Activity 7

The Effect of the Solar Wind on the Geomagnetic Field

Purpose

To monitor changes in the earth's magnetic field and relate these changes to solar events such as flares. Many variations of this design are in use by amateurs because of its simplicity, but now with the availability of inexpensive and sensitive Hall-effect sensors that easily interface to home computers, it should be possible to make more quantitative measurements of changes in the geomagnetic field due to solar wind. By monitoring changes in the geomagnetic field, aurorae and related effects can be forecast and studied.

*This activity is based on the jam-jar magnetometer described by Ron Livesey in the article "A Jam-Jar Magnetometer as 'Aurora Detector' " in the October 1989 issue of *Sky and Telescope*. Another magnetometer is described in the October 1993 issue of *Sky & Telescope*. This device is a bit harder to construct and although it requires some knowledge of electronics, it is suitable for high-school students.

Materials

1 glass jar 80–100 mm in diameter, 200 mm high with a non-magnetic lid

300 mm of thin nylon thread

200 mm of copper wire

1 small glass mirror approximately 5 mm wide by 10 mm tall painted flat black with a 1 mm wide clear slit in the center (a first surface mirror is best but standard mirror glass will be OK)

1 small bar magnet 20-mm to 30-mm long

cardboard and glue

ruler or meter stick

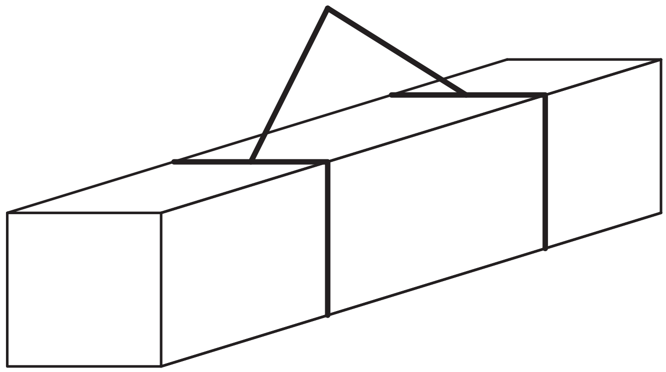
light source such as a flashlight, or a laser

A 1-m by 0.5-m vibration-free location, away from electrical and magnetic interference

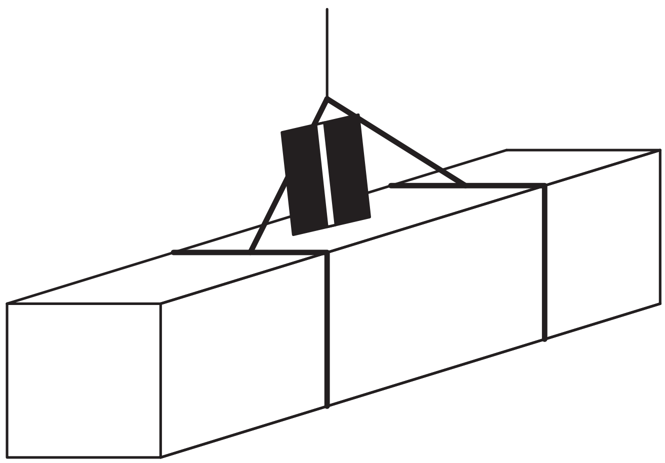
Procedures

Assembly

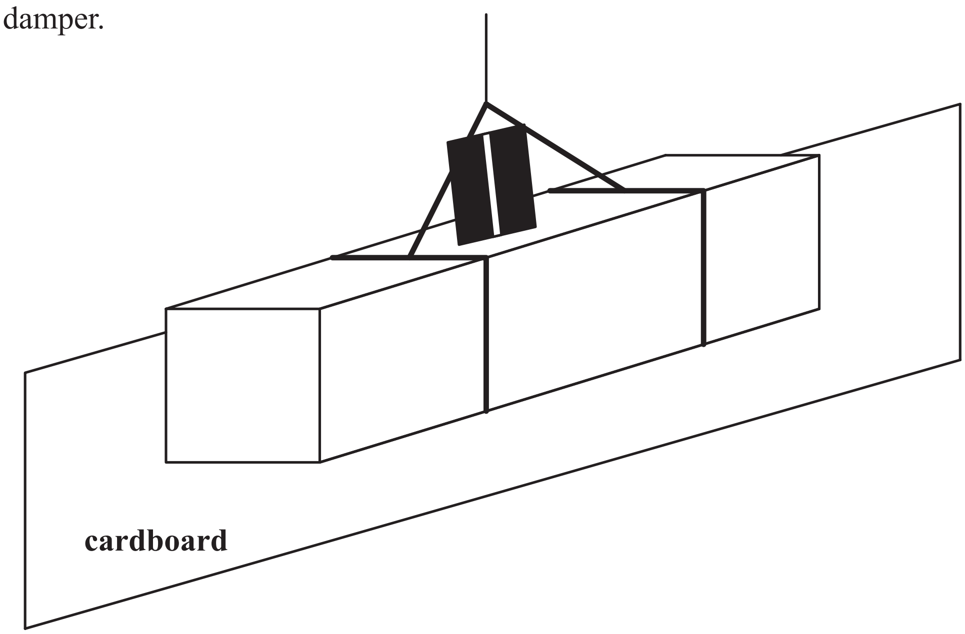
1. Use the copper wire to form a cradle for the magnet as shown:



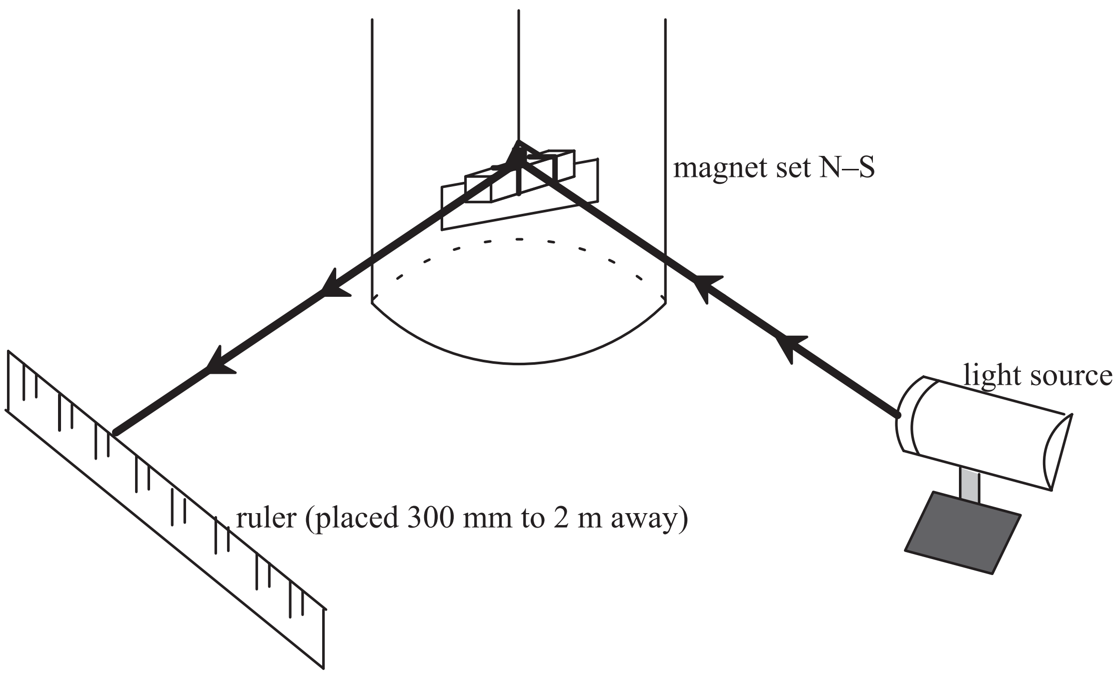
2. Tie one end of the nylon thread to the cradle and glue the mirror onto the top of the magnet against the cradle wire. Make sure the unpainted slit is vertical.



3. Glue a rectangle of cardboard to the back of the magnet to act as an air damper.



4. Drill or punch a small hole into the center or the jar lid and pass the free end of the nylon thread through it from inside.
5. When the magnet unit swings freely inside the jar with the lid in place, glue the thread to a toothpick or match on the lid.
6. Use a laser light or prepare a light source by cutting a mask with a narrow slit using razor blades or small squares of aluminum cut from a soda can to make a narrow beam.
7. Set up the apparatus as shown. It could be mounted on a board or table for less set up time when used.



Using the magnetometer: Since many factors can affect the orientation of the magnet, including cars, tools, appliances, vibrations, etc., realize that this device is made to detect changes in the direction of the geomagnetic field and not give a quantitative measure of strength.

1. Set the light to produce a bright spot on the ruler (not close to an end). Record the reading, date, and time.
2. Record data again later, making sure that no part of the apparatus has been moved. Record data hourly, unless you suspect that a magnetic disturbance is occurring, then more frequent readings should be taken.
3. In order to make the scale readings more useful and easier to compare with others' observations, it's best to convert the bar magnet's deflection change to an angular value. Using L as the distance from the mirror slit to the scale and S as the scale reading, then

$$D = 1719 \times \frac{S}{L}$$

*(D is given with formula in minutes of arc.)

4. Convert the time to UT, Universal time, and make a plot of D vs. UT.
5. Relate the data you've collected to the published information on solar flare activity and/or the reported auroral sightings.
6. To get an idea of the relative sensitivity of your instrument, move around an iron bearing object or another magnet at different distances from the magnetometer and careful note any deflection. Is it possible to show the inverse-square law for magnetic field strength with this device?

*Some simple geometry and the law of reflection will show that a deflection of D in the magnet will produce a 2D deflection at the scale.

Then, in radians,

$$2D = \frac{S}{L}$$

or $$D = \frac{S}{2 \times L}$$

Converting to arc min:

$$D = \frac{S}{2 \times L} radians$$

Therefore

$$D = 1719 \times \frac{S}{L}$$