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Educational Product	
Educators	Grades 3–5

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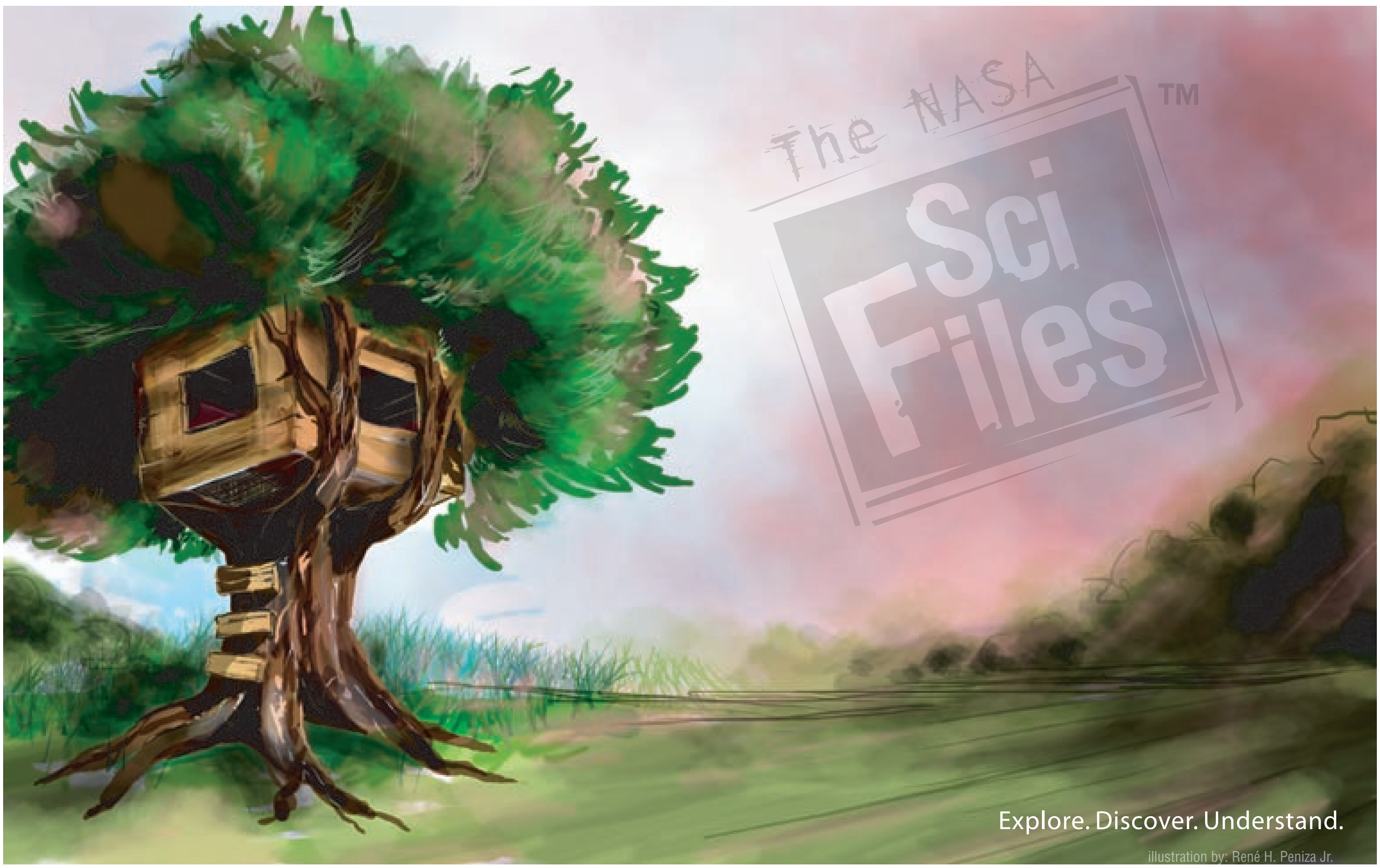
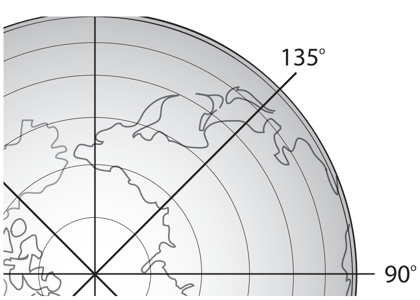
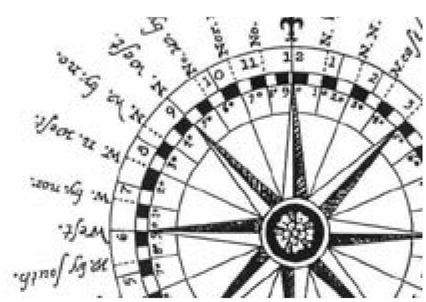
The NASA Sci Files™

The Case of the Technical Knockout

An Educator Guide with Activities in Mathematics, Science, and Technology







student activities begin on page 19

The Case of the Technical Knockout educator guide is available in electronic format.
A PDF version of the educator guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site:
http://scifiles.larc.nasa.gov

www.swe.org

www.sbo.hampton.k12.va.us

www.buschgardens.com

www.cnu.edu

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The NASA SCI Files™

The Case of the Technical Knockout

An Educator Guide with Activities in Mathematics, Science, and Technology

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For additional information about the NASA SCI Files™, contact Shannon Ricles at (757) 864-5044 or **s.s.ricles@larc.nasa.gov**.

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Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail **kimlien.vu@swe.org** or visit the NASA SCI Files™ web site **http://scifiles.larc.nasa.gov**

The NASA Sci Files™

Program Overview

Armed with Global Positioning System (GPS) receivers, compasses, maps, and travel bugs, the tree house detectives set off to do some "geocaching" in the national parks of Virginia. Unexpectedly, while trying to find their first cache, their GPS devices begin to give multiple coordinates, and the detectives think they might be lost. When they try to radio home base, they find that their two-way radios are also on the blink. Then, as quickly as the strange phenomenon began, it ends, and the detectives are back on track. They are concerned, however, that if the GPS and radio malfunctions occur again, they might not be so lucky. The detectives decide that they must solve this mystery and discover what caused their radio and GPS glitches. Their first stop is NASA Langley Research Center to speak with Charles Cope, a NASA pilot, to learn more about how a GPS is used for navigation. The next stop is a videoconference with Dr. D, who just happens to be in Oslo, Norway at the Viking Ship Museum. Dr. D tells the detectives how explorers have navigated around the world for thousands of years by using the stars, lodestones, and Iceland spar. Finally, they decide to prepare for their next expedition and head to the store to find a container for their cache.

Meanwhile, Tony and Catherine visit NASA Langley Research Center to talk to Mr. George Ganoe to learn more about a GPS and how it works. After speaking with Mr. Ganoe, the detectives decide that it probably wasn't the GPS satellite system that caused their problems. They begin to think that it might have something to do with radio waves, so they ask two of the NASA SCI Files™ Kids' Club members, Ole and Nina, to talk with Dr. D, who meets Ole and Nina at the ALOMAR Observatory in Andenes, Norway, where he explains the electromagnetic spectrum. Back in the U.S., Tony heads to Colorado and on the way stops by the University of Colorado to visit Dr. Fran Bagenal to learn more about electricity.

Still undecided about what might have caused the GPS and radio glitches, the detectives contact Ole and Nina to meet Dr. D again to learn about magnetism. Dr. D meets them at the Northern Lights Museum, where he performs several demonstrations and discusses how the Earth's magnetic field interacts with light particles coming from the Sun. To learn more about electromagnets, the tree house detectives dial up Mr. Jacobsen's class at Andenes Ungdomskole (middle school) in Andenes, Norway. Last stop for the detectives is NASA Goddard Space Flight Center in Greenbelt, Maryland, where RJ and Catherine talk with Dr. Nicky Fox to learn more about our star, the Sun.

Trying to put the final pieces of the puzzle together, the tree house detectives dial up Dr. Sten Odenwald to learn about solar flares, coronal mass ejections, and how they affect our Earth. To confirm their hypothesis, the detectives send Tony to visit Joe Kunches at the National Oceanic and Atmospheric Administration (NOAA) to learn more about space weather. At last the detectives think they know why their GPS receivers and radios went on the blink and had a few glitches. To wrap up the problem, they head to the airport to meet Dr. D as he returns from Norway.

National Science Standards (Grades K-4)

STANDARD	SEGMENT			
Unifying Concepts and Processes	**1**	**2**	**3**	**4**
Systems, orders, and organization	•	•	•	•
Evidence, models, and explanations	•	•	•	•
Change, constancy, and measurement	•	•	•	•
Evolution and equilibrium	•	•	•	•
Form and function	•	•	•	•
Science and Inquiry (A)				
Abilities necessary to do scientific inquiry	•	•	•	•
Understandings about scientific inquiry	•	•	•	•
Physical Science (B)				
Properties of objects and materials	•	•	•	•
Position and motion of objects	•	•	•	•
Light, heat, electricity, and magnetism	•	•	•	•
Earth and Space Science (D)				
Properties of earth materials	•	•	•	•
Objects in the sky	•	•	•	•
Changes in earth and sky	•	•	•	•
Science and Technology (E)				
Abilities of technological design	•	•	•	•
Understandings about science and technology	•	•	•	•
Abilities to distinguish between natural objects and objects made by humans	•	•	•	•
Science in Personal and Social Perspective (F)				
Changes in environments	•	•	•	•
Science and technology in local challenges	•	•	•	•
History and Nature of Science (G)				
Science as a human endeavor	•	•	•	•

National Science Standards (Grades 5-8)

STANDARD	SEGMENT			
Unifying Concepts and Processes	1	2	3	4
Unifying Concepts and Processes	•	•	•	•
Systems, order, and organization	•	•	•	•
Evidence, models, and explanations	•	•	•	•
Change, constancy, and measurement	•	•	•	•
Form and function	•	•	•	•
Science as Inquiry (A)				
Abilities necessary to do scientific inquiry	•	•	•	•
Understandings about scientific inquiry	•	•	•	•
Physical Science (B)				
Properties and changes of properties in matter	•	•	•	•
Motion and forces	•	•	•	•
Transfer of energy	•	•	•	•
Earth and Space Science (D)				
Structure of the earth system	•	•	•	•
Earth in the solar system	•	•	•	•
Science and Technology (E)				
Abilities of technological design	•	•	•	•
Understanding about science and technology	•	•	•	•
Science in Personal and Social Perspectives (F)				
Science and technology in society	•	•	•	•
History and Nature of Science (G)				
Science as a human endeavor	•	•	•	•
Nature of science	•	•	•	•
History of science	•	•	•	•

National Mathematics Standards for Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Number and Operations	1	2	3	4
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.			•	
Understand meanings of operations and how they relate to one another.			•	
Compute fluently and make reasonable estimates.			•	
Geometry				
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.		•		
Specify location and describe spatial relationships using coordinate geometry and other representational systems.	•	•		
Use visualization, spatial reasoning, and geometric modeling to solve problems.		•		
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	•	•	•	•
Apply appropriate techniques, tools, and formulas to determine measurements.	•	•	•	•
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	•	•	•	•
Select and use appropriate statistical methods to analyze data.	•	•	•	•
Develop and evaluate inferences and predictions that are based on data.	•	•	•	•
Understand and apply basic concepts of probability.	•	•	•	•
Problem Solving				
Build new mathematical knowledge through problem solving.	•	•	•	•
Solve problems that arise in mathematics and in other contexts.	•	•	•	•
Apply and adapt a variety of appropriate strategies to solve problems.	•	•	•	•
Monitor and reflect on the process of mathematical problem solving.	•	•	•	•

National Mathematics Standards for Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Communication	1	2	3	4
Organize and consolidate mathematical thinking through communication.			•	
Communicate mathematical thinking coherently and clearly to peers, teachers, and others.			•	
Representation				
Create and use representations to organize, record, and communicate mathematical ideas.			•	
Select, apply, and translate among mathematical representations to solve problems.			•	
Use representations to model and interpret physical, social, and mathematical phenomena.			•	

National Educational Technology Standards Performance Indicators for Technology-Literate Students Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Basic Operations and Concepts	1	2	3	4
Use keyboards and other common input and output devices efficiently and effectively.	•	•	•	•
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	•	•	•	•
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	•	•	•	•
Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use.	•	•	•	•
Technology Productivity Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	•	•	•	•

National Educational Technology Standards Performance Indicators for Technology-Literate Students Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	•	•	•	•
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	•	•	•	•
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	•	•	•	•
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	•	•	•	•
Use technology resources for problem solving, self-directed learning, and extended learning activities.	•	•	•	•
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	•	•	•	•
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	•	•	•	•
Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources.	•	•	•	•

International Technology Education Association Standards for Technological Literacy Grades 3-5

STANDARD	SEGMENT 1	2	3	4
The Nature of Technology	1	2	3	4
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	•	•	•	•
Standard 2: Students will develop an understanding of the core concepts of technology.	•	•	•	•
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	•	•	•	•
Technology and Society				
Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.	•	•	•	•
Standard 7: Students will develop an understanding of the influence of technology on history.	•	•	•	•

National Geography Standards

STANDARD	SEGMENT 1	2	3	4
The geographically informed person knows and understands:	1	2	3	4
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire process and report information from a spatial perspective		•		
Places and Regions				
The physical and human characteristics of places	•	•	•	•
That people create regions to interpret Earth's complexity	•	•	•	•
How culture and experience influence people's perceptions of places and regions	•	•	•	•
Human Systems				
The characteristics, distribution, and migration of human populations on Earth's surface	•	•	•	•
The characteristics, distributions, and complexity of Earth's cultural mosaics	•	•	•	•
The processes patterns, and functions of human settlement	•	•	•	•
The Uses of Geography				
How to apply geography to interpret the past	•	•		

Segment 1

Animals become the topic of the day when Catherine and Bianca encounter an injured animal while on an airboat ride in Orlando, Florida. Determined to learn more about animals and how to help and protect them, the tree house detectives decide to visit Mr. Rob Yordi, Zoological Manager at Busch Gardens Williamsburg. Mr. Yordi introduces Kali to the grey wolf while he explains how and why animals are classified. Next, Kali meets Dr. D at the Virginia Marine Science Museum in Virginia Beach, Virginia where he explains eight of the various phyla of invertebrates. Meanwhile, Catherine and Bianca head to NASA Kennedy Space Center (KSC) to meet Ms. Rebecca Smith, a wildlife ecologist. Ms. Smith describes five classes of vertebrates and explains why it is important for NASA to monitor the animals at KSC, and she even introduces the girls to one of her reptile friends!

Objectives

Students will

- understand the many uses of the Global Positioning System (GPS).
- learn how coordinate numbers are used to describe the exact position of something, such as a place on a map.
- learn how explorers navigated by using rudimentary technology such as Iceland spar and the stars.

Vocabulary

Arctic Circle—the line of latitude at 66° 30′ N that marks the boundary of the Arctic

cache—a secret place where a store of things is kept hidden

compass—a device for finding direction, usually with a magnetized needle that automatically swings to magnetic north

coordinate—each of a set of numbers that together describe the exact position of something, such as a place on a map with reference to a set of axes

geocaching—an adventure game using GPS devices and the Internet to hide and locate hidden caches of various items all over the world

Global Positioning System (GPS)—a satellite navigation system that gives special satellite signals that can be processed in a GPS receiver to compute position, velocity, and time

navigation—the science of plotting and following a course from one place to another and of determining the position of a moving ship, aircraft, or other vehicle

Polaris—the brightest star in the Little Dipper formation in the constellation Ursa Minor, located very near the celestial North Pole; also called the North Star, Pole Star, and Polar Star

sextant—a navigational instrument incorporating a telescope and an angular scale that is used to find latitude and longitude

sunstone—feldspar or quartz containing minute particles of iron compounds or, in some of the quartz types, mica; also called aventurine and Iceland spar

Viking—a member of any of the Scandinavian peoples who raided and invaded the coasts of Europe from the 8th to 11th centuries AD

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Before viewing Segment 1 of *The Case of the Technical Knockout*, read the program overview to the students. List and discuss questions and preconceptions that students may have about GPS devices, orienteering, satellites, and how technology changes our world.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them better understand the problem. To locate the following tools on the NASA SCI Files™ web site, select **Educators** from the menu bar, click on **Tools**, and then select **Instructional Tools**. You will find them listed under the **Problem-Based Learning** tab.

   Problem Board—Printable form to create student or class K-W-L chart

   Guiding Questions for Problem Solving—Questions for students to use while conducting research

   Problem Log and Rubric—Students' printable log with the stages of the problem-solving process

   Brainstorming Map—Graphic representation of key concepts and their relationships

   The Scientific Method and Flowchart—Chart that describes the scientific method process
3. **Focus Questions**—These questions at the beginning of each segment help students focus on a reason for viewing. They can be printed ahead of time from the **Educators** area of the web site in the **Activities/Worksheet** section under **Worksheets** for the current episode. Students should copy these questions into their science journals prior to viewing the program. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.

Video Component

4. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. You can print them by selecting **Educators** on the web site in the **Activities/Worksheet** section under **Worksheets** for the current episode.

