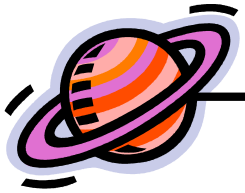


Terra Bagga

Middle/high school grades

Lesson Summary
Students will build a simulated planet with a magnetic field. They will use a simple magnetometer to determine the orientation of the "planet's" magnetic field.

Prior Knowledge & Skills
- Magnetism
- Characteristics of planets

AAAS Science Benchmarks
The Physical Setting
Forces of Nature
The Earth
The Nature of Technology
Technology and Science

NSES Science Standards
- **Physical science:** Properties and changes of properties in matter (5-8), Motions and forces, Structure and properties of matter (9-12)
- **Science and technology:** Understandings about science and technology
- **Earth and Space Science:** Structure of the Earth system (5-8), Energy in the Earth system (9-12)
- **Unifying concepts and processes:** Evidence, models and explanation

Why Do We Care?
Scientists study magnetic fields to learn more about the planets that produce them. To make a magnetic field, a planet needs to have some magnetic material inside it (say, iron) and a way to produce currents in that material (in the Earth's case, the iron core can have a moving current because it is still molten.) In our solar system, only Mercury, Earth, Jupiter, Saturn, Uranus, and Neptune have magnetospheres. A planetary magnetosphere may be critical to the development of life, as it protects life from dangerous charged particles spewed out by the sun.

Teaching Time: One 45-minute period

Materials
Each group will need
- 1 paper grocery bag made from recycled materials
- 1 plastic grocery page (optional)
- 1 dead D-size battery
- 2 ceramic donut magnets, 1 and 1/8 inch in diameter
- Masking tape
- 3 rubber bands (size 64 will work best)
- Marker or thick pen
- Magnetometer instrument
- Data recording worksheet
- Student instruction sheet

Advanced Planning
Preparation Time: 30 minutes
1. Gather materials
2. Copy worksheets
3. Review background information
4. Review lesson plan

Suggested background reading
Secrets of the Deep

LASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
UNIVERSITY OF COLORADO AT BOULDER

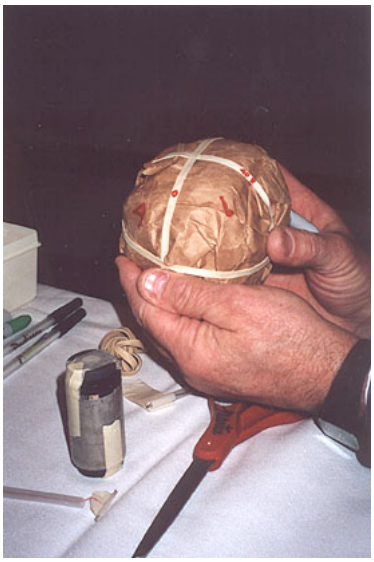
Terra Bagga Activity Using a Magnetometer

Summary
Students will build a simulated planet with a magnetic field. They will use a simple magnetometer to determine the orientation of the "planet's" magnetic field.

Source
Adapted from a TOPS Terra Bagga activity by Dave Mastie (Ann Arbor, MI).

Grade level
5-12

Time
30-45 minutes



Student Learning Outcomes

- Students will construct a simulated planet with a magnetic field.
- Students will be able to label the equator and lines of longitude on a globe.
- Students will determine the orientation of a magnetic field using a magnetometer.

Lesson format
Model/Hands-on Activity/Discussion

National Standards Addressed

- K-12: Unifying Concepts & Processes
  Standard: Evidence, models, and explanation
- K-4: Content Standard B: Physical Science: Light, heat, electricity, and magnetism
- K-4: Content Standard D: Earth and Space Science: Objects in the sky
- K-4: Content Standard E: Science and Technology: Understanding about science and technology
- 5-8: Content Standard B: Physical Science: Properties and changes of properties in matter & Motions and forces
- 5-8: Content Standard D: Earth and Space Science: Structure of the earth system & Earth in the solar system
- 5-8: Content Standard E: Science and Technology: Understandings about science and technology
- 9-12: Content Standard B: Physical Science: Structure and properties of matter & Motions and forces

