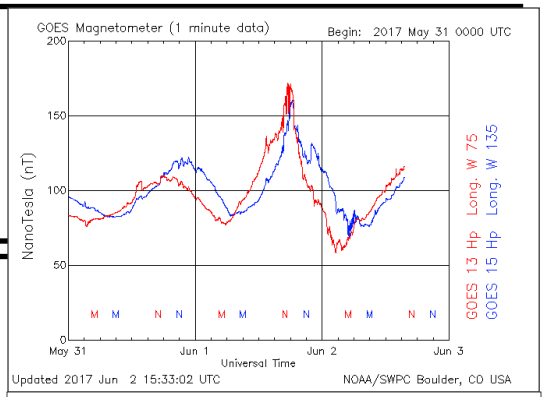
DIY Magnetometer

MATERIALS

1 2-Liter bottle
Sand or other weight
Sewing thread, 1 m in length
Needle
Drinking Straw, 3” in length
Clear tape
Index card
Cow or Bar Magnet
Mirror (3”x5” or smaller)
Laser Pointer
Scissors
Graph paper, in centimeters

Magnetometers measure the strength or direction of magnetic fields. Magnetometers have been installed in places throughout the world to measure and record the Earth’s magnetic field and how it changes.

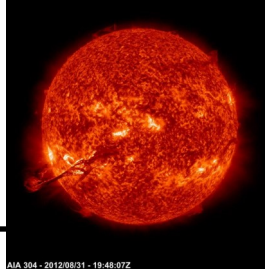


NOAA space weather operations GOES magnetometer provides information on the general level of geomagnetic activity

DIRECTIONS

1. As neatly as possible, cut your bottle into two pieces. Make your cut 1/3 of the way down the bottle (Picture 1), so that the top is smaller than the bottom piece.
2. Fill the bottom of the bottle with 2-3 cups of sand, or other heavy objects like marbles or pennies.
3. Using a needle, or a small nail and hammer, pierce the bottle cap to make a small hole. Twist the cap back onto the bottle.
4. Tape or glue the mirror to one side of the notecard (picture 2).
5. On the other side of the notecard: tape the straw to the top of the card and the magnet to the middle of the card (Picture 2).
6. Run the thread through the straw and then both ends through the small hole in the cap (Picture 3). Threading each end of the thread through a needle will make this easier. Secure the thread by taping it to the bottle cap.
7. Gently place the top of the bottle back onto the sand-filled base. If necessary, adjust the length of the thread holding the notecard so that the notecard does not touch the sand and can swing freely inside of the bottle.
8. Hold a magnet near the bottle and observe the magnet. Move the magnet. Try other magnets.
9. Place your laser pointer on a stack of books so that the beam passes through the bottle and hits the middle of the mirror. Avoid laser heights that will require the beam to pass through a ridge on the bottle. This will distort the laser beam reflection. Adjust the height of the notecard inside the bottle and the laser as needed. Tape down, or use rubber bands, to secure the laser to the stack of books.
10. Place the magnetometer on a sturdy table or on the floor 1 m from a wall. Place the laser 0.3 meters from the magnetometer, and tape the prepared graph paper to the wall behind, as shown. (Safety Tip: Do not place the magnetometer and laser on counters or other surfaces at eye level.)

Picture credits: Lawrence Hall of Science , University of California.
http://static.lawrencehallofscience.org/diy_sun_science/

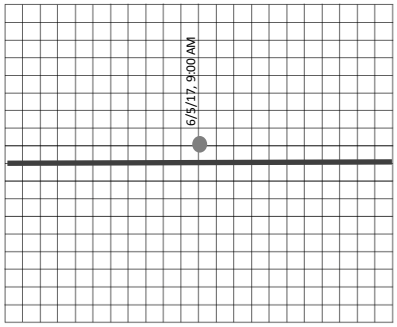


MEASUREMENTS

The magnetometer must be completely at rest before measurements can be taken. Allow the magnetometer to rest for at least 10 minutes. Like any compass, the magnet will align itself with the Earth's magnetic field. When the magnetometer is stable, you will see a stationary dot of reflected laser on the graph paper.

SET UP THE GRAPH PAPER

Turn your graph paper so that it is in the landscape position. Using a ruler, set up a horizontal axis in the middle of the page, marking off centimeters, as shown. On a standard sheet of 8.5"x11" cm-lined graph paper, you should mark off 26 cm.



Find the reflected dot of light on the wall and position the dot in the middle of your axis, around 14 or 15 cm mark, and tape the paper to the wall. (Tip: it will be easier to see the dot and record its position if you project the dot right above the axis.) Mark the dot's position on the paper, label it with the time and date.

TAKING MEASUREMENTS

During the course of this week we will take frequent measurements in order to determine if a solar weather event will occur. To take a measurement, carefully turn on the laser ensuring that you do not bump the table or alter the laser's position. Record the laser's position on the graph paper with a dot, and record the data in a table like the one below. If you miss a reading, leave it blank.

Date	Time	Behavior
6/5/17	9:00 AM	Stationary
	11:00 PM	
	1:00 PM	
	3:00 PM	
6/6/17	9:00 AM	

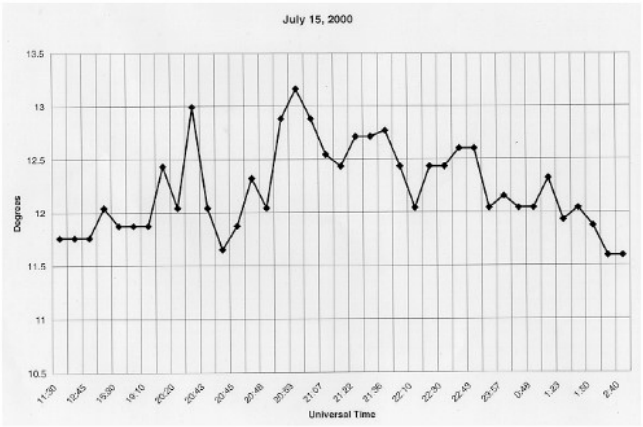
During measurements you may notice that the dot has a variety of behaviors. Most of the time, the dot should be stationary, or unmoving, in which case you should note this in your data table.

Other times you may see that the dot is oscillating. If you are sure that the apparatus has not been disturbed, watch the oscillations and record the range that it swings between (e.g. 13-17 cm).

ANALYZING THE DATA

After several days of measurements, plot your data points on a graph with time on the X-axis and position on axis (in cm) on the Y-axis.

Check any significant displacements in position against the magnetic activity index (Kp Index) to see if you recorded a solar weather event. The Kp index is the average strength of a magnetic storm that is felt at various locations around Earth. This information is updated every 3 hours by magnetometers placed worldwide. You can view the most recent data at: swpc.noaa.gov/products/planetary-k-index



Graph of sample data from *Exploring the Earth's Magnetic Field* curriculum
https://spacemath.gsfc.nasa.gov/NASADocs/magbook2002.pdf

RESOURCES

For more information about the analysis of data collected from magnetometers, visit:

NASA book with Sun-Earth activities for grades 3-12: spacemath.gsfc.nasa.gov/NASADocs/magbook2002.pdf

DIY Sun-Science document about creating your own magnetometer: static.lawrencehallofscience.org/diy_sun_science/downloads/diy_ss_detect_solar_storms.pdf

Real-time space weather conditions: swpc.noaa.gov/products/goes-magnetometer

Projects for school using real solar data: suntrek.org/