Careers

pilot
navigator
cartographer
mapping scientist
photogrammetrist
land surveyor
ship's captain

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Technical Knockout* in 15-minute segments and not in its entirety. If you are watching a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about orienteering, using a compass, GPS devices, how GPS works, and what it is used for. As a class, reach a consensus about what additional information is needed. Have the students conduct independent research or provide them with the necessary information.
4. Have the students complete **Action Plans**, which can be printed from the **Educators** area or the tree house **Problem Board** area in the **Problem-Solving Tools** section of the web site for the current online investigation. Students should then conduct independent or group research by using books and Internet sites noted in the **Research Rack** section of the **Problem Board** in the **Tree House**. Educators can also search for resources by topic, episode, and media type under the **Educators** main menu option **Resources**.
5. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students "solve" the problem along with the tree house detectives.
6. For related activities from previous programs, download the corresponding Educator Guide(s). On the NASA SCI Files ™ home page, click on the fence post for **Guides**. Click on the **Archives** tab and then click on the **2000–2001 Season**. To download the guide, click on Full Guide or the Segment indicated for *The Case of the Challenging Flight*.

   a. In the **Educator Guide** you will find

   a. Segment 2 – *Flight Plan* (cardinal direction)

   b. Segment 4 – *Rescue at Sea Game* (cardinal direction)

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2001–2002 Season**. To download the guide, click on **Full Guide** or the Segment indicated for *The Case of the Phenomenal Weather*.

   a. In the **Educator Guide** you will find

   a. Segment 2 – *Plotting to Rescue* (coordinates)

   b. Segment 3 – *The Fear Factor* (coordinates)

   c. Segment 4 – *NASA Needs Help!* (coordinates)

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2001–2002 Season**. To download the guide, click on **Full Guide** or the Segment indicated for *The Case of the Inhabitable Habitat*.

   a. In the **Educator Guide** you will find

   a. Segment 4 – *Where Have All the Turtles Gone?* (coordinates)
7. Have the students work individually, in pairs, or in small groups on the problem-based learning (PBL) activity on the NASA SCI Files™ web site. To locate the PBL activity, click on **Tree House** and then the **Problem Board**. Choose the **2004–2005 Season** and click on *The Mysterious Technology Glitches.*

- To begin the PBL activity, read the scenario *(Here's the Situation)* to the students.
- Read and discuss the various roles involved in the investigation.
- Print the criteria for the investigation and distribute.
- Have students begin their investigation by using the **Research Rack** and the **Problem-Solving Tools** located on the bottom menu bar for the PBL activity. The **Research Rack** is also located in the **Tree House**.

8. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess student progress. In the beginning, students may have difficulty reflecting. To help them, ask specific questions that are related to the concepts.
9. Have students complete a **Reflection Journal**, which can be found in the **Problem-Solving Tools** section of the online PBL investigation or in the **Instructional Tools** section under **Educators**.
10. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Resources *(additional resources located on web site)*

Books

Aberg, Rebecca: *Latitude and Longitude (Rookie Read-About Geography)*. Children's Press, 2003, ISBN: 0516277650.

Berger, Melvin: *Simple Science Says: Take One Compass*. Scholastic, 1990, ISBN: 0590423843.

Bredeson, Carmen: *Looking at Maps and Globes (Rookie Read-About Geography)*. Children's Press, 2002, ISBN: 0516259822.

Byers, Ann: *Communication Satellites*. Rosen Publishing Group, 2003, ISBN: 0823938514.

Discovery Channel School: *Mapping the Earth Files: Chart*. Discovery Channel School, 2001, ISBN: 1587381451.

Finch, Spencer: *Map Crosswords: 25 Map/Crossword Puzzles That Teach Map and Geography Skills*. Scholastic, 1996, ISBN: 0590896466.

MacLeod, Elizabeth: *Phone Book: Instant Communication from Smoke Signals to Satellites and Beyond*. Kids Can Press, 1997, ISBN: 1550742205.

Rosinsky, Natalie: *Satellites and the GPS*. Compass Point Books, 2004, ISBN: 0756505976.

Ulmer, Dave: *The Geocaching Handbook (Falcon Guide)*. Falcon, 2004, ISBN: 0762730447.

Whiting, Jim: *John R. Pierce: Pioneer in Satellite Communication*. Mitchell Lane Publishers, 2003, ISBN: 1584152052.

Winter, Jeanette: *Follow the Drinking Gourd*. Dragonfly books, 1992, ISBN: 0679819975.

Zuravicky, Orli: *Map Math: Learning About Latitude and Longitude Using Coordinate Systems (Powermath)*. PowerKids Press, 2005, ISBN: 1404229353.

Video

Discovery Channel School: *Satellite Technology*
Grades 6–12

Web Sites

The Viking Ship Museum
Come explore this site to learn more about the Viking ships on display. Read how these ships were once burial ships for prominent Norwegians from about 815–820 AD.
http://www.khm.uio.no/english/viking_ship_museum/index.shtml

Trimble: GPS Tutorial
Here's a simple tutorial to help you understand a GPS.
http://www.trimble.com/gps/

Howstuffworks: How GPS Receivers Work
Visit this site for an easy-to-understand, in-depth look at how GPS receivers work.
http://electronics.howstuffworks.com/gps.htm

Camp Silos: Farm Tech Trek
This site is a wonderful interactive lesson on how GPS technology helps farmers. Find background information on GPS, satellites, and much more, along with additional resources for both students and teachers.
http://www.campsilos.org/mod4/teachers/farmtrek.shtml

TerraServer USA
On this TerraServer web site, you can see real satellite imagery topographical maps of the United States.
http://terraserver.microsoft.com/default.aspx

US Geological Survey
Visit this web site to learn about topographical maps and become familiar with how to read and understand the symbols used on them.
http://mac.usgs.gov/mac/isb/pubs/booklets/symbols/

Color Landform Atlas of the United States
On this web site you can view topographical maps of the United States.
http://fermi.jhuapl.edu/states/states.html

Space.Com: GPS for Mars
This informative article discusses how NASA might someday create a Global Positioning System for Mars to help explorers navigate.
http://www.space.com/businesstechnology/technology/mars_gps_040707.html

SpaceRef.Com: NASA Satellite Technology Goes Down on the Farm
Read how GPS helps farmers whose tractors are equipped with GPS receivers.
http://www.spaceref.com/news/viewpr.html?pid=4778

NASA: Star Child
Begin your journey here to learn more about stars.
http://starchild.gsfc.nasa.gov/docs/StarChild/universe_level1/stars.html

NASA: Space Place—Make a Star Finder
Learn your way around the night sky by making a star finder. Download a PDF of the Star Finder pattern for each month. Follow simple directions and begin exploring the night sky.
http://spaceplace.nasa.gov/en/kids/st6starfinder/st6starfinder.shtml

Your Sky
Visit this web site and enter your latitude and longitude to create a star chart for your area.
http://www.fourmilab.ch/yoursky/

Stephan F. Austin Observatory
This site offers free PDF Star Charts that include directions on how to use them.
http://www.cox-internet.com/ast305/SFAStarCharts.html

Activities and Worksheets

In the Guide

There's a Rose in My Compass!
Use a compass and learn the four cardinal directions. 19

Boxing the Compass
Discover how young sailors had to learn the 32 points on a compass and try to "box the compass" yourself. 21

Flight of the Navigator
Your GPS is on the blink. Use a compass to help plot a route for the pilot as she flies across the U.S. 23

Dead Reckoning
Set your pace and learn how to use dead reckoning to find distance. 24

Answer Key
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On the Web

Celestial Navigations
Learn about the Big Dipper and find it in your own night sky.

Follow the Drinking Gourd
Learn how slaves used the Big Dipper to find the way north to freedom.

There's a Rose in My Compass!

Segment 1

Purpose

To understand cardinal direction and how to locate direction by using a compass

Materials

compass
4 index cards
tape
pen or marker
room with 4 walls
small toy items
plastic bag
science journal

Background

When you look at a map, how can you tell direction? Most maps have a diagram called a compass rose. The compass rose tells you which way is north. If you know a little about direction, once you know where north is, it is pretty easy to find the other directions. There are 4 main (cardinal) directions—North (N), South (S), East (E), and West (W). The first letter of each word is an abbreviation for the direction. A compass shows direction, and the 4 cardinal directions are printed on the compass. Inside the cover of the compass, there is also a tiny pointer needle that can turn freely. One end of the pointer is magnetic and it is usually red. It always points north. All magnets have two poles—a north and a south pole. Opposite poles (N—S) attract, while like poles (N—N and S—S) repel.

Teacher Note: Compass needles can be magnetized in the wrong direction. If this happens, the compass will be reversed. Check the compasses before use to make sure they are oriented correctly.

Procedure

1. On each index card, write one of the 4 cardinal directions: North, South, East, or West.
2. Observe your compass and locate the north-seeking end of the needle. Make sure that the red (or other designated color) end is pointing to the N. If not, tilt the compass and reposition it until it is aligned.
3. Hold the compass in the palm of one hand and observe the direction the needle is pointing.
4. Turn your body so that you are facing the same direction the needle is pointing. You are now facing north.
5. On a spot on the wall in front of you (to the north), tape the "North" index card to the wall.
6. If north is in front of you, then south is directly behind you. Turn around and face south.
7. Look at the compass and observe where the needle is pointing. It's still pointing north!
8. On a spot on the south wall, tape the "South" index card.
9. Face north again. If north is in front of you, then east is to your right.

There's a Rose in My Compass!

Segment 1

10. Turn your body so that you are now facing east. Observe the compass. Is it still facing north?
11. On a spot on the east wall, tape the "East" index card.
12. Face north again. If north is in front of you, west is to your left.
13. Turn your body so that you are now facing west. Observe the compass. Is it still facing north?
14. On a spot on the west wall, tape the "west" index card.
15. Always remember when you are facing north—
    a. north is in front of you.
    b. south is behind you.
    c. east is to your right.
    d. west is to your left.
16. To make a compass rose, draw a circle in your science journal. Draw a line to divide the circle in half from top to bottom. Label the line at the top N and the bottom line S.
17. Draw a second line to divide the circle in half from side to side, making four equal quarters. Label the line on the right E and the left W.
18. Look at the four directions and try to memorize them in a clockwise direction. A saying that might help is "Never (N), Eat (E), Sour (S), Watermelon (W)."
19. Now that you have identified the 4 cardinal directions in the room, you are ready to create a cache, hide it, and write directions to find it.
    a. To create a cache, choose 1–2 small toy items and place them in a small plastic bag.
    b. Find a location to hide your cache.
    c. In your science journal, write a set of directions using N, S, E, and/or W to guide someone to your cache. For example: Begin at the door and take 4 steps N. Turn to the W and take 2 steps. Turn to the E and take 4 steps. Turn to the S and take 1 step, and so on.
20. Exchange directions with another student and try to find each other's caches.

Conclusion

1. Explain why the compass needle always points north.
2. Give an example of how you would use a compass to find your way while hiking.
3. Help the tree house detectives and brainstorm for some ideas of what might make a compass give a wrong direction. Remember that the needle is a magnet.

Extensions

1. Go outside or to a large, enclosed area and practice using a compass.
2. Write a set of directions to maneuver around a set of obstacles.
3. Use a compass to determine in which direction the Sun rises and sets. The Moon?
4. Take a short walk around the house or classroom with your compass. Hold the compass next to different items such as a sink, table, door, TV, refrigerator, or other object. What happens to the compass needle with each item?
5. Research the difference between the magnetic pole located in the north and the geographical north pole. How far apart are they from each other? Explain why they are different.

Boxing the Compass

Segment 1

Purpose

To learn the order of cardinal and intercardinal points on a compass

Materials

Per Student
- sheet of unlined paper
- ruler
- pencil
- small compass

Background

A compass rose is a symbol drawn on a map to show direction. It has appeared on charts and maps since the 1300s and was first used to show wind direction. A compass rose gets its name from a flower because the figure is said to resemble the petals of a rose. The Portuguese cartographer (mapmaker), Pedro Reinel, drew the first standard compass rose. The standard compass rose has 32 points. Long ago, if you were a young sailor between the ages of 8 and 12, the first thing you would do is memorize all 32 points in order. Being able to recite all 32 points in their correct order was called, "to box a compass." Today a compass rose shows the four cardinal points of north (N), south (S), east (E), and west (W) and some still have the intercardinal points between the four cardinal points.

To learn more about a compass rose, visit the following web sites:

http://www.gisnet.com/notebook/comprose.html#32points

http://www.rootsweb.com/~mosmd/comrosbig.htm

Procedure

1. Fold the paper in half (bottom to top). See diagram 1.
2. Open up the paper and fold it from side to side. See diagram 2.
3. Open the paper and place it flat on the table or desk.
4. Use a ruler to draw lines along the fold lines. See diagram 3 on page 22.
5. Place a small compass where the two lines intersect.
6. Turn your compass so that north is pointing to the top of the page. All four lines should be aligned with the cardinal points. See diagram 4 on page 22.
7. Label the end of each line with a direction: N for north, S for south, E for east, and W for west.
8. Use the ruler to draw a line between south and west from the center to the lower left-hand corner.
9. It points southwest. Label it SW. See diagram 5 on page 22.
10. Use the ruler to draw a line between north and west from the center to the upper left-hand corner.
11. It points northwest. Label it NW.
12. Use the ruler to draw a line between north and east from the center to the upper right-hand corner.

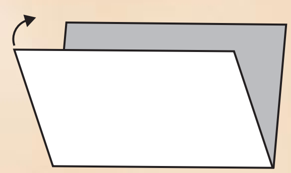


Diagram 1

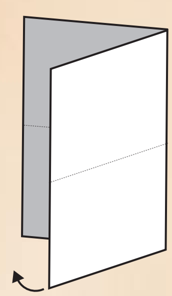


Diagram 2

Boxing the Compass

Segment 1

13. It points northeast. Label it NE.
14. Use the ruler to draw a line between south and east from the center to the lower right-hand corner.
15. It points southeast. Label it SE.
16. The drawn lines indicate the 8 main points on a modern day compass. Try to "box the compass" by memorizing all 8 points in order, starting with north.

Conclusion

1. Why was it important for young sailors to "box the compass?"
2. How does learning to "box the compass" help you?

Extension

1. Research the origin of the compass rose and explain how and why it was created.
2. Draw and label all 32 points on a compass rose. Explain how and why sailors used the 32 points.

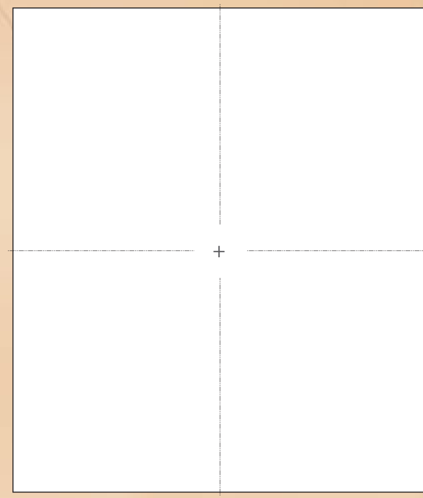


Diagram 3

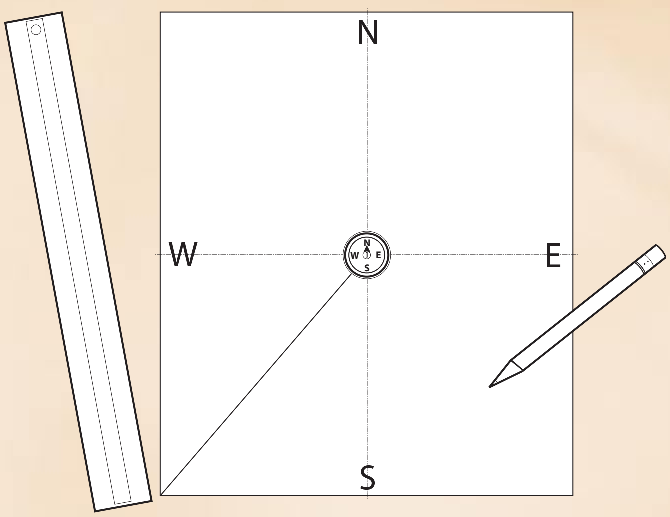


Diagram 5

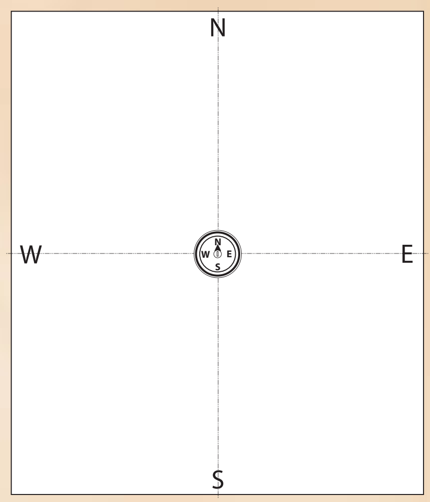


Diagram 4

Flight of the Navigator

Segment 1

Purpose

To demonstrate knowledge of direction

Your GPS is on the blink! Luckily you have a compass. As flight navigator, it is up to you to map a route so the pilot can safely fly from city to city. Use your compass to plot the course to the following cities, being sure to direct the pilot to each city in the order it is listed. Write the directions for the route in your science journal. When you are finished, exchange directions with a partner and try to "fly" to the cities by using your partner's directions. Discuss any difficulties you might encounter!

Materials

US map
compass
science journal

Extension

Research how pilots actually fly in great circles. Describe a great circle and explain how the actual flight path would differ from one drawn on a flat map as a straight line.