- 9-12: Content Standard D: Earth and Space Science: Energy in the earth system
- 9-12: Content Standard E: Science and Technology: Understandings about science and technology

MATERIALS AND WORKSHEETS

- 1 paper grocery bag made from recycled materials (these bags will break down the best)
- one plastic grocery bag (optional)
- 1 dead D-size battery
- 2 ceramic donut magnets, 1 and 1/8 inch in diameter
- masking tape
- 3 rubber bands (size 64 will work best)
- marker or thick pen
- magnetometer instrument (see Magnetometer Activity, http://www.windows.ucar.edu/tour/link=/teacher_resources/magnetism/teach_magnetometer.html, for instructions about building a simple, inexpensive magnetometer)

Worksheets

- Worksheet for recording data about magnetic fields of "planets" that students explore
- Instructions about building Terrabagga for Students

DIRECTIONS

Overview: Students will build a simulated planet with a magnetic core. The core will consist of a battery with "donut" magnets taped onto the ends, creating the equivalent of a larger bar magnet. The core will be wrapped in a crumpled paper bag (the bulk of the "planet"). The bag will be held shut by rubber bands, which will also serve as latitude and longitude lines dividing the "planet" into eight segments. The students will use a magnetometer to determine which octant of the planet the north and south magnet poles are beneath. They will record this info, then swap planets with other groups so they can repeat the "finding the poles" process on several different "planets".

Refer to our Terrabagga photos to see pictures of the stages of this procedure: http://www.windows.ucar.edu/tour/link=/teacher_resources/terra_photos.html

1. You may wish to demonstrate the process of building a "planet" and finding the orientation of its magnetic field to your students first, and then having them do the process themselves.

2. The first step in building a "planet" with a magnetic field in it is to create the dipolar magnet that will go inside the world. Take the two magnets and place them on top of each other so that the magnets are attracted to each other. Now without flipping either magnet over, place the top magnet on the top of the battery. Tape this magnet in place. Place the bottom magnet on the bottom of the battery (remember, the side that was facing up, should now be against the casing of the battery). Tape this magnet in place.
3. Next turn the paper bag inside out. This creates a clean surface that will be labeled later on. Work the bag by crumpling it and folding it.
4. When the bag is turned inside out and is pretty workable, place your battery (with the magnets taped on) inside the paper bag. It does not matter which way the battery is facing. Work the paper bag around the battery to create a nice smooth (fairly round) world. Try to center the battery/magnet in the middle of the "planet". If one pole is too close to the surface, the opposite pole may be buried too deeply to sense with the magnetometer. You may wish to use the optional plastic bag to add extra padding to the "planet's" interior to help center the magnetic core, or you may want to "double-bag" the "core" to accomplish the same result (i.e. first wrap the plastic bag around the "core", then surround both with the paper bag).
5. Now it's time to put the rubber band markers on your world. The first rubber band can just be placed wherever it's most needed to hold your world together. Just stretch the rubber band around your world.

6. Now stretch one more rubber band across your world. This rubber band should meet at right angles with the first rubber band so that your world is now split into 4 equal segments. Pick one of the intersections of your two rubber bands to be the geographic north pole. Make sure the north pole is facing up.
7. Now it's time to label parts of your world. Note that the rubber bands make a "X" when looking down on the north pole. The four "branches" represent four lines of longitude separated by 90°; the prime meridian at 0°, 90° west longitude, the international dateline at 180°, and 270° west longitude (which is the same as 90 east longitude). Pick one of the two rubber bands to label first (either one - it doesn't matter which you do first). Use the marker to write a zero on the rubber band on one side of the North Pole, then write "180" on the same rubber band on the opposite side of the North Pole.
8. Now turn your world so that you are looking at the prime meridian (the line of zero longitude) with the "North Pole" up. Everything east (right) of the prime meridian all the way to the international dateline is the eastern hemisphere. Everything west (left) of the prime meridian all the way to the international dateline is the western hemisphere. Label the part of your (unlabelled) rubber band that lies in the eastern hemisphere 90 E, because it represents the longitude of 90 degrees east. Label the part of that same rubber band that lies in the western hemisphere, 90 W, because it represents the longitude of 90 degrees west.
9. Next add the third rubber band to your world. This rubber band should stretch across both of the other rubber bands meeting those rubber bands at right angles. This rubber band is your world's equator, so it should be stretching across the middle of your world. Once that rubber band is in place, label that rubber band "equator". Everything above equator towards the geographic north pole is the northern hemisphere and everything to the south of the equator is the southern hemisphere. Your world should now have eight equal segments.
10. It's time to label the 8 segments. The segments in the northern hemisphere should be labeled 1-4 with segment 1 being between 0 and 90 E. Segment 2 is then between 90 E and 180, segment 3 is between 180 and 90 W and segment 4 should end up being between 90 W and 0. The segments in the southern hemisphere should be labeled 5-8 with segment 5 being below segment 1 and so on so that segment 8 is below segment 4.
11. Have students make up a name for their "planets". Have them write the "planet's" name on the "planet" somewhere (at the geographic south pole would be good).
12. Students should use their magnetometer to test where the magnetic north pole of their world is. The magnetometer end labeled north should dramatically point in where the magnetic north pole of their world is. Have

