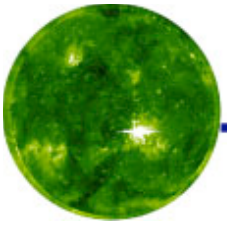

Measuring the Interplanetary Magnetic Field

Middle School Grades

Lesson Summary
Students design an experiment to measure the magnetic field of the Earth using a bar magnet and compasses

Prior Knowledge & Skills
Completed the lesson:
- *Learning about Space Weather*

AAAS Science Benchmarks
The Nature of Science
Scientific Inquiry
The Physical Setting
The Universe
Motion
Forces of Nature

NSES Science Standards
Science as Inquiry
Abilities to do Scientific Inquiry
Understandings of Scientific Inquiry
Physical Science
Motions and Forces
Earth and Space Science
Earth in the Solar System
Science and Technology
Understandings about Science and Technology
History and Nature of Science
Science as a Human Endeavor
Nature of Science

Teaching Time: One to two 45-minute periods

Materials per Team
- Bar magnet, 100 mm x 7 mm (2)
- Small magnetic compasses (4)
- Paper clips (20)
- Small box (6"x 3"x 3") (1)
- Construction paper
- Aluminum foil
- Wax paper
- Newspaper
- Tape
- Glue
- Scissors

Advanced Planning
Preparation Time: 20-30 minutes
1. Read and review the lesson plan
2. Gather required materials
3. Form student teams

Exploring Magnetism, pp. 3-7 to 3-9, UC Berkeley (2004)
http://cse.ssl.berkeley.edu/impact/magnetism/flash/mag_flash.html

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Activity 2: Measuring the IMF

In this activity, your students will discuss how they would measure the Interplanetary Magnetic Field (IMF). They will experiment with different ways of measuring Earth's magnetic field direction using a compass that is in some way attached to a box with a strong magnet inside. Earth's magnetic field represents the interplanetary magnetic field and the box with a magnet represents a spacecraft with currents inside. The currents inside the spacecraft create a magnetic field stronger than the magnetic field of the interplanetary magnetic field, just as the magnet inside the box has a stronger magnetic field than Earth's magnetic field.

The day before this activity, you can have your students bring materials in from their home that they might want to use in their experiment, such as a cardboard box, cardboard, aluminum foil, or newspaper.

This is an inquiry activity, so you should not reveal to the students how scientists and engineers have solved the puzzle. Emphasize to the students that they are to experiment and come up with their own ideas. To learn more about how scientists and engineers design a spacecraft boom so that the spacecraft magnetic fields do not interfere with the experiment to measure the IMF, see the Background Material section. In addition to a boom, engineers sometimes also use "mu-materials" to shield magnetic fields from motors. These materials are not readily available for the classroom, however.

Materials Needed (per group of students)

- 2 Alnico bar Magnets
- 4 small compasses
- 20 paper clips
- 1 small cardboard box (about 6x3x3" in size)
- Construction paper
- Aluminum foil
- Wax paper
- Newspaper
- Scotch tape
- Glue
- Scissors

16. Tell the students to imagine that they are NASA scientists who want to better understand the Interplanetary Magnetic Field (IMF). They want to learn more about the magnetic fields that are ejected from the sun. Ask the students: "How would you measure the IMF?" Continue probing until someone suggests that they would put a satellite into space with some way to measure the magnetic field direction (such as using a compass). [If a student asks why we have to go to space to measure the IMF, explain that the IMF at Earth's distance from the sun is 10,000 times less strong than Earth's own magnetic field and

there are continuous variations in Earth's magnetic field that are much larger than the IMF strength.]

17. Tell the students that an instrument to measure magnetic fields is called a magnetometer. This word can be broken down into its two basic parts: magnet and meter, meter meaning a device used to make measurements. A compass is a very simple magnetometer; it is also an incomplete magnetometer since it cannot measure the strength of the field.

Designing an experiment to measure the IMF

18. Tell your students that they will now design a simplified experiment to measure the IMF. Explain the puzzle that scientists and engineers have when they want to measure the interplanetary magnetic field (IMF): The electricity on the spacecraft that is needed to run the instruments creates a magnetic field (see Figure 3.5). This magnetic field is stronger than the interplanetary magnetic field. If they put their magnetometer on the spacecraft body, called a "spacecraft bus," they will measure the magnetic field of the spacecraft and not of the IMF.

19. Tell the students that they will solve this puzzle by pretending a box with a magnet inside is the spacecraft and Earth's magnetic field is the IMF. They will have available many materials to use for their designs, such as construction paper, aluminum foil, tape or glue, a compass, and any other materials they have brought from home.

20. Next, have your students get into groups. Each group should have a small box (on the order of a 6x3x3" box), a strong bar magnet, and several compasses. Have each group put the bar magnet inside the box and close the box.

21. Now tell the students that they have to solve the same puzzle that the scientists and engineers have to solve when they want to measure the IMF: they must somehow attach the compass or compasses to the box but they have to measure the direction of Earth's magnetic field and not the magnetic field of the bar magnet inside the box. To solve this puzzle first they must answer the question: "How would you determine which magnetic field you are measuring (Earth's or the bar magnet)?" Have a small discussion so that the students understand the question.

22. Next ask the students: "How might you design your experiment to keep the

compass attached to the box, but make sure the compass is measuring Earth's magnetic field and not the magnetic field of the bar magnet inside the box?" Again have a short discussion so that students understand the question.

23. Now have the students discuss with the others in their group what experiment they are going to design and how they will determine what magnetic field direction they are measuring (students should use worksheet 3.1).

24. After the groups are finished deciding their approach to the puzzle, give them at least 30 minutes to experiment and build their design.

25. Tell them that they will share their discoveries with the class in the next class period (activity).

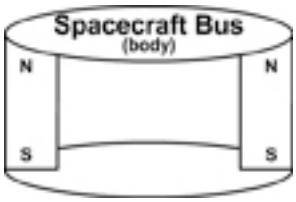
Worksheet 3.1

Name:_____

Date:_____

1.

Draw a design of your magnetometer (instrument to measure a magnetic field) system, which will measure the interplanetary magnetic field (IMF). Your magnetometer has to be attached in some way to the spacecraft bus, drawn for you below. Indicate what materials you will use on your design.



2.

Write down why you designed the magnetometer experiment the way you did. Why did you choose particular materials? Why did you put the magnetometer where you did?