0		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

7. Sketch or print a graph of the magnetic field strength (y-axis) vs the angle (x-axis). Be sure to include units and a scale on the graph.



8. Find and label the coordinates of the data point with the highest magnetic strength value and the lowest magnetic strength value.
9. What was the highest and lowest magnetic strength value recorded?

10. At which locations on the magnet was the field strength the greatest? At which locations was it the least?

Synthesis Questions

Use available resources to help you answer the following questions.

1. Is the Earth's magnetic field a static, rigidly set magnetic field like a bar magnet? Explain.

2. Humans use compasses to navigate the world. What other animals use Earth's magnetic field? Explain.

3. How does the magnetic field of the Earth protect the planet in space?

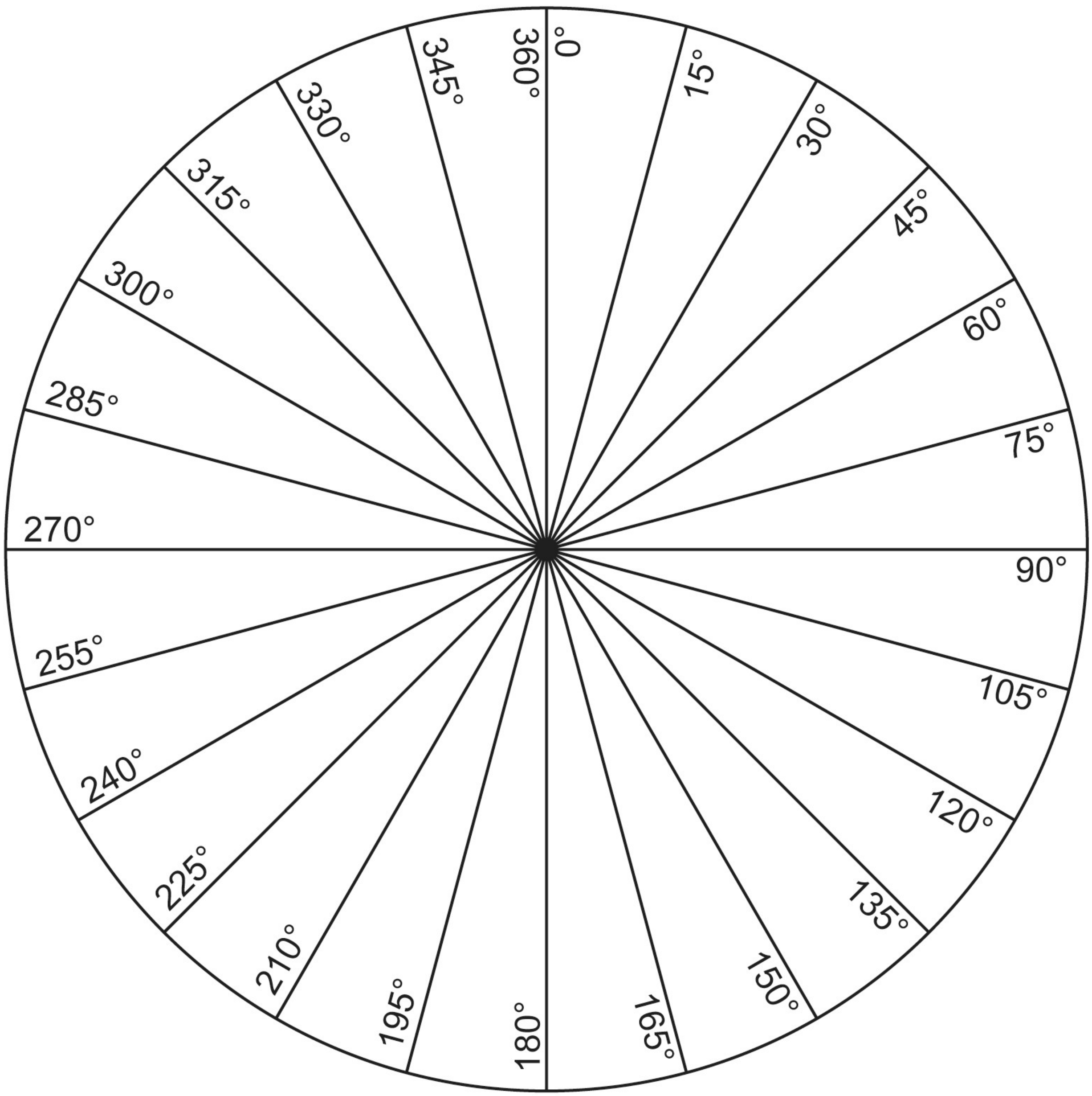
4. What would cause the magnetic field of Earth to disappear altogether? Explain.

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. The needle on a compass points north because the Earth's magnetic field resembles a
   A. Horseshoe magnet
   B. Bar magnet
   C. Refrigerator magnet
   D. Single pole magnet
   E. None of the above
2. Which statement best describes how the strength and direction of a bar magnet's magnetic field varies around the magnet?
   A. Field is strongest near the poles and weaker farther away
   B. Field is strongest at the midpoint and weakest at the poles
   C. Field is uniform everywhere
   D. Field alternates between positive and negative in a regular pattern around the magnet
   E. None of the above

3. Which statement best describes the orientation of magnetic field lines around a bar magnet?
    A. The magnetic field lines resemble straight lines from the north to the south pole in two dimensions
    B. The magnetic field lines resemble straight lines from the north to the south pole in three dimensions
    C. The magnetic field lines form two-dimensional loops from one pole to the other
    D. The magnetic field lines form three-dimensional loops from one pole to the other
    E. The magnetic field lines run perpendicular to the surface of the magnet
4. Which statement best describes the Earth's magnetic field?
    A. The Earth's magnetic field is permanent
    B. The Earth's magnetic field reverses every 1000 years
    C. The Earth's magnetic field has varied in strength and orientation over time
    D. The Earth's magnetic field is static
    E. The Earth's magnetic field varies in strength and orientation with the lunar cycle
5. Magnetic declination:
    A. Varies according to location
    B. Is stronger near the South Pole
    C. Is constant within a hemisphere
    D. Is stronger near the North Pole
    E. Is zero at the Equator



0°
360°
15°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°
180°
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°