the students write the segment number where they find the magnetic north pole of their world onto their student worksheet. Have them follow a similar process to locate the magnetic south pole of their "planet".

13. Have student groups trade planets. Students should use their magnetometers to locate the north and south magnetic poles for several planets and record that information on their student worksheets.

ASSESSMENT

- Check to see whether students correctly labeled the rubber bands representing longitudinal meridians and the equator to assess their understanding of these geographic concepts.
- Check whether students understand that magnets have opposite north and south poles. See if the students correctly labeled the poles on the "planet" they created.
- Check whether students correctly used their magnetometers to find the north and south magnetic poles of the other worlds they explored (the ones created by other student groups).

BACKGROUND INFORMATION

This activity requires use of a magnetometer. See the Magnetometer Activity link for instructions about building a simple, inexpensive magnetometer.

Have students work in groups of 2-3 for this activity.

The instructions to students for this activity are written at a level that may not be suitable for younger students. If you teach elementary-aged students, you may need to revise the instructions or provide them verbally to your students. Also, teachers of younger students may wish to revise this activity by building the Terrabaggas for the students and simply having the students test the pre-assembled planets to determine the directions of their magnetic fields.

The dead D-size batteries in this lesson are used for their steel casing. Most recycling centers that have battery recycling will gladly let you take a bagful of dead D batteries home with you for free. The battery with the donut magnets taped on create the "bar magnet" found in the core of many of the planets and moons. The donut magnets used for this activity can be found at Radio Shack stores across the nation. These magnets have a definite north and south pole - with the top face of the magnet being one polarity and the bottom face of the magnet being the opposite polarity!

This activity brings up many interesting points of discussion. You may choose to discuss with your students lines of longitude and lines of latitude. You may choose to discuss why geographic and magnetic poles don't always line up. Or you may choose to discuss what a magnetic field around a planet or moon tells us (magnetic fields point to convection of molten material in a body's interior and this in turn could mean the body has tectonic activity or volcanic activity). It is at least important for the students to know that most planetary space missions carry magnetometer instruments. The magnetometer instrument the students built and