San Francisco
Las Vegas
Everett, Washington
Denver, Colorado
Kansas City, Missouri
Fargo, North Dakota
Memphis, Tennessee
Oklahoma City, Oklahoma
College Station, Texas
Atlanta, Georgia
Cleveland, Ohio
Yorktown, Virginia
New York, New York

Dead Reckoning

Segment 1

Purpose

To learn how math helped explorers navigate

Materials

yardstick*
duct tape
large area > 100 ft
calculator (optional)

Background

Long before people had GPS receivers, they navigated with nothing but a compass, a clock, and math. Explorers frequently relied on dead reckoning. Dead reckoning is an estimated linear measurement. To use dead reckoning, people first had to calculate their average pace, or how many steps they took in a given space. They could then divide the distance they walked by the average number of paces to calculate the average number of feet per step. If they wanted to measure a distance by dead reckoning, all they would have to do is count the number of steps they took and multiply that number by their average pace. Although the method is crude, people who practice pacing can get fairly accurate measurements over long distances. Early ships frequently relied on dead reckoning, but it was often inaccurate because a ship's travel speed is inconstant, and ocean currents can cause the ship to drift off course. Even on land dead reckoning is difficult because of rocks, trees, and other obstacles that cause detours. Even so, throughout history most great explorers relied on dead reckoning. Today it is a dying art. However, if your GPS goes on the blink as the tree house detectives' did, or if the batteries die, dead reckoning can be a good navigational tool to have.

***Note:** This activity is in standard units of measurement but can be converted to metric.

Procedure

1. Place a piece of duct tape at one end of the large area.
2. Use the yardstick to measure 100 ft from the duct tape and mark the end with a second piece of duct tape.
3. Start at one of the markers with your feet together and walk directly to the other marker, counting each step you take. Make sure to walk with a normal gait.
4. Stop when you get to the second marker and record in the chart the number of paces you took.
5. Turn around and walk back to the first marker.
6. Record the number of paces.
7. Repeat steps 3–6 two more times.
8. Calculate the average number of paces you took for 100 ft.
9. Divide 100 by your average number of paces to find your pace in terms of feet per step.
10. Choose a different spot and walk to it, counting your paces as you go.
11. Record the number of paces in the chart.
12. To measure the distance by dead reckoning, multiply the number of paces by your average feet per step.
13. Use the yardstick to measure the actual distance. Record and compare the two numbers.

Dead Reckoning

Segment 1

Trial	Number of Paces per 100 ft
1	
2	
3	
4	
5	
6	
Total Number of Paces per 100 ft	

____________ ÷ 6 = __________________
Total Number of Paces **Average Number of Paces per 100 ft**

__________________ __________ = ______________
Number of paces to new location Average feet/step Dead Reckoning Distance

Actual Distance: ____________

Conclusion

1. How did your numbers compare?
2. How could you improve your margin of error?
3. What might be some factors that cause error in your ability to correctly use dead reckoning?
4. When would dead reckoning be useful?

Extension

Conduct research to learn how ancient ships' crews used dead reckoning. Discuss the differences and similarities between dead reckoning on a ship and by pacing on land. Share your research with the class.

Answer Key

Segment 1

There's a Rose in My Compass!

1. The compass needle and the Earth are both magnets. Magnetic poles are determined by the direction that the magnetic field flows. A magnetic field always flows from the north pole to the south pole. See diagram 1. Our Earth has gone through many field (pole) reversals throughout time. Currently, the magnetic north pole is located in the geographic south pole region and the magnetic south pole is located in the geographic north pole region. See diagram 2. The end of the compass needle that points north is actually a north pole and because opposites attract, it is attracted to the Earth's magnetic South Pole, which is in the North. The Earth's magnetic field is constant; therefore, the compass needle will always point north until the poles reverse again.
2. Answers will vary, but might include to track the direction you hike so that you can find your way back.
3. Answers will vary, but should include that because the compass needle is a magnet, it is sensitive to iron and thus will be attracted to items with iron in them. If an iron item were nearby, it would create a stronger attraction than the Earth's magnetic field and cause the compass to give a wrong direction.

Boxing the Compass

1. Answers will vary but might include that young sailors were expected to know direction as part of their seamanship training because it was very important for them to know about wind direction. The 32 points originally represented wind direction and that information could be very useful because ships depended on wind to fill their sails! The 32 points also let them define their direction more precisely.
2. Answers will vary, but might include helping you find your way, giving other people directions, and helping you read maps.

Dead Reckoning

1. Answers will vary.
2. Answers will vary but might include conducting more trials or practicing pacing more evenly.
3. Answers will vary, but might include that the pace was off due to being tired or having a sore foot, or that someone did not count the paces correctly.
4. Answers will vary, but might include the following: when you are hiking in the woods, sometimes you know that you need to go a certain distance in a specific direction to reach a destination.

The NASA SCI Files™
The Case of the Technical Knockout

Segment 2

Still concerned that their Global Positioning System (GPS) receivers and radios might go on the blink again, Tony and Catherine go to NASA Langley Research Center to talk to Mr. George Ganoe to learn more about the GPS and how it works. After speaking with Mr. Ganoe, the detectives decide that it probably wasn't the GPS satellite system that caused the communications problem, but they begin to think that it might have something to do with radio waves. They decide to email two of the NASA SCI Files™ Kids' Club members in Norway, Ole and Nina, to talk with Dr. D. He meets Ole and Nina at the ALOMAR Observatory in Andenes, Norway where he explains the electromagnetic spectrum. Meanwhile, back in the U.S., Tony heads to Colorado and takes time to stop by the University of Colorado to visit Dr. Fran Bagenal to learn about electricity.

Objectives

Students will

- understand that the GPS depends on a system of 24 satellites.
- understand how the GPS works.
- recognize that the electromagnetic spectrum consists of many different forms of light.
- know that light has various wavelengths and frequencies.
- label the parts of an atom.
- understand attractive forces.
- know the difference between static and current electricity.

Vocabulary

atom—the smallest particle of an element that still has all the properties of that element

attract—to drive or bring together

battery—one or more cells that are connected and use chemicals to generate and store energy

current—moving electrical charges

electricity—a form of energy produced by the flow or accumulation of charges

electromagnetic spectrum—the classification of electromagnetic waves, either by wavelength or frequency

electromagnetic wave—a wave with electric and magnetic components

electron—one of three subatomic particles; has a negative charge

force—a push or pull; a force can be attractive or repulsive

frequency—number of complete waves (or cycles) that pass a fixed point in a given unit of time

magnetism—a phenomenon produced by moving charges

neutron—one of the two particles that make up the nucleus of an atom; it has no electric charge

nucleus—the positively charged central region of an atom, consisting of protons and neutrons and containing most of the mass

proton—one of the two particles that make up the nucleus of an atom; it has a positive electric charge

radio waves—electromagnetic waves having long wavelengths; used to transmit voice, music, video, and data over distances

repel—to drive or to force away

satellite—an object put into orbit around Earth or any other planet to relay communications signals or transmit scientific data

sphere—a round, three-dimensional object whose surface at all points is the same distance from its center

static electricity—the buildup of electrical charges on surfaces produced by rubbing two dissimilar materials against each other. In this type of electricity, the electrical charge is on something, and it does not move through a circuit.

three dimensional—possessing or appearing to possess the dimensions of length, width, and height

trilateration—mathematical principle that uses the intersection of three circles or spheres to locate a specific point in either two- or three-dimensional space

two-dimensional—used to describe a figure that has length and width but no depth

wave—a pattern that repeats itself in time and space

wavelength—the distance between a point on one wave and the identical point on the next wave; usually measured crest-to-crest or trough-to-trough

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of Technical Knockout*, discuss the previous segment to review the problem and reaffirm what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** is also in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 1.
5. Read the Overview for Segment 2 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 of the Video

For optimal educational benefit, view *The Case of Technical Knockout* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what they now know about orienteering, using a compass, GPS, satellites, the electromagnetic spectrum, and electricity. As a class, reach a consensus on what additional information is needed.
4. Organize the information and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information the tree house detectives need to determine what has caused the GPS and the radios to go on the blink. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the **Educator Guide**. On the NASA SCI Files™ home page, select **Educators**. Click on **Episodes** in the menu bar at the top. Scroll down to the **2002–2003** Season and click on *The Case of the Shaky Quake*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

   a. Segment 4 – *Locating an Epicenter* (triangulation/ trilateration)

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2000–2001** Season. To download the guide, click on **Full Guide** or the Segment indicated for *The Case of the Electrical Mystery*.

a. In the **Educator Guide** you will find

   a. Segment 1 – *Cling On* (static electricity), *Atoms & Atoms Everywhere* (parts of an atom)

   b. Segment 2 – *Battery Tester* (current electricity)

   c. Segment 3 – *Light the Bulb!* (current electricity)

   d. Segment 4 – *Word Search, Measuring Electricity 101, Electrifying Math*

   Close the PDF window and return to the page for **Guides**. Click on the **Archives** tab and then click on the **2001–2002** Season. To download the guide, click on **Full Guide** or the **Segment** indicated for *The Case of the Mysterious Red Light*.

a. In the **Educator Guide** you will find

a. Segment 1 – *Roping the Wave* (light travels in waves), *Wave Upon Wave* (frequency), *Roll Out the Frequency* (frequency and wavelength), *The Incredible Edible Wave* (parts of a wave)

b. Segment 3 – *Over the Rainbow* (visible spectrum), *Primary Colors of Light* (white light), *Rainbow of Knowledge* (visible spectrum)

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under **After Viewing** on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

   Research Rack—books, Internet sites, and research tools

   Problem-Solving Tools—tools and strategies to help guide the problem-solving process

   Dr. D's Lab—interactive activities and simulations

   Media Zone—interviews with experts from this segment

   Expert's Corner—listing of Ask-An-Expert sites and biographies of experts featured in the broadcast

9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.

10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. For more assessment ideas and tools, go to **Educators** and click on **Instructional Tools** in the menu bar.

Careers

computer programmer
electrical engineer
electronics engineer
electrician
physicist
radar technician
robotics engineer
satellite engineer/technician
spacecraft engineer

Resources *(additional resources located on web site)*

Books

Baler Wendy, Alexandra Parsons, and Andrew Haslam: *Electricity (Make it Work! Science)*. Two-Can Publishers, 2000, ISBN: 1587283549.

Barnes and Noble: *Satellite World Atlas*. Barnes and Noble Books, 2003, ISBN: 0760747474.

Cast, C. Vance and Sue Wilkinson: *Where Does Electricity Come From?* Barron's Educational Series, 1992, ISBN: 0812048350.

Cole, Joanna: *The Magic School Bus and the Electric Field Trip*. Scholastic, Inc., 1997, ISBN: 0590446827.

Gould, Alan and Stephen Pompea: *Invisible Universe: The Electromagnetic Spectrum from Radio Waves to Gamma Rays: Grades 6–8 (Gems Guides)*. LHS GEMS, 2002, ISBN: 0924886692.

Levine, Shar and Leslie Johnstone: *Shocking Science: Fun and Fascinating Electrical Experiments*. Sterling Publishing Co., Inc., 1999. ISBN: 080693946X.

de Pinna, Simon: *Electricity*. Raintree Steck-Vaughn Publishers, 1998, ISBN: 0817249451.

Snedden, Robert: *Electricity and Magnetism*. Heinemann Library, 1999, ISBN: 1575728680.

Trumbauer, Lisa: *What Is Electricity? (Rookie Read-About Science)*. Children's Press, 2004, ISBN: 0516258451.

Van Cleave, Janice: *Janice Van Cleave's Electricity: Mind-Boggling Experiments You Can Turn Into Science Fair Projects*. John Wiley & Sons, Inc., 1994, ISBN: 0471310307.

Video

Disney: *Energy (Bill Nye, the Science Guy)*
Grades 3–8

Disney: *Light and Color (Bill Nye, the Science Guy)*
Grades 3–8

Schlessinger Media: *Forces (Physical Science in Action)*
Grades 5–8

Web Sites

NASA: Look to the Future—Careers in Space
Not every space career involves hopping around in a big space suit. Some are very "down-to-Earth." Explore this site to learn about lots of available opportunities for exciting space careers and read about the men and women who are working in them now. This site also offers some great tips on how to pursue your dream of a space career!
http://mgs-mager.gsfc.nasa.gov/Kids/careers.html

NASA Satellite Tracking
Do you know where the Hubble Space Telescope and other satellites are? Visit this site to find out as you track their paths across the Earth's surface.
http://liftoff.msfc.nasa.gov/academy/rocket_sci/satellites/

NASA: Visible Earth Images
Spend some time at this site looking through the hundreds of images taken by the many satellites orbiting our Earth.
http://visibleearth.nasa.gov/

Canadian Space Agency: Careers
Visit this site to learn about exciting careers in aerospace and more.
http://www.space.gc.ca/asc/eng/educators/careers_engineers.asp

HowStuffWorks: Trilateration Basics
This site offers a great explanation, graphics, and animations of trilateration in both two- and three-dimensional space.
http://electronics.howstuffworks.com/gps1.htm

Global Positioning System Overview
An in-depth look at how a GPS works by Peter H. Dana. The University of Texas developed the content for this site (posted by the University of Colorado at Boulder).
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

GPS Constellation
At this site, view a graphic representation of the constellation of satellites that orbit the Earth for the GPS.
http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

Artic Lidar Observatory for Middle Atmosphere Research (ALOMAR)
Learn how the observatory studies the middle atmosphere to learn more about auroras and clouds.
http://alomar.rocketrange.no/rmr.html

PBS Online: Radio Transmission
This PBS web site shares a wealth of information about radio waves. Check out an interactive explanation of radio transmission.
http://www.pbs.org/wgbh/aso/tryit/radio/#

The Electromagnetic Spectrum
Visit this NASA web site to learn about electromagnetic waves. Get detailed descriptions of each type of electromagnetic wave.
http://imagers.gsfc.nasa.gov/ems/radio.html

Waves and Wave-Like Motion
Visit this web site to learn about the nature, properties, and behavior of waves.
http://www.glenbrook.k12.il.us/gbssci/phys/Class/waves/u10l1a.html

Tucson Electric Power Company's "Sunsite Funsite"
Experience an introduction to solar energy on this interactive web site.
http://www.eeexchange.org/solar/frameset.htm

Power Discovery Zone
Discover electricity, learn about the atom, play games, get some great lesson plans and more on this site.
http://www.powerdiscoveryzone.com/home.html

Home's Cool: Electricity A to Z
This wonderful site has great modules on everything from A to Z in electricity. Watch animated modules and use easy-to-read texts. Find some easy and fun-filled experiments to do at home.
http://homeschooling.gomilpitas.com/explore/electricity.htm

Solar Matters
The Florida Solar Energy Center's web site offers numerous facts about solar energy.
http://www.fsec.ucf.edu/ed/sm/ch1-general/whatis.htm

NASA's Kids Science News Network™ (KSNN™)
Visit KSNN™ to learn more about trilateration. Watch the one-minute news clip, "How do you tell time in space?" There are also additional activities and resources available.
http://ksnn.larc.nasa.gov

Activities and Worksheets

In the Guide

It Takes Four
Learn how to determine elevation with topographical maps. 33

Transversing the Wave
Learn about wavelength and frequency while walking a wave course. 35

Charge!
Have some fun with balloons as you learn about static electricity. 37

The Current Detective
Create your very own device to detect electrical current. 39

Answer Key
. 40

On the Web

Groovin' On the AM Waves
Make a simple radio-wave generator to learn more about radio waves.

It Takes Four

Segment 2

Purpose

To use topographic maps to determine the elevation of a specific location

Teacher Prep

Using a clear plastic storage container with a clear lid and clay, form a hill in the middle of the box(es). Be sure that the hill is not larger than the height of the box.

Materials

clear plastic landform box
water
beaker
transparency
metric ruler
tape
transparency marker
white paper

Background

Elevation is the distance above or below sea level, and it is useful to know the elevation of an area for many reasons. For example, elevation can affect the cooking times of many recipes, as well as your ability to run long distances or even hike. If you are out hiking and have at least four satellites linked to your GPS device, you might be able to determine the elevation of the area. However, many hikers also depend on topographic maps to give them accurate elevation information. A topographic map shows the changes in the elevation of Earth's surface. With a topographic map, you can tell how steep the mountain trail is. It also shows natural features such as mountains, hills, plains, lakes, rivers, and cultural features such as roads, cities, dams, and other man-made structures. Before starting a hiking trip, you could look at the contour lines on the topographic map to see what elevation changes the trail has. A contour line on a map connects points of equal elevation, and they never cross. The contour interval is the difference in elevation between two side-by-side contour lines. By looking at the contour interval to see how close the contour lines are to each other, you can determine whether a trail is steep or if it is gently sloping. Knowing the elevation can prepare you for your hike. The ancient Chinese were the first people to develop physical relief maps. These maps, produced sometime in the 3rd century BC, showed changes in elevation and were often carved from wood or made from molded rice.

Procedure

1. Using the ruler and the transparency marker, make marks up one side of the clear box 2 cm apart. The bottom of the box will be zero elevation. See diagram 1.
2. Use tape to secure the transparency to the top of the clear box lid.
3. Using the beaker, pour water into the box to a height of 2 cm.
4. Place the lid back on the box and observe.
5. Use the transparency marker to trace the top of the water line on the transparency.
6. Using the scale 2 cm = 10 m, mark the elevation on the contour line.
7. Remove the lid and add water until it is 4 cm deep.
8. Repeat steps 4–6.
9. Continue adding water and repeating the process until the hill is mapped.
10. Remove the transparency from the lid and place it under a piece of plain, white paper.
11. Carefully trace the lines from the transparency onto the white paper and label the contour intervals.

