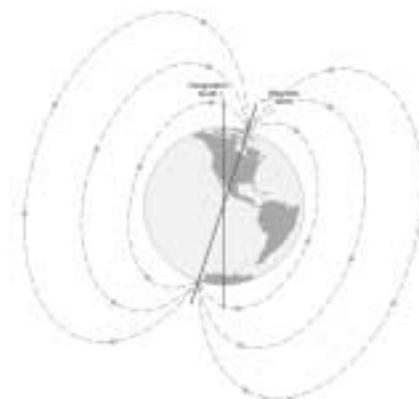


Where IS North?

It depends. Do you mean geographic north or magnetic north? The geographic (true) north pole is the point at 90°N latitude. It is aligned with the rotational axis of the Earth. The Earth is surrounded by a magnetic field with a north and south magnetic pole. The magnetic north pole is the point to which a compass needle points. It is currently in northern Canada, but moves at an average rate of 15 km per year due to complex fluid motion in the outer core of Earth. Depending on your location, the difference between magnetic north and geographic north, called *magnetic declination*, can range from 0° to 30° .



Earth's magnetic field

Similar to a bar magnet, the Earth is surrounded by 3-dimensional magnetic field lines. The field lines of the Earth start near the south pole, curve around in space and converge again near the north pole. A compass needle aligns itself along the direction of the magnetic field lines. *Magnetic inclination*, or dip angle, is the angle that the Earth's magnetic field makes with the horizontal plane at a specified location. Magnetic inclination is 0° at the magnetic equator and 90° at each of the magnetic poles.

The Earth's magnetic field is used by many animals to determine direction. Every location on Earth has its own unique combination of magnetic field intensity and inclination. The Loggerhead turtle detects magnetic field intensity and magnetic inclination and uses this information on its 10 year migration around the Atlantic Ocean. Many birds use both stars and the magnetic field of the Earth to navigate. The birds can detect magnetic inclination. Birds in the northern hemisphere follow a line of decreasing dip angle that guides them on their southerly migration path.

In Part I of this experiment, you will measure the magnetic field of the Earth. You will use this data to determine magnetic north. Knowing the direction of true north, you will calculate the magnetic declination at your location. In Part II you will measure the magnetic inclination of your location.

OBJECTIVES

In this experiment, you will

- Use a Magnetic Field Sensor to measure the magnetic field of the Earth.
- Calculate magnetic declination for your location.
- Measure the magnetic inclination of your location.

Experiment 3

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator	ruler
EasyData application	degree wheel
data-collection interface	pointer
Vernier Magnetic Field Sensor	tape
protractor	

PROCEDURE

Part I Finding Magnetic North

1. Tape the pointer on top of the white dot of the Magnetic Field Sensor and bend it so that it is perpendicular to the sensor as shown in Figure 1.
2. Turn on the calculator. Set the Magnetic Field Sensor to the 0.3 mT position. Connect the Magnetic Field Sensor, data-collection interface, and calculator.
3. Set up the calculator and interface for data collection.
 - a. Start the EasyData application, if it is not already running.
 - b. Select **[File]** from the Main screen, and then select **New** to reset the application.
 - c. Select **[Setup]** from the Main screen, and then select **Events with Entry**.
4. Place the tip of the Magnetic Field Sensor on the center of the degree wheel with the pointer pointing toward 0°. Hold the sensor vertically.
5. Select **[Start]** to begin data collection.
6. Measure the magnetic field at the zero degree position.
 - a. When the magnetic field readings stabilize, select **[Keep]**.
 - b. Enter **0** (the position in degrees).
 - c. Select **[OK]**. You have now saved the first position-magnetic field pair.
7. Rotate the Magnetic Field Sensor so that the pointer points toward 15° and repeat Step 6 entering the current pointer position.
8. Continue taking a data point every 15° until 360° is reached. When data collection is complete, select **[Stop]**.
9. As you move the cursor right and left on the displayed graph, the position (X) and magnetic field (Y) values of each data point are displayed above the graph. Locate the point with the greatest magnetic field intensity. Record the corresponding direction in the data table. This location is magnetic north.
10. Print a copy of the graph as directed by your teacher.



Figure 1

Part II Magnetic Inclination (Dip Angle)

11. Select **(Main)** to return to the Main screen.
12. Place the tip of the Magnetic Field Sensor at the center of the degree wheel with the pointer pointing toward magnetic north. Make sure the sensor is held vertically.
13. Slowly tilt the sensor down in the direction of magnetic north. Monitor the magnetic field intensity at the top of the main screen. Continue to tilt until a maximum reading is displayed. Hold the sensor in that position.
14. Use a protractor to measure the angle between vertical and the Magnetic Field Sensor. This is the magnetic inclination for your location. Record this value.

DATA

Magnetic north direction (°)	
Magnetic inclination (°)	

PROCESSING THE DATA

1. The difference between the measured magnetic north and true north is called magnetic declination. What is the magnetic declination for your location? What modifications would be needed on a compass in your location to keep you on course when following a map?
2. How does the measured magnetic inclination compare with the accepted magnetic inclination for your location?
3. Scientists have found that the magnetic field of the Earth is continually changing. What would be the implications of a big change?

EXTENSION

1. Compare the magnetic declinations of various locations on your continent and discuss the adjustments needed on a compass at each location to stay on course.
2. Research current theories on why the magnetic north pole moves.

TEACHER INFORMATION

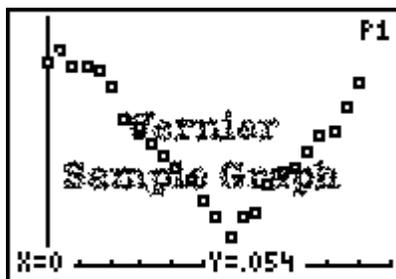
Where IS North?

1. There are several different combinations of equipment that will work for measuring magnetic field strength. The most common method, which uses the USB port on TI-84 Plus calculators, is to connect a Magnetic Field Sensor to an EasyLink. For more information on EasyLink refer to *Appendix F*.

The other method, which works for both the TI-83 Plus and TI-84 Plus families of calculators, is to use a Magnetic Field Sensor attached to a LabPro or CBL 2.

2. Make one copy of the degree wheel and pointer for each student group. Tape the circle to each group's work space with 0° aligned with true north. True north can be located using a GPS or blue prints for your school. If these are not available, you can determine true north by using a compass to find magnetic north, then correct for the magnetic declination. If you don't know the magnetic declination at your location, it can be calculated at several locations on the Internet, including <http://www.ngdc.noaa.gov/seg/geomag/declination.shtml>.
3. The Magnetic Field Sensor needs to remain vertical the entire time during Part I. Students should be careful to keep the sensor centered on the dot.
4. Readings may fluctuate due to deviation, the influence of the immediate environment upon your sensor, caused by things such as electrical currents, computer monitors, or metal brackets. Try to avoid these influences.
5. A paper protractor cut in half makes it easy to measure the magnetic inclination.
6. The magnetic inclination can be calculated using the length of the Magnetic Field Sensor and the distance from the top of the sensor to the table instead of measuring the angle directly.
7. The Magnetic Field Sensor does not need to be zeroed at any time during this experiment since you are looking for a peak reading location rather than the actual magnetic field intensity.

SAMPLE RESULTS



Magnetic north direction ($^{\circ}$)	xxxx
Magnetic inclination ($^{\circ}$)	xxxx

ANSWERS TO QUESTIONS

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.