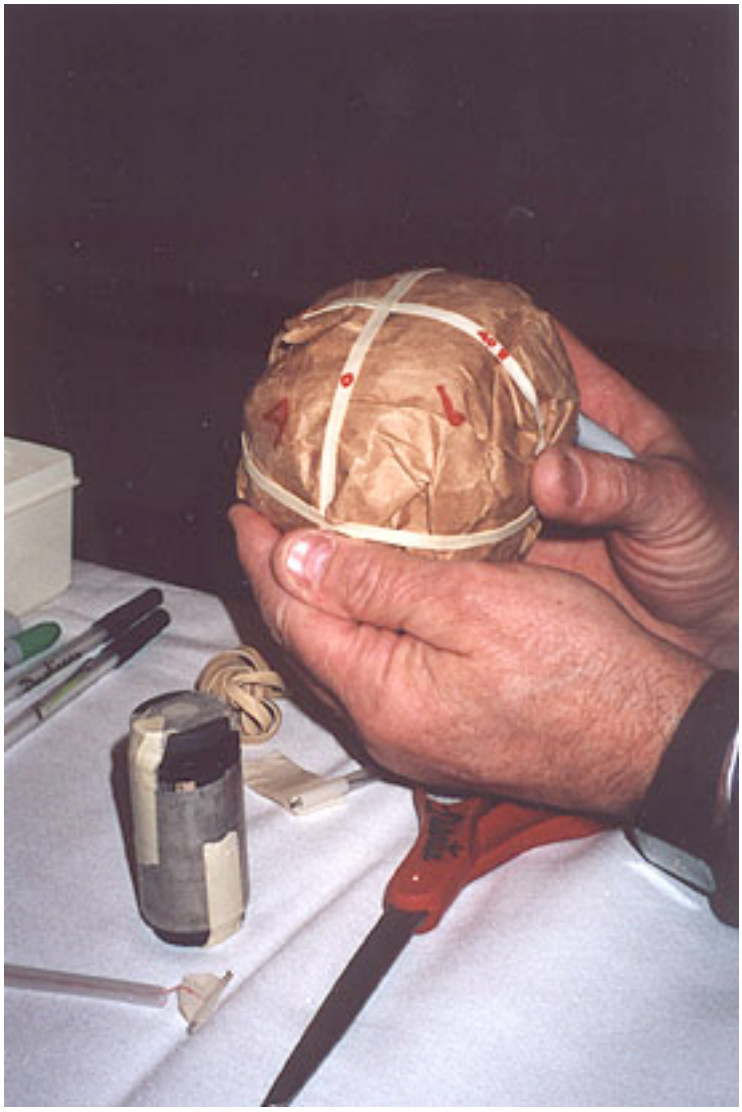
used is just a simplification of the magnetometer instruments that get launched into space onboard spacecraft headed to Mars, Jupiter and beyond!

Terrabagga Worksheet
Names of Members in Group:_____

Results

Name of the World	Segment number where magnetic north pole was found	Segment number where magnetic south pole was found