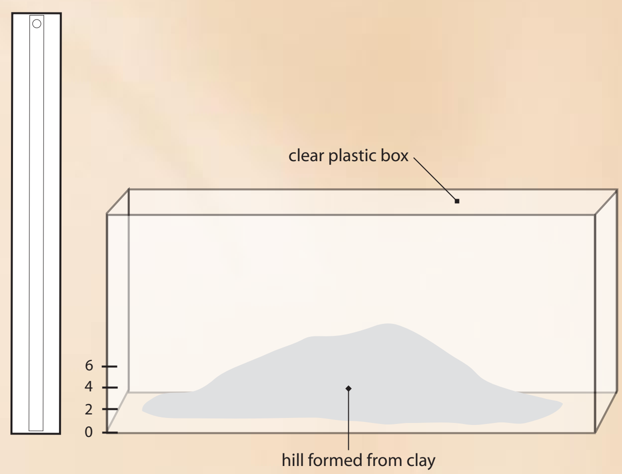


Diagram 1

It Takes Four

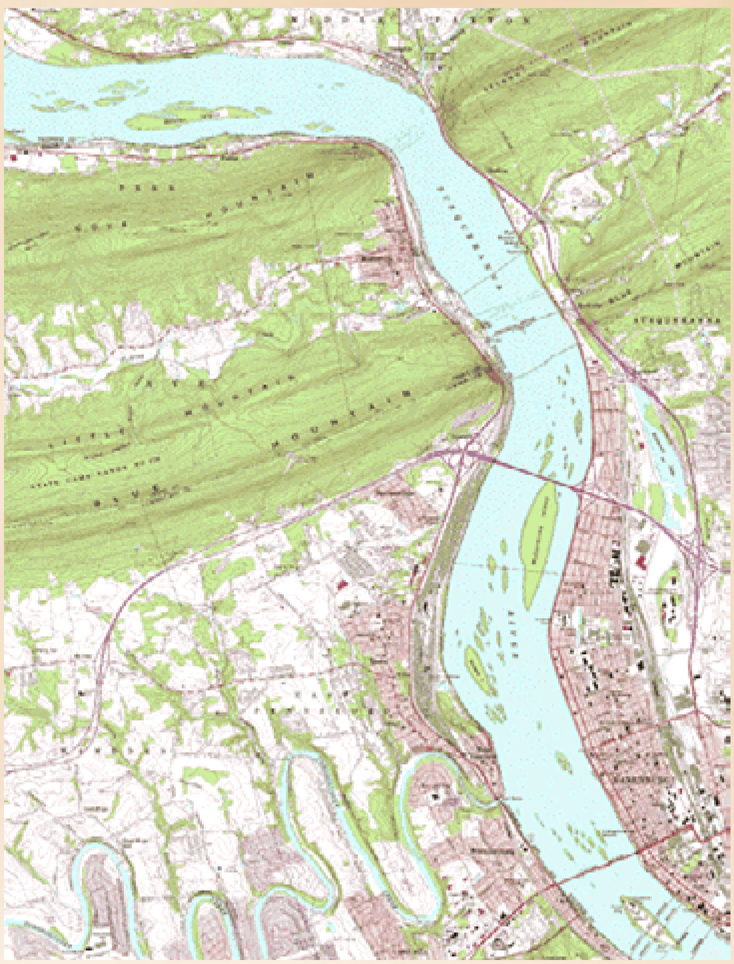
Segment 2

Conclusion

1. What is the contour interval of this topographic map? What is the total elevation of the hill?
2. How does the distance between the contour lines show the steepness of the slope on this model of a hill?
3. Do all topographic maps have a 0-m elevation contour line? Explain.
4. On a topographic map, how would the contour interval of an area that has hills compare to one that is very flat.
5. GPS devices can be used to show elevation and location. Why would it be a good idea to also carry a topographic map when hiking? What other supplies would you want to have?

Extensions

1. Visit the United States Geological Survey (USGS) site to learn more about topographic maps. http://geography.usgs.gov/digitalbackyard/topobkyd.html
2. Visit Topozone to find a free, topographic map of your area. http://www.topozone.com/
3. Visit USGS's TerraWeb for Kids to check out satellite images and to learn how computers use the images to make 3-D models of the Earth's surface. http://terraweb.wr.usgs.gov/TRS/kids/



Transversing the Wave

Segment 2

Materials

Per Group of 4
2-m rope
science journal

Purpose

To understand the relationship between wavelength and frequency

Background

Waves are all around us. You can see some of them, such as water and light waves. Others, like sound and radio waves, you cannot see. A wave is a repeating disturbance or movement that transfers energy through matter or space. For example, ocean waves disturb the water, earthquakes create waves that disturb the earth, and light is a type of wave that can travel through empty space. They all transfer energy from one place to another. Think about the last time you threw a pebble in a pool of water and watched how ripples formed. The pebble caused a disturbance that moved outward in the form of a wave and because it was moving, it had energy. As it splashed into the water, the pebble transferred some of its energy to nearby water molecules, causing them to move. Those molecules then passed the energy along to neighboring water molecules and so on until the energy moved farther and farther away from the disturbance.

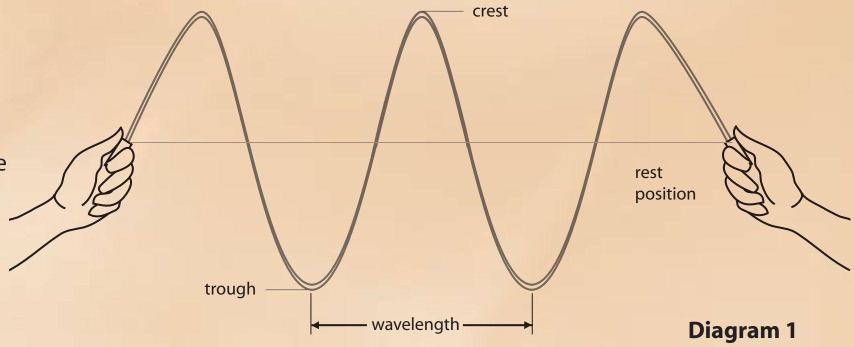


Diagram 1

Waves also have a property called wavelength, which is the distance between one point on a wave and the nearest point just like it. For example, in a transverse wave, there are alternating high and low points. The highest points are called the crests, and the lowest points are called the troughs. To measure wavelength, you would measure either crest to crest or trough to trough, as shown in Diagram 1.

Frequency is the number of wavelengths that pass a fixed point each second. You could find the frequency of a transverse wave by counting the number of crests or troughs that pass by a point each second. Frequency is expressed in hertz (Hz). A frequency of 1 Hz means that one wavelength passes by in one second.

If you move a rope up and down to make a transverse wave, you can increase the frequency by moving the rope up and down faster so more waves pass by a given point in one second. By moving the rope faster, you also shorten the wavelength.

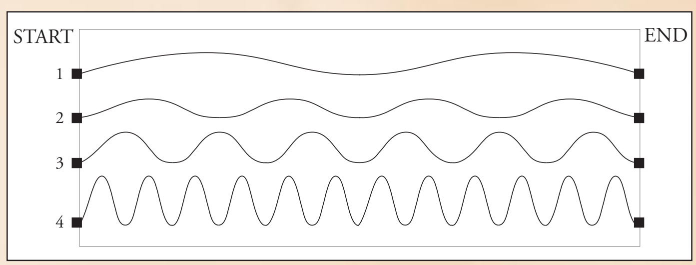


Diagram 2

Teacher Prep

In a large, open area, use ropes and/or cones to mark four waves with the same distance between end points but with different wavelengths. For example, draw one wave with only two crests in a 20-m distance. Draw a second wave with three or four crests for the same distance, and so on, increasing the number of crests with each wave. Mark the beginning of each wave and number all of them, starting with the longest wavelength as number 1. See diagram 2. NOTE: If you use ropes to mark off the waves, the various lengths of the four ropes will be determined by whatever distance between end points you choose.

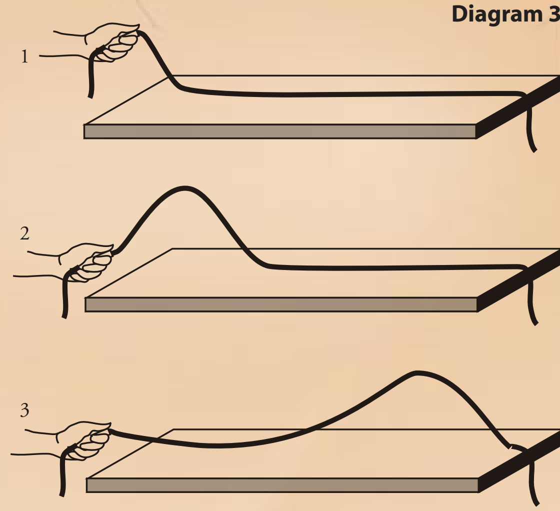
Transversing the Wave

Segment 2

Procedure

Part 1

Diagram 3



1. Hold one end of the rope and move your hand to make the rope move up and down. See diagram 3.
2. Observe and record your observations in your science journal.
3. Move your hand faster and observe. Watch what happens when you stop moving your hand. Record your observations.
4. In your science journal, explain what gives the rope the energy to move up and down.

Part 2

5. Have each person in your group stand at the beginning of one of the four waves.
6. The person on wave number 1 will walk at a normal pace while the other three will need to change their paces so that they will finish at exactly the same time as the person on wave number 1.
7. Start walking when you're selected.
8. Once you have finished, record in your science journal any personal physical observations such as sweating, being out of breath, and so on.
9. In your science journal, describe how students on wave numbers 2–4 had to adjust their walking speed to finish at the same time as wave number 1 students.

Conclusions

1. What happened to the speed of the rope when you moved your hand faster?
2. What happened to the wavelength as the rope moved faster?
3. What happened to the number of crests and troughs as the rope moved faster?
4. When you walked the waves, what happened as the wavelengths got shorter?
5. If these were real waves passing a fixed point, which wave would have more crests and troughs to pass in the same amount of time? Explain.
6. Did you notice any physical changes as the wavelengths got shorter?
7. In your own words, describe the relationship between wavelength and frequency.

Extension

1. Using the colors of the electromagnetic spectrum, create different color signs to carry while walking the waves (red for the longest wavelength and violet for the shortest wavelength, and so on).
2. Research the various types of waves: transverse, longitudinal (compressional), sound, water, and seismic. Create a Venn diagram that shows the similarities and differences among the various waves.

Charge!

Segment 2

Purpose

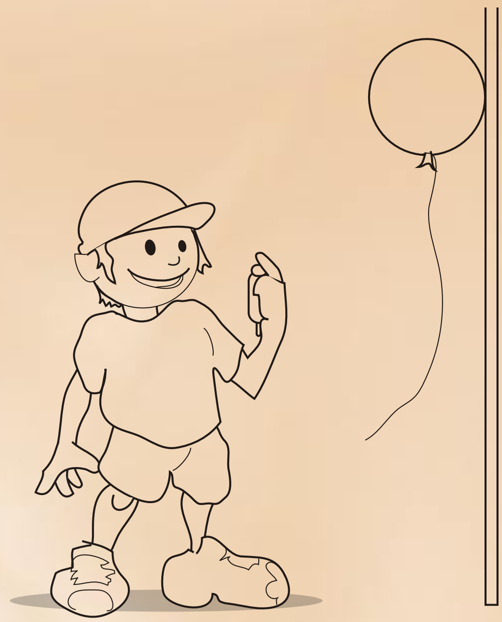
To understand that a static electrical charge is an increased concentration of an electrical charge in one place

Materials

balloon
stopwatch or clock with second hand
calculator (optional)

Background

All matter, including all living things, is made of very tiny pieces called atoms. An atom is the smallest piece of an element that can still be identified as that element. Atoms are made of even smaller pieces called protons (positive or +), neutrons (neutral), and electrons (negative or –). Atoms usually have the same number of protons and electrons. The amount of positive and negative charge is the same. In some materials, electrons are easily pulled off their atoms, which allows the electrons to move to another material. When the electrons are pulled from a material, it then has a more positive electrical charge. The material to which the electrons moved now has a more negative electrical charge. The two materials have opposite charges. Opposite charges attract while similar charges repel. When an electrical charge is connected to something and is not moving, we call it static electricity. You may have experienced static electricity when you've seen clothes stick together after coming out of the dryer. It is called static cling because it is caused by static electricity!



Procedure

1. Blow up one balloon and tie it closed.
2. Rub the balloon against your hair or clothes for 30 seconds and stick it on a wall.
3. Begin timing how long the balloon stays on the wall.
4. In the chart, record the time in seconds.
5. Repeat steps 2–4 for two more trials.
6. Repeat steps 2–5 for different intervals of time: 60 seconds, 90 seconds, and 120 seconds.
7. Calculate and record the average number of seconds the balloon stayed on the wall for each time interval. Note: To calculate the average, find the sum of all three times for each time interval and divide by three.
8. In the graph provided, create a bar graph of the results (average times).
9. Rub the balloon for 60 seconds, but this time have your partner rub his/her hands all over the balloon.
10. Stick it to a wall.
11. Observe. Record what happened and explain your observations.

Conclusions

1. What made the balloon stick to the wall?
2. Why did the balloon eventually fall off the wall?
3. Did the length of time you rubbed the balloon make a difference in the length of time the balloon stayed stuck to the wall? Explain why or why not.
4. What changed when you rubbed the balloon with your hands?
5. In your own words, explain static electricity.

Charge!

Segment 2

6. Why did the tree house detectives need to learn about electricity?

Trial	30 Seconds	60 Seconds	90 Seconds	120 Seconds
1				
2				
3				
Average Time				

Extension

1. Measure and cut 1.5 m of string. On one end of the string, tie a loop large enough to fit your hand through. Use helium to blow up two balloons. Tie each balloon closed and attach the end of the string without a loop to the balloon. Sit facing your partner and hold your balloons securely. Rub one of the balloons on your hair and then float both balloons above your heads. Move the balloons close together and observe. Rub both balloons on your hair and repeat the experiment. Explain what happened and why.
2. Tear a piece of paper into tiny pieces. Use the balloon to pick up the pieces of paper. Explain how this experiment works.
3. Rub a balloon on your hair for 60 seconds and then move the balloon slowly towards a tiny stream of running water. Observe what happens and explain.

The Current Detective

Segment 2

Purpose

To make a device to detect electric current

Background

Electrical current flowing in a coil of wire creates a magnet. Moving a magnet in a coil of wire creates an electrical current. The kind of current you use in your home is called alternating current—AC for short. It's called AC because the flow of the current changes direction.

Materials

compass
bar magnet
D-cell battery
D-cell holder
cardboard tube
3-m insulated wire with ends stripped (18 to 24 gauge)
1-m insulated wire with ends stripped (18 to 24 gauge)
transparent tape
science journal

Procedure

1. To make a current detector, use the 1-m wire and wrap 6 to 8 loops around the middle of the compass, going from north to south and leaving about 20 cm of extra wire on each end. See diagram 1.
2. Place the D-cell battery in the holder.
3. Line up the compass on your desk so that the needle points north and lines up with the wire loops.
4. Connect one end of the wire to the D-cell.
5. Briefly touch the end of the wire to the other end of the D-cell. See diagram 2.
6. Observe and record your observations in your science journal.
7. Wrap the 3-m wire around the cardboard tube. Make the loops as close together as possible but be sure not to overlap any loops. Leave 50 cm of wire at each end. See diagram 3.
8. Connect one wire on the current detector to one wire on the cardboard tube.
9. Repeat with the other two ends of wire. NOTE: You can use an empty D-cell battery holder to hold the wires together. See diagram 4.
10. Position the tube as far away as possible from the current detector.
11. Insert the bar magnet into the cardboard tube while your partner observes the compass.
12. Switch positions and record your observations in your science journal.
13. Predict what will happen when you reverse the position of the bar magnet.
14. Test your prediction and explain.

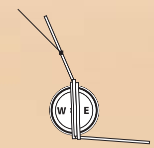


Diagram 1

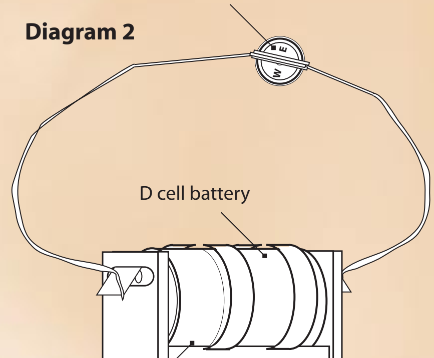


Diagram 2

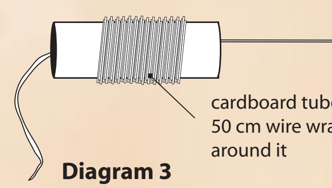


Diagram 3

Conclusions

1. Describe what happened to the compass when current ran through the wire.
2. Describe what happened when you reversed the position of the bar magnet in the tube.
3. In what way is the compass needle's movement evidence of a current in the wire?
4. What do you think produced a current in the wire?

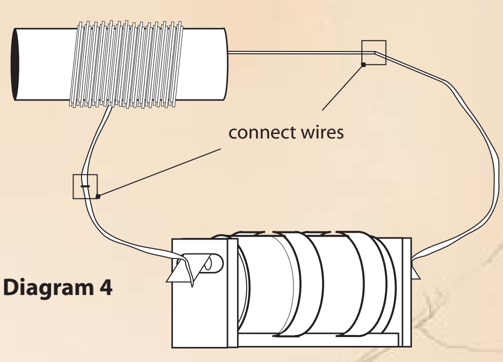


Diagram 4

Answer Key

Segment 2

It Takes 4

1. The contour interval is 10 m. The total elevation will vary but will always equal the height of the model in centimeters times 1000.
2. The closer together the contour lines are on the map, the steeper the slopes on the model. Increased distances between contour lines indicate relatively flat areas of the model.
3. No, the 0-m contour line is only on maps that have an elevation at sea level.
4. Generally, the greater the relief of an area, the larger the contour interval. Relatively flat areas of low relief are represented by smaller contour intervals.
5. Answers will vary but should include that GPS devices can sometimes stop working for various reasons, such as a dead battery. Therefore, a topographic map would be useful if GPS weren't available. Answers will vary and might include a compass—just in case the GPS has problems.

Transversing the Wave

1. As your hand moved faster, the speed of the rope increased.
2. The wavelength became shorter as the rope moved faster.
3. The number of crests and troughs increased as the rope moved faster. Frequency.
4. As the wavelengths got shorter, students had to walk faster to reach the end at the same time as the first wave.
5. The shortest wavelength would have more crests and troughs pass a fixed point. Because the wavelength is shorter, there are more of them in the same linear distance.
6. Answers will vary, but should include that as wavelength decreases, frequency increases.
7. They are inversely proportional.

Charge!

1. A neutral wall contains countless positive and negative charges. As a negatively charged balloon approaches the wall, the positive charges on the wall move toward the balloon and the negative charges move away from it. Because negative and positive charges attract each other, the balloon sticks to the wall. The wall becomes polarized and continues to attract the balloon and hold it in place until other forces act upon it.
2. Due to water vapor (humidity) being in the air, the excess charge leaks off into the atmosphere and the balloon goes back to a neutral charge. Once the balloon is neutral, it is not "attracted" to the wall and falls.
3. Answers will vary, but generally, the longer you rub the balloon, the longer it will stay on the wall. When you rub the balloon for a longer period of time, you increase the amount of charge on the balloon.
4. When you rubbed the balloon with your hands, the extra charge moved to your body, spread out, and traveled to the ground. Getting rid of extra electric charge by safely transferring it to the ground is called grounding the charge. Grounding is the easiest way to get rid of static electricity.
5. Answers will vary, but should include that static electricity is a buildup (excess) of nonmoving electric charge in one place that is caused by an excess or a lack of electrons.
6. Answers will vary but should include that the tree house detectives had problems with their two-way radios, and they know that an electrical charge can create radio waves. Therefore, they conclude that they should learn more about electricity.

The Current Detective

1. The compass moved when current ran through the wire.
2. The compass needle swings one way when the magnet is inserted and it swings the other way when it is pulled out. When you reverse the magnet, you cause the compass needle to swing in the opposite direction from how it originally swung.
3. When you moved the bar magnet into the coil of wire (tube), it induced a weak electric current in the coil. A compass is sensitive to electric current. When a compass detects an electric current, it moves.
4. The movement of the magnet through the coil produces the current. Faraday observed that whenever a coil is in the presence of a changing magnetic field, it causes a current in the coil.

On the Web

Groovin' On the AM Waves

1. When the bare wire moved against the fork, it generated electromagnetic radiation by releasing electric energy from the battery.
2. Answers will vary but should indicate that as the distance increased, the corresponding static was less.

Segment 3

Still undecided about what might have caused the GPS and radio glitches, the detectives contact Ole and Nina to meet Dr. D to learn about magnetism. Dr. D meets them at the Northern Lights Museum in Andenes, Norway, where he performs several demonstrations and discusses how the Earth's magnetic field interacts with light particles coming from the Sun. To learn more about electromagnets, the tree house detectives dial up Mr. Jacobsen's class at Andenes Ungdomskole (middle school). Last stop for the detectives is NASA Goddard Space Flight Center in Greenbelt, Maryland, where RJ and Catherine talk with Dr. Nicky Fox to learn more about our star, the Sun.

Objectives

Students will

- understand that opposite magnetic poles attract and like magnetic poles repel.
- observe a magnetic field around a bar magnet.
- understand that the Earth's magnetic field is similar to that of a bar magnet.
- construct an electromagnet and experiment with various voltages.
- describe the layers of the Earth's atmosphere
- label the layers of the Sun's atmosphere.
- understand how sunspots, solar flares, and coronal mass ejections occur on the surface of the Sun.

Vocabulary

aurora—a phenomenon occurring in the night sky around the polar regions, caused by atmospheric gases interacting with solar particles to create streamers, folds, or arches of colored light

convection—circulating movement in a liquid or gas, resulting from regions of different temperatures and different densities rising and falling in response to gravity

coronal mass ejection (CME)—huge bubble of gas threaded with magnetic field lines that are ejected from the Sun over the course of several hours. CMEs have the most energy of all solar events. They can disrupt the flow of the solar wind and produce disturbances that strike the Earth—sometimes with catastrophic results.

electromagnet—a temporary magnet formed when electric current flows though a wire or other conductor

ionosphere—a high layer of Earth's atmosphere, made up of ions that reflect radio waves

magnet—a piece of metal, often bar-shaped or U-shaped, that has the power to draw iron or steel objects toward it and to hold or move them

magnetic field—a region of space surrounding a magnetized body or current-carrying circuit in which the resulting magnetic force can be detected

magnetic poles—either of the two points at the end of a magnet where the magnet's field is most intense; either of the two regions on the Earth's surface near the geographic poles where the Earth's magnetic field is most intense

magnetosphere—the region surrounding Earth in which charged particles are trapped and affected by the Earth's magnetic field

mesosphere—the layer of the Earth's atmosphere in which temperature decreases rapidly, located between the stratosphere and thermosphere

plasma—a state of matter that is a hot, ionized gas made up of ions an electrons that are found in the Sun, stars, and fusion reactors

solar flare—a tremendous explosion on the surface of the Sun that releases energy in many forms

solar wind—the flow of high-speed ionized particles from the Sun's surface into interplanetary space

stratosphere—the region of the Earth's atmosphere located between the troposphere and mesosphere and in which the ozone layer is located

sunspot—one of the relatively cool, dark patches that appear in cycles on the Sun's surface and possess a powerful magnetic field

terrella—magnetized sphere used inside vacuum chambers, together with electron beams, to study the motion of fast-charged particles near the Earth

thermosphere—the region of the Earth's atmosphere above the mesosphere in which temperature steadily increases with height, beginning at about 85 km above the Earth's surface

travel bug—any small item that has been tagged with a unique tracking number and placed in a cache for geocachers to find

troposphere—the lowest layer of Earth's atmosphere, in which we live, and where clouds and weather occur

volt—unit of electric potential difference

voltage—a type of "pressure" that drives electrical charges through a circuit

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Before viewing Segment 3 of *The Case of the Technical Knockout*, discuss the previous segment to review the problem and assess what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on **Tools**. The **Problem Board** is also in the **Problem-Solving Tools** section of the latest online investigation. Have students use this section of the web site to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during previous segments. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 2.
5. Read the overview for Segment 3 and have students add any questions to their list that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the **Educators** area of the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program so they will be able to answer the questions. An icon will appear when the answer is near.
7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. You can print them from the **Educators** area of the web site ahead of time for students to copy into their science journals.

Careers

aerospace equipment scientist
atmospheric chemist
instrumentation engineer
solar astronomer
solar physicists
stellar physicist

View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Technical Knockout* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what they now know about orienteering, using a compass, GPS, satellites, the electromagnetic spectrum, electricity, magnets, auroras, and the Sun.
4. Organize the information, place it on the Problem Board, and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information the tree house detectives need to determine what caused the GPS and radios to go on the blink. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the corresponding **Educator Guide**(s). On the NASA SCI Files™ home page, click on the fence post for Guides. Click on the **Archives** tab and then click on the **2001–2002 Season**. To download the **guide**, click on **Full Guide** or the **Segment** indicated for *The Case of the Mysterious Red Light.*

   a. In the **Educator Guide** you will find

   a. Segment 4–*Layer Upon Layer* (atmospheric layers), *Layers of the Atmosphere* (atmospheric layers)

   Close the PDF window and return to the page for **Guides 2001-2002** Season. To download the guide, click on **Full Guide** or the **Segment** indicated for *The Case of the Phenomenal Weather.*

   a. In the **Educator Guide** you will find

   a. Segment 1 – *Convection to Perfection* (convection)

8. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under **After Viewing** on page 15 and begin the PBL activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:
   - **Research Rack**—books, Internet sites, and research tools
   - **Problem-Solving Tools**—tools and strategies to help guide the problem-solving process.
   - **Dr. D's Lab**—interactive activities and simulations
   - **Media Zone**—interviews with experts from this segment
   - **Expert's Corner**—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast
9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon, as suggested on the PBL Facilitator Prompting Questions instructional tool found by selecting **Educators** on the web site.
10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools found on the web site. Visit the **Research Rack** in the Tree House and find the online PBL investigation main menu section, **Problem-Solving Tools**, and the **Tools** section of the **Educators** area for more assessment ideas and tools.

Resources *(additional resources located on web site)*

Books

Akasofu, Syun-Ichi: *Secrets of the Aurora Borealis*. Alaska Geographic Society, 2002, ISBN: 1566610583.

Apt, Jay and Michael Helfert: *Orbit: NASA Astronauts Photograph the Earth*. National Geographic Society, 2003, ISBN: 0792261860.

Baylor, Byrd: *The WayTo Start a Day*. Simon and Schuster, 1986, ISBN: 0689710542.

Burke, Christopher: *Magnetism*. Gareth Stevens Audio, 2003, ISBN: 0836833600.

Carmi, Rebecca and Judith Stamper: *Amazing Magnetism*. Scholastic, Inc., 2002, ISBN: 0439314321.

Cooper, Christopher: *Magnetism: From Pole to Pole*. Heinemann Library, 2003, ISBN: 1403435510.

Esbensen, Barbara Juster: *Night Rainbow*. Scholastic, Inc., 2000, ISBN: 053130244X.

Freeman, John: *Storms in Space*. Cambridge University Press, 2001, ISBN: 0521660386.

Hall, Calvin: *Northern Lights: The Science, Myth, and Wonder of Aurora Borealis*. Sasquatch Books, 2001, ISBN: 1570612900.

Kinsey-Warnock, Natalie: *Fiddler of the Northern Lights*. Dutton Juvenile, 1996, ISBN: 0525652159.

Kosek, Jane Kelly: *What's Inside the Sun?* Rosen Publishing, 2003, ISBN: 0823952797.

Nicolson, Cynthia Pratt: *The Sun*. Kids Can Press, Limited, 1997, ISBN: 1550741586.

Simon, Seymour: *The Sun*. William Morrow and Company, 1990, ISBN: 0688092365.

Vogt, Gregory: *Sun*. Capstone Press, 2000, ISBN: 0736805168.

Whitethorne, Baje: *Sunpainters: Eclipse of the Navajo Sun*. Salina Bookshelf, 2002, ISBN: 1893354334.

Ytter, Harald and Torbjorn Lovgren: *Aurora: the Northern Lights in Mythology, History, and Science*. Bell Pond Books, 1999, ISBN: 0863152872.

Video

NASA CONNECT™: *Dancing in the Night Sky*
Grades 6–12

NASA CONNECT™: *Solar Flares*
Grades 6–12

Discovery Channel School: *Savage Sun*
Grades 6–12

Disney: *Atmosphere (Bill Nye, the Science Guy)*
Grades 3–8

Disney: *Magnetism (Bill Nye, the Science Guy)*
Grades 3–8

Schlessinger Media: *All about the Sun (Space Science for Children)*
Grades K–4

Schlessinger Media: *Earth's Atmosphere (Space Science in Action)*
Grades 5–8

Schlessinger Media: *Electromagnetic Energy (Energy in Action)*
Grades 5–8

Web Sites

NASA CONNECT™
Educators, visit this site to find video and lessons on auroras and solar flares.
http://connect.larc.nasa.gov

NASA: 3-D Images of Coronal Mass Ejections
NASA funded scientists created the first three-dimensional (3-D) view of massive solar eruptions called Coronal Mass Ejections (CMEs). Visit this site to see some awesome images and learn more about how the images will help researchers around the world.
http://www.nasa.gov/centers/goddard/news/topstory/2004/07023dcme.html

NASA Imagers: The Adventures of Echo the Bat
This NASA interactive web site for children features a multimedia adventure game that teaches facts about light and the electromagnetic spectrum. Also choose a downloadable book and web activities for children to try.
http://imagers.gsfc.nasa.gov/echohome.html

NASA: Polar Cap History
Here you can read all about how auroras were studied and analyzed throughout modern history. See a picture of Dr. Kristian Birkeland and his terrella and find more information on his theory.

NASA: Coronal Mass Ejections
Learn more about coronal mass ejections (CME) and view some awesome photos.
http://science.nasa.gov/ssl/pad/solar/cmes.htm

NASA: Solar Flare
Discover facts about solar flares and the problems they can cause here on Earth.
http://science.msfc.nasa.gov/ssl/pad/solar/flares.htm

NASA: Sunspots
Learn all about sunspots and the sunspot cycle.
http://science.msfc.nasa.gov/ssl/pad/solar/feature1.htm#Sunspots

NASA Jet Propulsion Laboratory: Educator's Guide to Convection
Discover how convection works and learn more about convection cells on the Sun.
http://www.solarviews.com/eng/edu/convect.htm

Amazing Space
Find an interactive activity called "Star Light, Star Bright" that teaches about the electromagnetic spectrum.
http://amazing-space.stsci.edu/resources/explorations/

Exploratorium Solar Max
Check out the wonderful pictures and numerous links to find out more about the sun and sunspots.
http://www.exploratorium.edu/solarmax/index.html

Windows to the Universe
This web site uses diagrams to offer a simple explanation about the layers of the atmosphere.
http://www.windows.ucar.edu/tour/link=/earth/Atmosphere/layers.html

The Sun
On this University of Virginia web site, you can learn about the sun and watch actual footage of the sun, including the corona, sunspots, and eclipses.
http://www.astro.uva.nl/demo/sun/kaft.htm

The Sun
Find numerous pictures and a wealth of information about the sun.
http://www.nineplanets.org/sol.html

Surfing for Sunbeams
"Surf" this site for important facts about the sun and watch informative video that clarifies concepts from the web site.
http://www.lmsal.com/YPOP/Spotlight/Tour/index.html

Sunspots
Exploratorium's web site has detailed information about sunspots, including video and pictures to explain the phenomena.
http://www.exploratorium.edu/sunspots/index.html

Exploratorium Auroras
This web site explains what auroras are and shows beautiful pictures and a video of the northern lights.
http://www.exploratorium.edu/auroras/index.html

Auroras: Paintings in the Sky
Find out what auroras look like on Earth and from space. Learn how they are created and where you can find them.
http://www.exploratorium.edu/learning_studio/auroras/

The Aurora Page
See many pictures of auroras and find links to other aurora web sites.
http://www.geo.mtu.edu/weather/aurora/

NORDLYS – Northern Lights
Learn about the northern lights— what they are, where they are, and what they look like.
http://www.northern-lights.no/index.shtml

Activities and Worksheets

In the Guide

Let the Force Be With You
Experiment with magnets to learn how they repel and attract. 47

Magnetizing the Field
Use iron filings to learn what a magnetic field looks like. 49

Now Showing in 3D
Create your own 3D version of a magnetic field. 50

Electrifying Electricity
Build an electromagnet and calculate its strength with various voltages. 52

The Sun's Layers
Learn about the layers of the sun. 54

Answer Key
. . . . 56

On the Web

Layer Upon Layer
Compare and contrast the various layers of Earth's atmosphere.

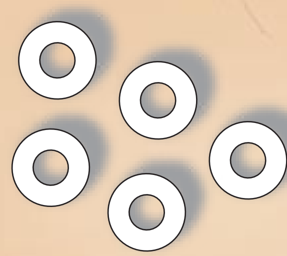
Let the Force Be With You

Segment 3

Purpose

To understand that magnets have positive and negative poles

To learn that similar poles repel and opposite poles attract

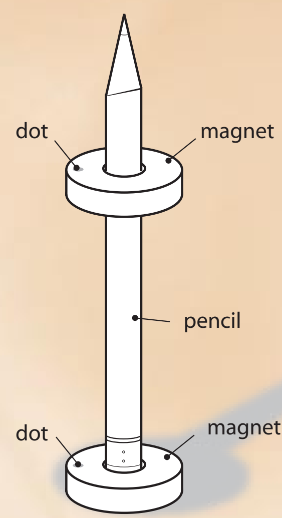


Materials

5 identical doughnut magnets
pencil
small dot stickers
science journal

Procedure

1. Bring two of the magnets near each other.
2. Turn one magnet until the other magnet attracts it. Let them come slowly together until they touch.
3. Rotate one of the magnets to find the position in which it is most strongly repelled by the first magnet.
4. In your science journal, describe what happened as you put the magnets together in the different positions.
5. Take any two of the five magnets and rotate them until they are attracted to each other and stick together.
6. Place a small dot sticker on the side of each of the magnets that stuck together.
7. Repeat with the other magnets until all are marked with stickers.
8. Place two magnets together with the dots facing each other.
9. In your science journal, record your observations.
10. Place two magnets together with the dots facing away from each other.
11. Record your observations.
12. When two objects push away from each other, scientists say that they repel. And when two objects stick together, scientists say that they attract. Complete the following data chart using the terms "repel" and "attract."
13. Slide one magnet, dot side up, onto a pencil.
14. Repeat sliding the remaining magnets onto the pencil with dot side up. See diagram.
15. Draw a picture in your science journal and describe what you observe. Explain in your own words what occurred and why.
16. Slide the magnets off the pencil.
17. Slide one magnet, dot side up, onto the pencil.
18. Slide the next magnet, dot side down, onto the pencil.
19. Continue sliding the magnets onto the pencil—dot side up, dot side down, and finally dot side up.
20. In your science journal, describe what you observed and illustrate. Explain in your own words what happened and why.