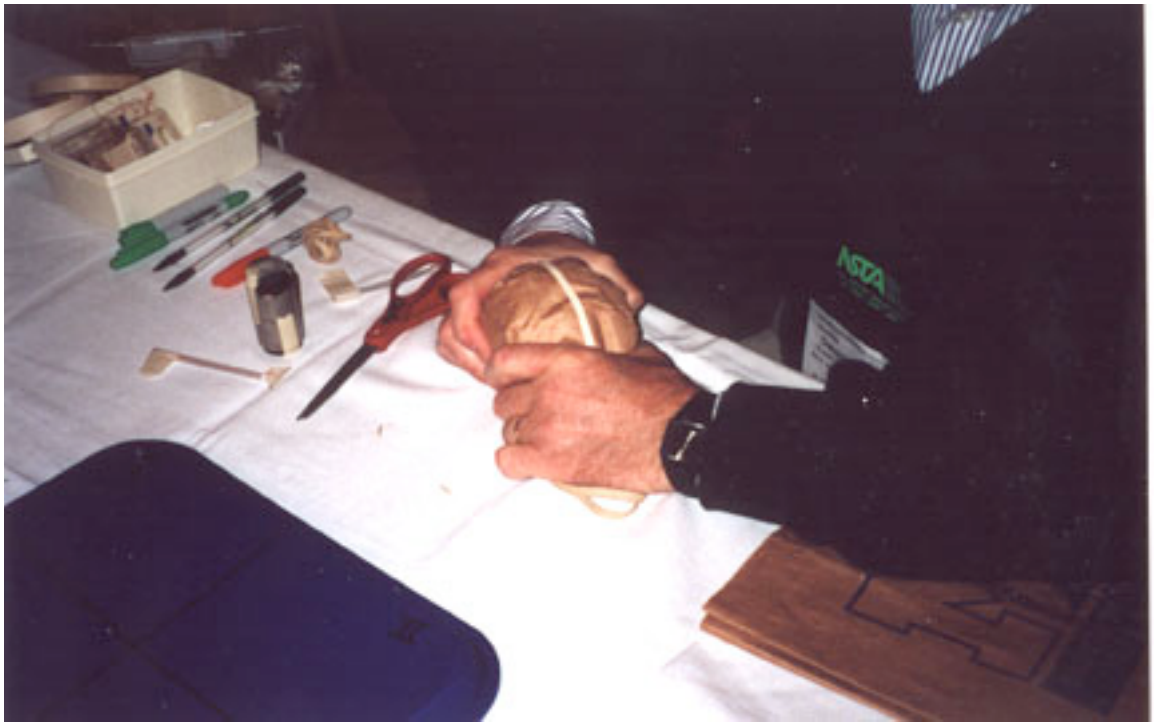
Terrabagga Photos



This picture shows all of the materials needed for each group to build its own world: a paper grocery bag, a dead D-size battery, 2 ceramic donut magnets, masking tape, 3 rubber bands, a marker, a magnetometer instrument.

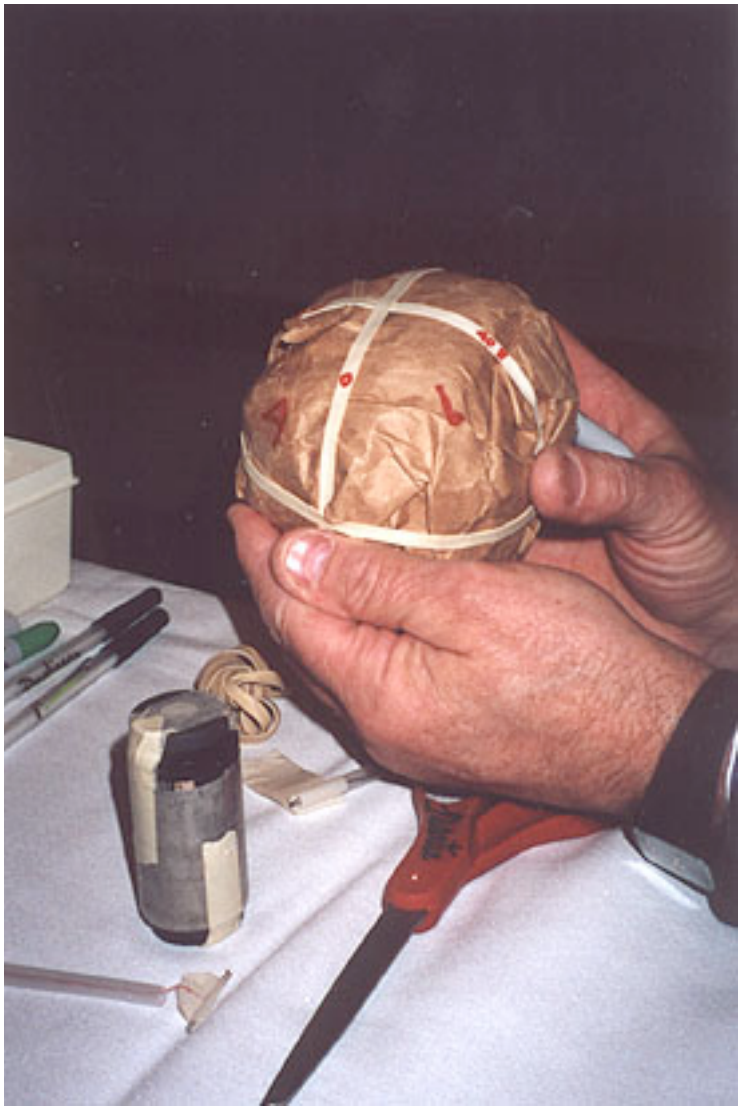
The first step in building a world with a magnetic field in it is to create the dipolar magnet. Take the two magnets and place them on top of each other so that the magnets are attracted to each other. Now without flipping either magnet over, place the top magnet on the top of the battery. Tape this magnet in place. Place the bottom magnet on the bottom of the battery (remember, the side that was facing up, should now be against the casing of the battery). Tape this magnet in place. Now turn your paper bag inside out!

Place your battery inside the paper bag now. Work the paper bag around the battery to create a nice smooth world.



Now it's time to put the rubber band markers on your world. The first rubber band can just be placed whereever it's most needed to hold your world together.

The two other bands should meet at right angles with the first rubber band.



Now it's time to label your world.

Here you can see the magnetometer instrument pointing at the south pole of the world that was just made.

The south pole for this world ended up being in the segment #1.