Let the Force Be With You

Segment 3

Conclusion

1. What happens when like poles come together? Why?
2. What happens when opposite poles come together? Why?
3. In your own words, explain why the magnets "floated" when they were placed on the pencil with opposite poles together.

Extension

1. Place two magnets on a pencil so that they float. Use a metric ruler to measure the distance between the two magnets. Add a third magnet so that it also floats. Measure the distance between the first two magnets again and also the second and third magnets. Continue adding magnets and measuring until all five magnets are floating. Describe what happened.
2. Research Peter Perigrinus who made spheres from naturally magnetic lodestones in 1269. Explain how lodestones find north.

Magnetizing the Field

Segment 3

Materials

bar magnet
iron filings
small, clear plastic box
science journal

Purpose

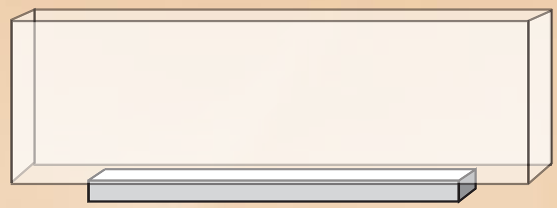
To observe the magnetic field around a bar magnet

Background

A magnet is surrounded by a magnetic field that exerts a magnetic force. When an object made of iron or another magnet is placed in the magnetic field, it reacts to the magnetic force. The magnetic field is strongest close to the magnet and weakest far away. Lines of force, or magnetic field lines, can represent the magnetic field.

Procedure

1. Place the bar magnet on a flat surface.
2. Place the small, clear plastic box on top of the bar magnet.
3. Sprinkle the iron filings in the box so that they cover the area in and around the bar magnet.
4. Tap the box gently to make the pattern appear more clearly.
5. Observe and record your observations in your science journal.
6. Draw a picture of the magnetic field lines created by the iron filings.



small clear box sitting on top of a magnet

Conclusion

1. Describe the pattern that the iron filings made around the bar magnet.

Extension

1. Try differently shaped magnets (such as round, square, or oval) and illustrate and describe their magnetic field lines.
2. Try different numbers of magnets in different arrangements and illustrate and describe the resulting magnetic field lines.

Now Showing in 3D

Segment 3

Purpose

To observe a magnetic field in 3D

Materials

magnet
extra-fine steel wool
small plastic bottle filled with baby oil
scissors
goggles

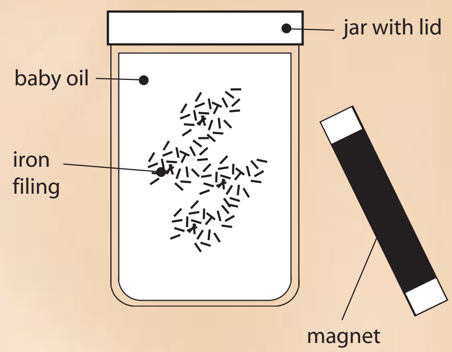
Teacher Note

Cow magnets work well with this experiment. Cow magnets are very strong magnets that you can purchase at a feed store or from scientific catalogs. If cow magnets are not available, substitute four or five donut magnets stacked upon each other or a very strong bar magnet.

Teacher Prep

For each group, either spray paint one side of a small plastic bottle or place a plain white label on one side. The white paint or label will help the students see the fibers better. Fill each bottle with baby oil almost to the top, leaving only a small space to add the fibers. Secure the cap of each bottle before dispensing to the groups.

Procedure



1. Wear goggles to protect your eyes from the steel wool pieces.
2. Unroll one end of the steel wool.
3. To trim evenly, use scissors to cut across the unrolled end of the steel wool. Discard the frayed fibers.
4. Cut across the steel wool, making very narrow cuts (2–3 mm wide).
5. Continue cutting until you have a little more than a teaspoon of fibers.
6. Gently wad the fibers (do not pack too tightly) and drop them into the bottle of baby oil.
7. Securely place the cap on the bottle and shake the bottle until the fibers are spread evenly throughout the oil.
8. While the fibers are still mixed in the oil, hold a magnet about 2–3 cm from one side of the bottle and observe the tiny fibers. It helps to hold the bottle in bright light to better see the fibers against the white portion of the bottle.
9. If the fibers start to settle to the bottom, just shake the bottle again. If the fibers clump against the magnet, you are holding the magnet too close to the bottle.
10. Vary the position of the magnet. For example, hold the magnet up and down, sideways, or with just one pole near the bottle.
11. Record your observations and illustrate each.

Now Showing in 3D

Segment 3

Conclusion

1. Explain in your own words why the iron filings lined up the way that they did.
2. Describe how the magnetic fields changed as you varied the position of the magnet.
3. What do you think creates a magnetic field?
4. What do you think the Earth's magnetic field looks like? Draw a picture.

Extension

Fill a small plastic soda bottle (remove label) about one-fifth full of iron filings. Place a cow magnet in a plastic test tube. The test tube should be about 75% fuel as long as the bottle is tall. To enlarge the size of the top of the test tube so it won't fall into the soda bottle, wrap the outer top rim of the test tube with masking tape. Also wrap masking tape over the top opening of the test tube. Place the test tube into the soda bottle, making sure it fits snugly. Add tape if needed. Put the bottle cap back onto the top of the bottle. Turn the bottle on its side and rotate. Watch what happens to the iron filings.

Electrifying Electricity

Segment 3

Problem

To build an electromagnet and to calculate the average number of paper clips lifted by using four different voltages

Background

A volt is a unit that measures the potential to move charges. The more voltage a battery has, the greater the electrical current. As the current increases in an electromagnet, the magnet's strength increases.

Teacher Prep

Use tape to label each of the four battery slots with the correct voltage: 1.5 V, 3.0 V, 4.5 V, and 6.0 V.

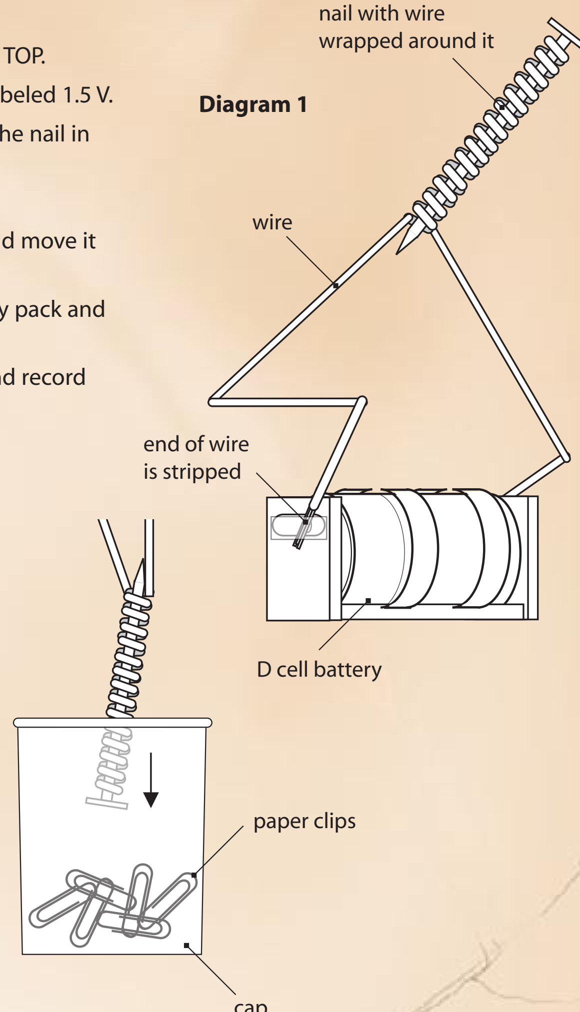
Materials

large iron nail (16 cm)
3-m insulated stranded copper wire (18 to 24 gauge)
four 1.5-volt D cell batteries
battery holder for 4 batteries
100 metal paper clips
small container for paper clips
alligator clips
Electromagnets Data Chart (p.53)
Electromagnets Results Graph (p. 53)

Procedure

1. Take the end of the wire that does not have an alligator clip and straighten it.
2. To construct your electromagnet, neatly wrap the straightened end of the wire around the nail 25 times. Start wrapping at the flat part (head) of the nail and work your way towards the nail's point.
3. Clip one end of the wire to the screw on the battery pack labeled TOP.
4. Hold the other end of the wire onto the metal near the voltage labeled 1.5 V.
5. Touch the wire to the metal screws and have your partner place the nail in the container of paper clips. See diagram 1.
6. Gently mix the paper clips with the electromagnet.
7. Carefully lift the electromagnet out of the paper clip container and move it to a clean spot on the table.
8. Turn the electromagnet off by removing the wire from the battery pack and let the paper clips fall.
9. Count the number of paper clips the electromagnet picked up and record the number in the Electromagnets Data Chart on page 53.
10. Repeat steps 4–9 for two more trials.
11. Repeat steps 4–10 with the other three voltages you used.
12. Average the number of paper clips for the three trials for each voltage.
13. Graph your results on the Electromagnets Results Graph.

Diagram 1



Conclusion

1. What happened to the electromagnet's strength when you added more volts?

Extension

Experiment with different numbers of wire wraps around the nail.

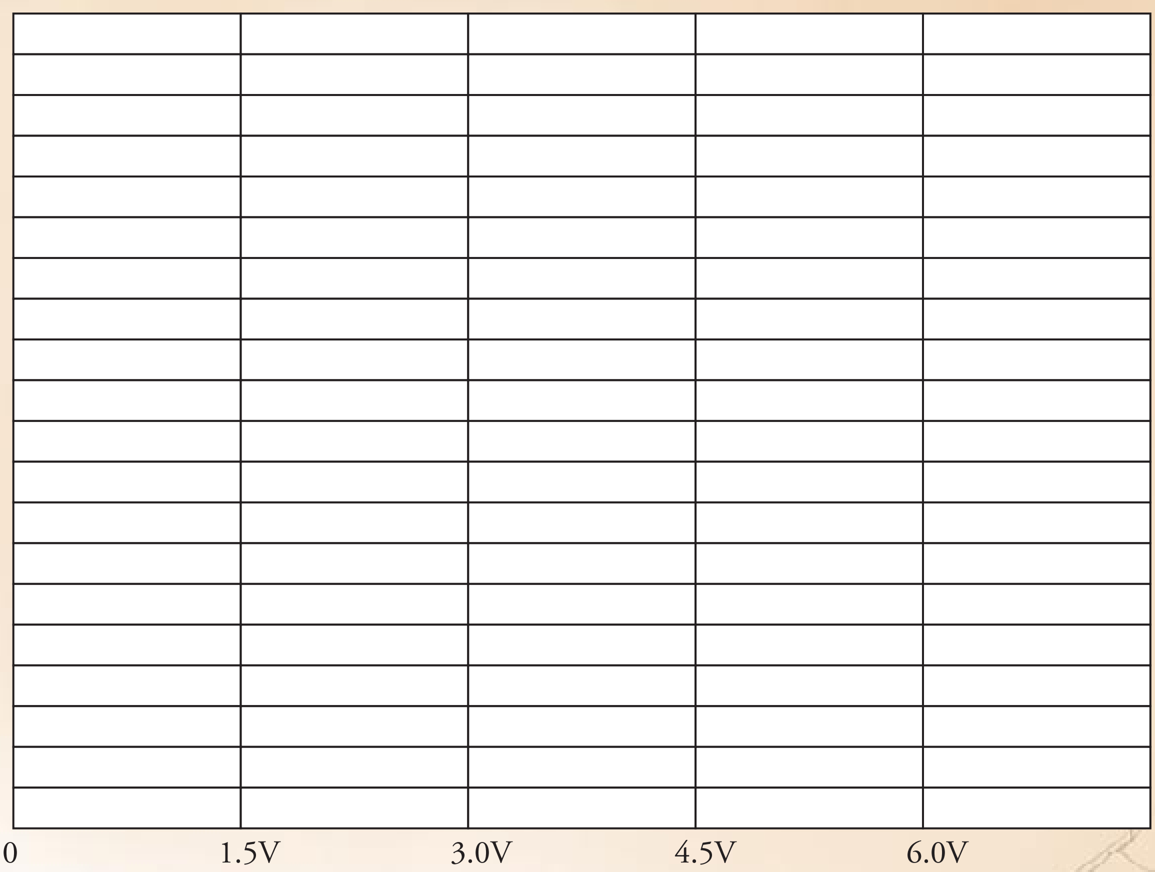
Electrifying Electricity

Segment 3

ELECTROMAGNETS DATA CHART

Battery Voltage	Paper Clips Trial 1	Paper Clips Trial 2	Paper Clips Trial 3	Average
1.5V				
3.0V				
4.5V				
6.0V				

ELECTROMAGNETS RESULTS GRAPH



The Sun's Layers

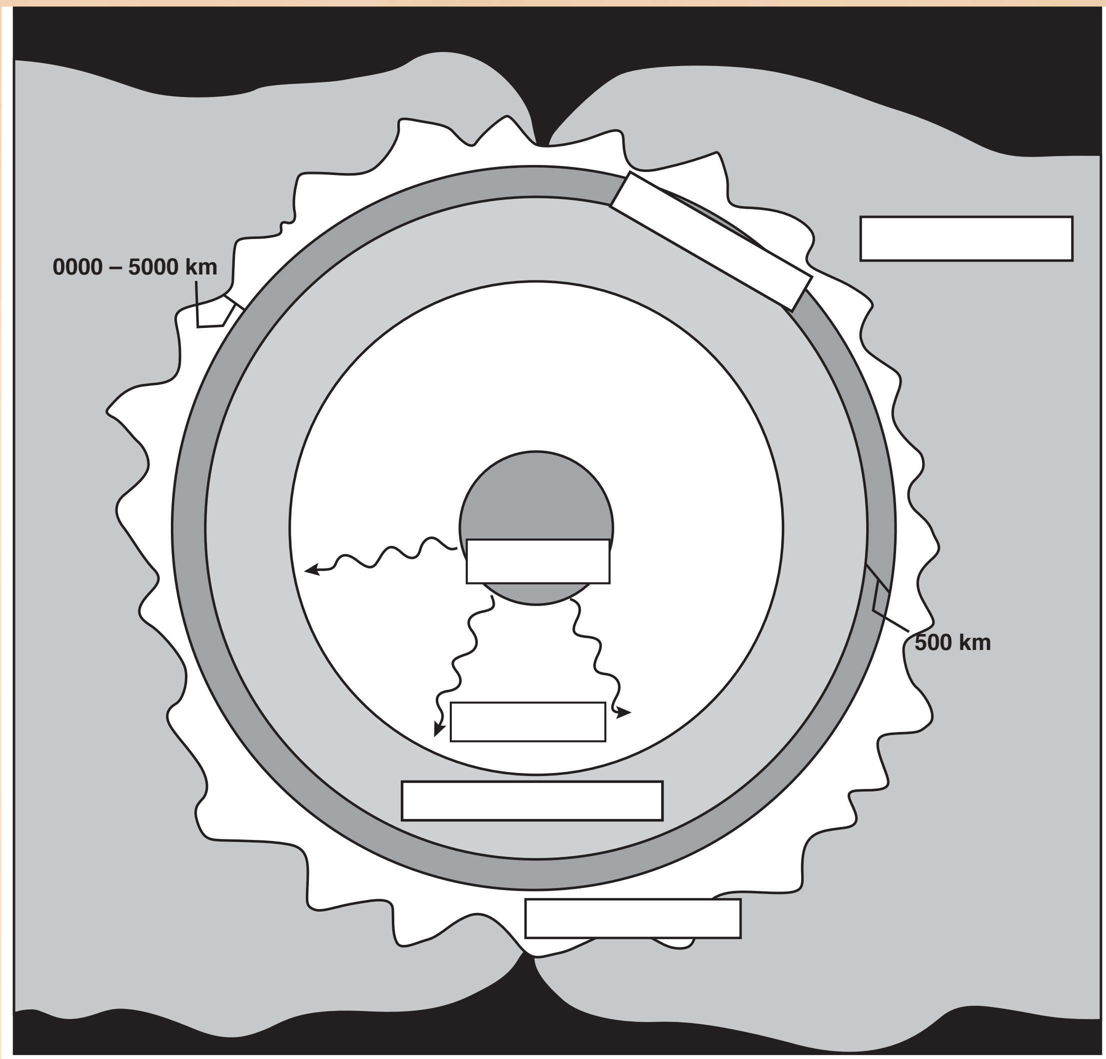
Segment 3

Purpose:

To label and describe the layers of the Sun.

Label the 4 inner layers and 2 outer layers of the Sun in the box for the layer you are labeling.
Use these vocabulary words:

Core	Radiation layer	Convection layer
Photosphere	Corona	Chromosphere



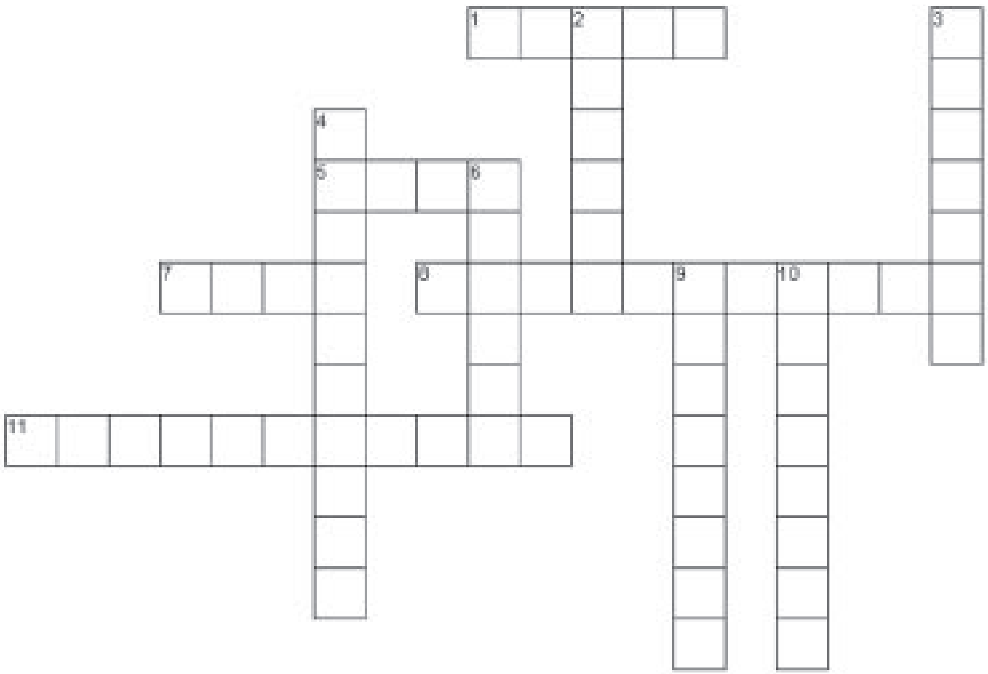
Extension

Conduct research to learn more about the various layers of the Sun. Create a poster, model, or written report describing what is known about each layer. In the show, Dr. Fox compared and contrasted the layers of the Sun to the layers of the Earth. Describe how they are similar and/or different.

Our Very Own Star

Segment 3

Use the word bank to help you complete the crossword puzzle.



ACROSS

1. Our Sun is a medium yellow________ star.
5. The Sun spins on its_______________.
7. The center of the Sun is the ___________.
8. The __________is the surface of the Sun.
11. The Sun gives off ________ rays.

DOWN

2. Sunspots can __________ the Earth's weather.
3. ___________ was the first scientist to observe and record sunspots.
4. We get valuable data about the Sun from ____________.
6. The Sun is in the shape of a ___________.
9. _____________ are irregularly shaped dark areas on the Sun.
10. The Sun is made up mainly of _________.

VOCABULARY

Ultraviolet
Photosphere
Core
Axis
Dwarf
Affect
Hydrogen
Sphere
Satellites
Gallileo
Sunspots

Answer Key

Segment 3

Let the Force Be With You

1. When like poles came together, they pushed away from each other because like poles always repel.
2. When opposite poles came together, they stuck to each other because opposite poles attract.
3. Answers will vary.

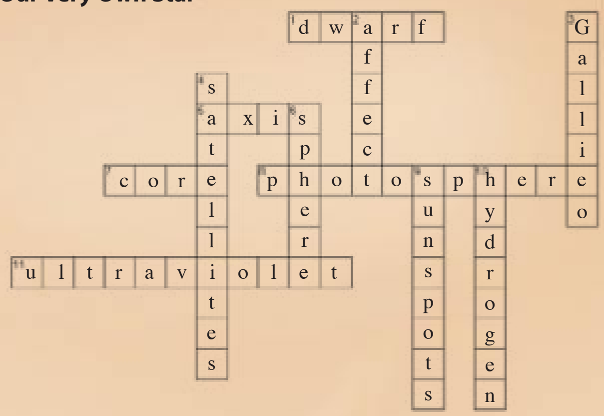
Magnetizing the Field

1. The iron filings should have made a pattern of lines coming from one pole and going to the other pole. Concentration of the iron filings is greatest at the poles.

Now Showing in 3D

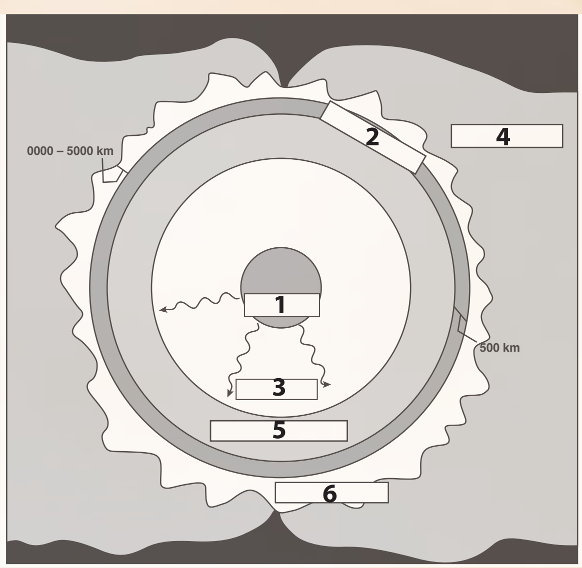
1. Answers will vary, but might include that each iron filing became a tiny magnet with a north and south pole when you brought the magnet near them. The atoms in the iron aligned themselves with the magnetic field.
2. Answers will vary.
3. Motion of electrical charges. For example, the magnetic field of a bar magnet results from the motion of negatively charged electrons in the magnet.
4. Answers will vary, but hopefully students will understand that most magnetic fields are similar and that our Earth's magnetic field looks very similar to the one they created with the bar magnet. The origin of the Earth's magnetic field is not completely understood, but scientists think it is associated with electrical currents that are produced by the coupling of convective effects and the rotation, in the spinning liquid metallic outer core, of iron and nickel. This mechanism is called the dynamo effect.

Our Very Own Star



The Sun's Layers

1. Core
2. Photosphere
3. Radiation layer
4. Corona
5. Convection layer
6. Chromosphere



Segment 4

Trying to put the final pieces of the puzzle together, the tree house detectives dial up Dr. Sten Odenwald to learn about solar flares and coronal mass ejections and their effect on Earth. To confirm their hypothesis, the detectives send Tony to visit Joe Kunches at the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado, to learn more about space weather. At last the detectives think they know why their GPS receivers and radios went on the blink and had a few glitches. To wrap up the problem, they head to the airport to meet Dr. D as he returns from Norway.

Objectives

Students will

- understand how solar flares and coronal mass ejections occur.
- learn how disruptions to the ionosphere can affect radio transmissions.
- learn that space weather can affect us on Earth.
- distinguish between sunspot maximum and sunspot minimum.

Vocabulary

aurora—a faint visual phenomenon associated with geomagnetic activity, which occurs mainly in the high-latitude night sky

coronal mass ejection—billion-ton cloud of charged particles released by the Sun during large solar flare events

geomagnetic storm—a disturbance in the Earth's magnetic field associated with charged particles from solar flares and sunspot activity

ionosphere—layer of the Earth's upper atmosphere in which incoming ionizing radiation from space creates ions and free electrons that can reflect radio signals, enabling their transmissions around the world

magnetometer—a device for measuring the direction and intensity of a magnetic field

magnetosphere—the area of space around the Earth that is controlled by the Earth's magnetic field

space weather—includes all solar flares and coronal mass ejections that can cause disturbances to the ionosphere

solar cycle—the approximately 11-year variation in frequency or number of solar active events

solar flare—a brief sudden eruption of high-energy hydrogen gas from the surface of the Sun, associated with sunspots. Can cause interruptions of communication systems on Earth.

sunspot maximum—the months during the solar cycle that have the highest monthly average sunspot numbers that reach a maximum

sunspot minimum—the months during the solar cycle that have the highest monthly average sunspot numbers that have a minimum

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Technical Knockout*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 3.
5. Read the overview for Segment 4 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of the Technical Knockout* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. At the end of Segment 4, lead students in a discussion of the Focus Questions for Segment 4.
2. Have students discuss and reflect on what the tree house detectives did to solve the mystery of what caused the technical glitches to occur. Ask the students what they would have done differently to solve the problem.
3. The following instructional tools located in the Educators area of the web site may aid in the discussion: Experimental Inquiry Process Flowchart and/or Scientific Method Flowchart.
4. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
5. Wrap up the featured online PBL investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Find sample evaluation tools in the Educators area of the web site under the main menu topic **Tools** by clicking on **Instructional Tools**.
6. Have students write in their journals what they have learned about GPS, satellites, auroras, electricity, magnets, and the Earth's atmosphere so that they can share their entry with a partner or the class.

Careers

archeoastronomer
astrobiologist
astrometrist
astrophysicist
cosmologist
cultural astronomer

Resources *(additional resources located on web site)*

Books

Anawalt, Paula Bonnier: *The Crystal Palace: A Tale from the Gold Country*. Abongold Books, 2000, ISBN: 0966841409.

Canizares, Susan: *Northern Lights*. Scholastic, Inc., 1998, ISBN: 0590761552.

Kalman, Bobbie: *The Sun*. Crabtree Publishing, 2000, ISBN: 0865056927.

Love, Ann and Jane Drake: *The Kids Book of the Night Sky*. Kids Can Press, 2004, ISBN: 1553371283.

St. Antoine, Sara: *Stories from Where We Live: The Great Lakes*. Milkweed Editions, 2003, ISBN: 1571316396.

Souza, Dorothy: *Northern Lights*. Lerner Publishing Group, 1994, ISBN: 0876146299.

Tocci, Salvatore: *Experiments with the Sun and the Moon*. Scholastic Library, 2003, ISBN: 0516274694.

Waboose, Jan Bourdeau: *Skysisters*. Kids Can Press, 2002, ISBN: 1550746995.

Video

NOVA: Magnetic Storm: *Earth's Invisible Shield*
Grades 6–adult

Planet Earth: *The Solar Sea*
Grades 3–6

Schlessinger Media: *Telecommunications (The Way Things Work)*
Grades 6–adult

Web Sites

NASA: What is the Magnetosphere?
Visit this great web site to learn all about the magnetosphere and how it helps protect Earth from magnetic storms.
http://science.nasa.gov/ssl/pad/sppb/edu/magnetosphere/

NASA's Laboratory for Astronomy and Solar Physics Solar Flare Theory
This NASA web site spotlights solar flares, the biggest explosions in the solar system. NASA provides some general information about solar flares, a feel for scientific research into the energetic emissions from flares, and a glance into the future of solar flare research.
http://hesperia.gsfc.nasa.gov/sftheory/index.htm

NASA: Ask the Space Scientist
NASA astronomer Dr. Sten Odenwald addresses such topics as the Sun, solar storms, auroras, and the Earth's magnetism on this FAQ site.
http://image.gsfc.nasa.gov/poetry/ask/askmag.html

Space Weather
Find out what the "weather" is going to be like today in space! Get the current space weather conditions, the number of sunspots, the probability of disturbances, the aurora forecast, and much more.
http://www.spaceweather.com/

NASA: The Sun-Earth Connection Forum (Viewer)
On this "must visit" site for everyone, manipulate real time Sun images by zooming in and out while comparing the size of the Sun to a scale model of the Earth. There are also some great graphics to help you understand more about the internal and external workings of the Sun and how it affects our Earth. Mini video clips offer more explanations and interviews with real astronomers and scientists.
http://sunearth.gsfc.nasa.gov/sunearthday/media_viewer/flash.html

NASA: The Sun-Earth Connection Forum (Educators Area)
Visit this web site for lots of great classroom activities on everything to do with the Sun-Earth connection! Free educator guides for download.
http://sunearth.gsfc.nasa.gov/edsecef.htm

The Aurora Page
See beautiful pictures of auroras taken by Jan Curtis.
http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis/

Iceland Worldwide – Northern Lights
This site contains beautiful pictures of the Northern Lights as seen from Iceland.
http://www.iww.is/art/shs/pages/thumbs.html

NORDLYS Northern Lights
Located above the Arctic Circle in Norway, the Andoy Rocket Range in Andenes is home to the annaul Northern Lights Festival that celebrates the wonder and beauty of auroras. Visit this site to see some awesome pictures of auroras, learn about auroral mythology, the science behind auroras, and real-time measurements of auroral activity.
http://www.northern-lights.no/english/arts/nordlyst.shtml

Activities and Worksheets

In the Guide

Sunspots Pairs
Use magnets to learn about sunspots and what causes solar flares and coronal mass ejections. 62

What's the Delay?
Run a relay race to learn how signals travel to and from satellites. 63

How Many Spots Does the Sun Have?
Plot sunspots over time to learn about the solar cycle. 65

The Magnificent Magnetosphere
Create a simple paper model of the magnetosphere. 66

Plotting the Aurora Oval
Plot coordinate points to pinpoint the location of the auroral oval and where to view the northern lights. 68

Making a Magnetometer
Make your own magnetometer. 70

Answer Key
. 71

On the Web

Matching Magnetic Activity
View some awesome images of solar activity and find the ones that match.

Sunspot Pairs

Segment 4

Purpose

To learn how sunspots are created and that they are often in pairs

Materials

small, plastic box
2 small books
iron filings
bar magnet
2–3 donut magnets
pencil
tape
science journal
goggles

Procedure

1. Tape a bar magnet to one end of a pencil. The magnet will represent a simple sunspot pair. See diagram 1.
2. Place two books so that the space between them is just a little less than the width of the plastic box.
3. Place the plastic box on the books so that the two books support the box and there is an open space underneath the box. See diagram 2.
4. Put on goggles for eye protection.
5. Sprinkle a small number of iron filings in the box to create a thin layer. The box represents the surface of the Sun.
6. Insert the bar magnet underneath the box.
7. Observe the iron filings and the pattern that they create. You can gently tap the box to make the pattern more apparent.
8. Record your observations and illustrate the pattern. **NOTE:** *The pattern seen shows the lines of force of a classic dipole magnetic field. Sunspot pairs with magnetic fields like this one don't often produce solar flares.*
9. Tape 2–3 donut magnets to your pencil in a random arrangement. See diagram 3.
10. Shake the box to redistribute the iron filings into a thin layer again. If needed, empty the iron filings and repeat step 5.
11. Insert the donut magnets and observe. Record and illustrate your observations.

    NOTE: *This magnetic field configuration on the Sun's surface might lead to a solar flare. Complicated magnetic fields store lots of energy. Think of a twisted rubber band. When it snaps back, energy is released. The same thing happens to sunspot magnetic fields. When they get twisted and tangled, they want to snap back to look like the field of a simple bipolar sunspot group. The energy that's released when a magnetic field snaps triggers a solar flare or a coronal mass ejection.*

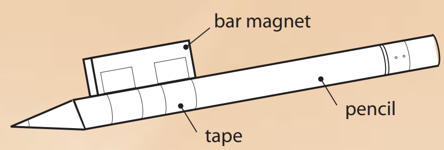


Diagram 1

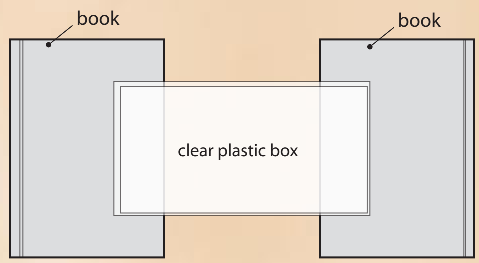


Diagram 2

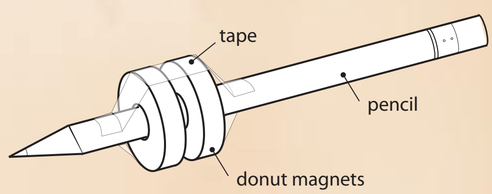


Diagram 3

Conclusion

1. In your own words, describe what causes a solar flare and/or coronal mass ejection.

Extension

Research solar flares and/or coronal mass ejections. Create a report, poster, model, or some other type of presentation to explain how, why, and when they occur.

What's the Delay?

Segment 4

Purpose

To understand that satellite transmission of radio waves can be delayed because of interference

Teacher Prep

Number 10 cups from 1 to 10. Number 10 cups in a different color from 1 to 10. Divide the class into two equal teams. For the relay area (large open area), place 2 pieces of tape about 3 meters apart to mark the start lines for each team. Place a small table approximately 10 meters from each start line. Put one set of cups on each table.

Materials

2 sets of 10 numbered cups
large, open area
2 small tables or large, flat surface

Background

Satellites use radio waves to send information to a receiver. Because it takes time for the waves to travel, there is usually some delay. The length of the delay is equal to the radio wave's travel time. GPS receivers use the travel time to determine their distance from at least four satellites, which in turn helps pinpoint their exact location on Earth. If anything causes a change in the travel time, misinformation may be transmitted.

Procedure

1. In your team, designate one person to be an astronaut at the command and control center and one person to be a satellite. The remaining team members will be "signals."
2. The satellite person needs to go to the satellite table and stand behind it.
3. The signals people will line up in a straight line behind the start line.
4. The astronaut person will stand to the left of the first signal at the start line.
5. Begin the relay race following these rules:
   a. The objective of the relay race is to build a pyramid out of the 10 cups.
   b. The astronaut will give a command to the first signal. He/she will carry (relay) the command to the satellite, who in turn will obey. Only one command at a time. For example, you can say, "Pick up cup number 1." But you cannot say, "Pick up cup number 1 and place it next to cup number 2." That would be two directions!
   c. The satellite must only do exactly what the signals tell him/her to do. They cannot make a move without a command.
   d. Once a signal has given the command, he/she returns to the end of the line to wait for a turn to carry out another command.
   e. The astronaut may send the signals as quickly as he/she desires but only as long as they are sent one at a time. Be careful because problems may arise when the satellite receives too many signals at one time.
   f. The team that completes the pyramid first wins.
6. After completing the relay race, play again, but this time choose one person from each team to represent interference.
7. Students representing interference will walk back and forth across the relay line and the signals will have to stop and/or go around the interference.

What's the Delay?

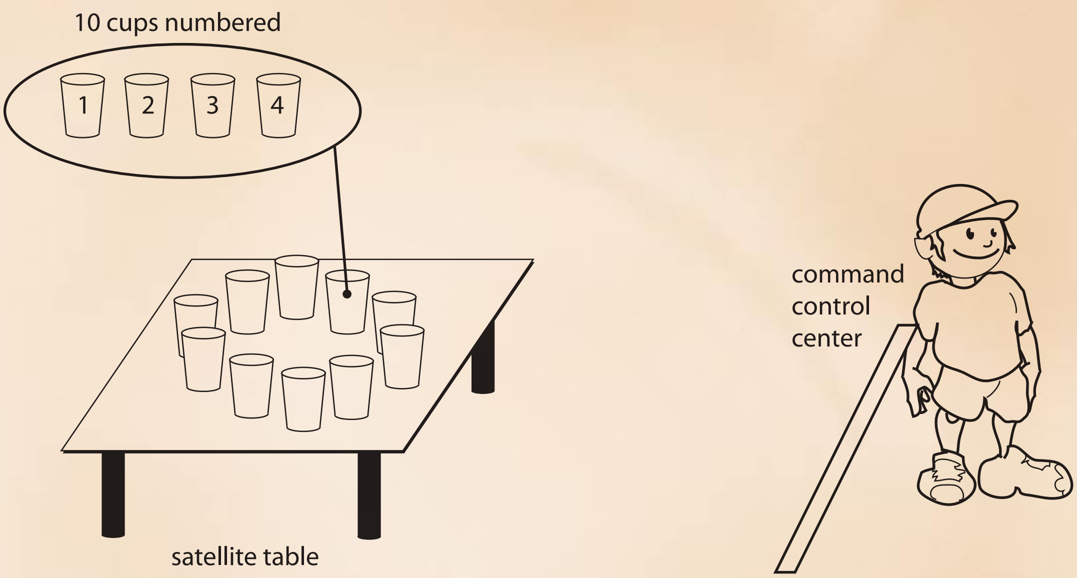
Segment 4

Conclusion

1. What problems did your team encounter with the sending and receiving of commands?
2. What would you do differently next time?
3. What would happen if you increased the distance between the astronaut and the satellite? Decreased the distance?
4. How does distance affect the signal?
5. What happened when interference interrupted the relay of signals?
6. What might cause interference with real satellite signals?
7. Describe what happened to cause the tree house detectives' technical problems.

Extension

Run the relay race again, but have the satellite build a different configuration out of the cups. Compare it with the pyramid and decide which was easier to build and why.



How Many Spots Does the Sun Have?

Segment 4

Astronomers have been observing and recording the number of sunspots for hundreds of years. After analyzing the data, astronomers have determined that sunspots increase and decrease over an 11-year cycle. Listed in the chart below is the number of sunspots seen in December of each year over an 11-year period.

Look at the data and graph. Determine the increment to be used on the graph for the number of sunspots and label it. Also be sure to give the graph a title and label each axis appropriately.

1991-144 sunspots

1992-82 sunspots

1993-48 sunspots

1994-26 sunspots

1995-10 sunspots

1996-13 sunspots

1997-41 sunspots

1998-81 sunspots

1999-84 sunspots

2000-104 sunspots

2001-132 sunspots

Answer the following questions based on the data and graph.

1. According to the data, in what year did astronomers see the most sunspots? The fewest?
2. If the number of sunspots seen follows the same pattern, what do you predict will be the number of sunspots seen in 2006? 2012?
3. As the number of sunspots increases, what do you think will happen on Earth?

The Magnificent Magnetosphere

Segment 4

Purpose

To create a simple paper model of the magnetosphere

Materials

Magnetosphere Model (p. 67)
scissors
colored pencils
glue or tape

Background

A stream of ionized gases (called a solar wind) blows outward from the Sun at about 400 km/second but varies in intensity with the amount of surface activity on the Sun. The Earth's magnetic field shields the Earth from much of the solar wind. When the solar wind encounters Earth's magnetic field, it is deflected like water around the bow of a ship. The imaginary surface at which the solar wind is first deflected is called the bow shock. The corresponding region behind the bow shock and surrounding the Earth is called the magnetosphere. It represents a region of space dominated by the Earth's magnetic field that prevents most of the solar wind from entering. However, some high-energy charged particles from the solar wind leak into the magnetosphere. These high-energy particles are trapped in the Earth's magnetic field, and as they flow back and forth along the magnetic field lines, they come down into the atmosphere near the north and south poles. As the charged particles enter the atmosphere, they collide with oxygen and nitrogen molecules. As the molecules collide, they decay from the excited states. As they decay, they emit delicate colors of light that we see in an aurora.

Procedure

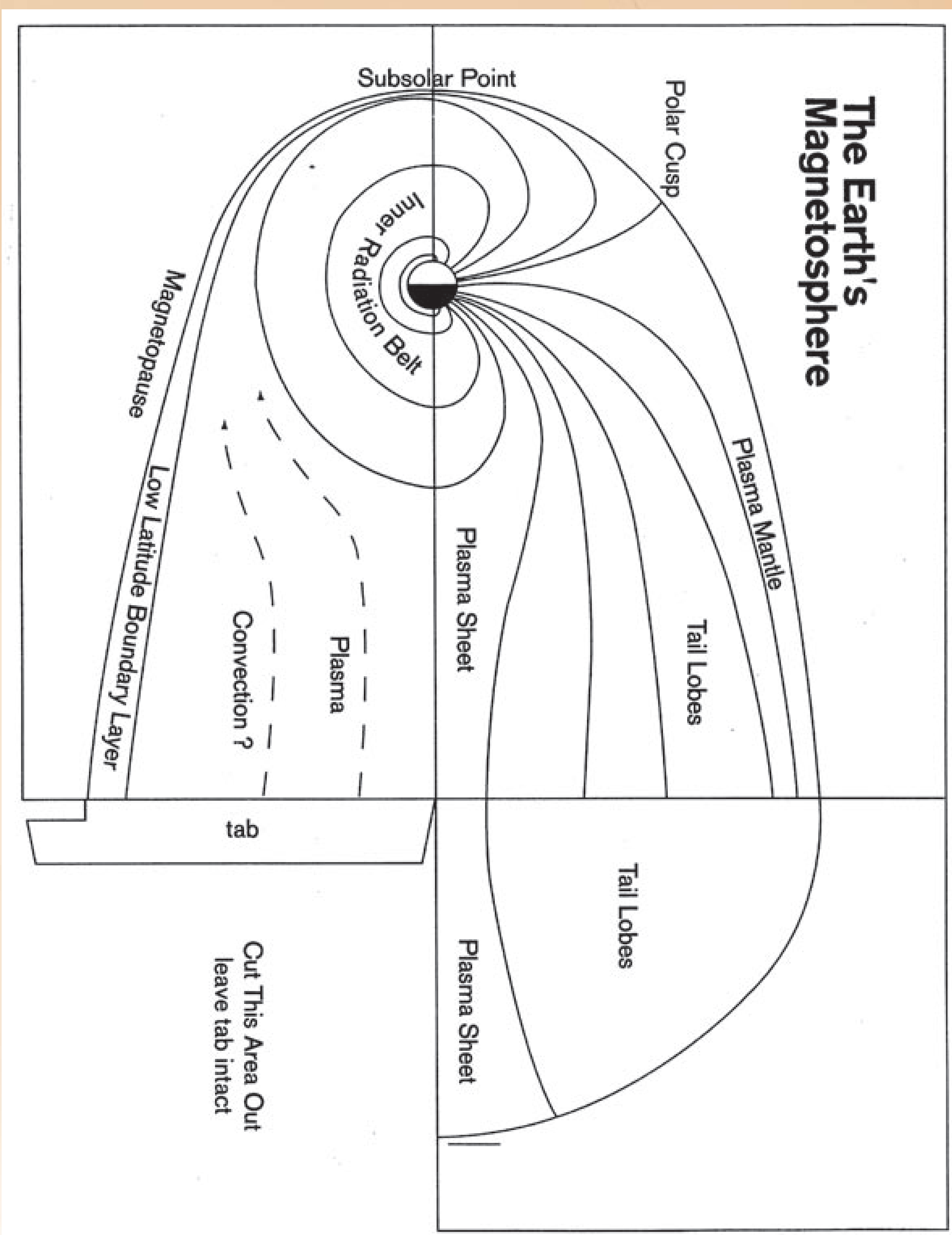
1. Color the diagram on page 67.
2. Using scissors carefully, cut along the outer edge of the diagram.
3. Fold along the main solid line that borders the tab.
4. Fold along the main solid line that intersects the Earth.
5. Glue or tape the tab in place.
6. Conduct research to learn more about the magnetopause, plasma mantle, magneto tail (tail lobes), plasma sheet, polar cusp, and inner radiation belt.

Extension

Create a three dimensional (3D) model of the Earth and the magnetosphere.

The Magnificent Magnetosphere

Segment 4



Plotting the Aurora Oval

Segment 4

Materials

metric ruler
colored pencils
Activity Sheet (p. 69)
atlas

Purpose

To find and plot locations on maps by using geographic coordinates

Teacher Prep

Students should have a good working knowledge of latitude and longitude. Review coordinates and how to plot points. Discuss lines of latitude and longitude by using a globe and compare how they look on a globe instead of on a flat map.

Background

The most spectacular example of the way that the Sun and Earth are connected is the phenomenon of the Aurora Borealis (northern lights) and the Aurora Australis (southern lights). In North America, the northern lights are seen most dramatically in only certain places over the Arctic region. This area is called an auroral oval.

Procedure

1. On the Activity Sheet, label the latitude lines. Begin at the center point (Arctic) with 90 degrees and mark each circle 10 degrees less than the previous circle. End at 30 degrees.
2. Plot the points for the outer ring of the oval.
3. Connect the points in the outer ring.
4. Plot the points for the inner ring.
5. Connect the points in the inner ring.
6. Using the grid scale (1 cm = 1400 km) measure (in km) the approximate widths of the auroral oval to determine its shortest and longest distances between the inner and outer rings.
7. Record the distances on the Activity Sheet in the spaces provided.
8. Color the oval with your favorite auroral colors.

Conclusion

1. Where would you travel in North America to see an aurora?
2. Give the approximate coordinates for the center of the auroral oval?
3. How far is the center of the auroral oval from the geographic North Pole (90 degrees North)?
4. If your location were 205 degrees, 65 degrees, in which area of the sky would you look for the aurora?

Extension

1. Read a story that describes a folktale or legend associated with auroras. Using what you have learned about magnetic field lines, the ionosphere, the magnetosphere, and so on, try to explain the "truth" while describing how the folktale might have begun.
2. Pretend your classmates are an ancient people and have just experienced an aurora. Write a story about what you saw and why. Remember that you have no scientific knowledge, so this explanation or story will be a folktale.
3. In class, tell your story to another person and ask that person to tell it to someone else, and so on, until everyone has heard the story. Have the last person tell the story to the whole class and compare it to your original story. Discuss how and why legends change through many "tellings" by many generations.

Plotting the Aurora Oval

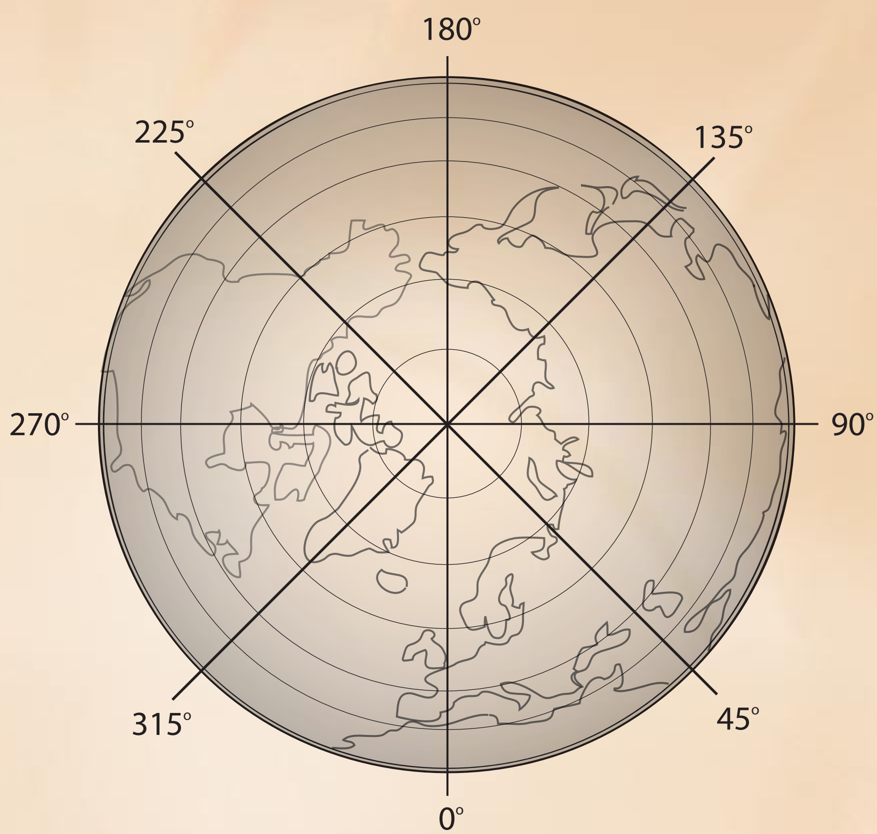
Activity Sheet

Outer Ring of Auroral Oval:

Point 1 (90,65)	Point 7 (0,60)
Point 2 (135,64)	Point 8 (320,63)
Point 3 (180,60)	Point 9 (315,60)
Point 4 (225,55)	Point 10 (300,60)
Point 5 (270,50)	Point 11 (245,50)
Point 6 (45,63)	Point 12 (200,58)

Inner Ring of Auroral Oval:

Point 1 (90,78)	Point 7 (0, 75)
Point 2 (135,72)	Point 8 (320,72)
Point 3 (180, 70)	Point 9 (315,70)
Point 4 (225,67)	Point 10 (300,67)
Point 5 (270,65)	Point 11 (245,62)
Point 6 (45,67)	Point 12 (200,70)



Grid Scale: 1 cm = 1400 km

Making a Magnetometer

Segment 4

Purpose

To make a simple magnetometer

Background

Magnetic field lines are invisible. We can only see the effects of the magnetic force that they exert. Magnetometers are devices used to detect and measure the strength of magnetic fields. Like compasses, magnetometers give you information about magnetic fields. A magnetometer will dip or point toward a source of magnetism.

Materials

- 10-cm piece of plastic straw
- 2 straight pins
- masking tape
- sewing thread
- bar magnet with poles marked

Procedure

1. On a small piece of masking tape, stick the straight pins so that they point in opposite directions. See diagram 1.
2. Lay the sewing thread crosswise to the masking tape and pins so that it sticks to the tape. See diagram 2.
3. Thread the other end of the sewing thread through the straw.
4. Pull the thread from the top to adjust the thread so that the pins at the bottom have just enough clearance to swing freely.
5. Tape the thread in place at the top of the straw. See diagram 3.
6. Lay the tape on a flat surface with the pins facing up.
7. To magnetize the pins, stroke the pins from left to right several times with the bar magnet.
8. Pick up the straw and hold the straw so that the pins move freely.
9. Bring the north end of the bar magnet near the pins and observe what happens. If they repelled, mark that end of the tape with an "N" for north. If they were attracted to each other, mark with an "S" for south.
10. Use your magnetometer to find magnetic things in your classroom.

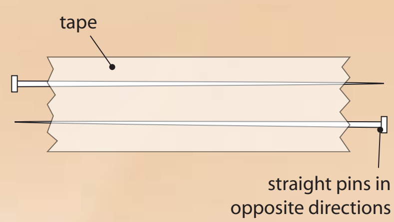


Diagram 1

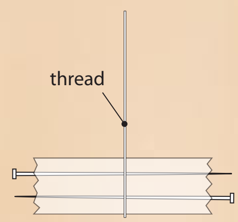


Diagram 2

Conclusion

1. What magnetic items did you find in your classroom ? How did you know?

Extension

Build a more complicated magnetometer to help you study the Earth's magnetic field.
http://image.gsfc.nasa.gov/poetry/workbook/magnet.html

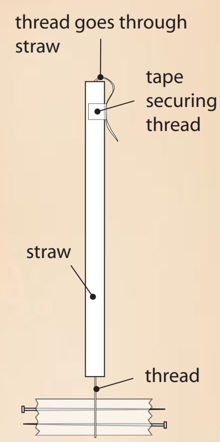
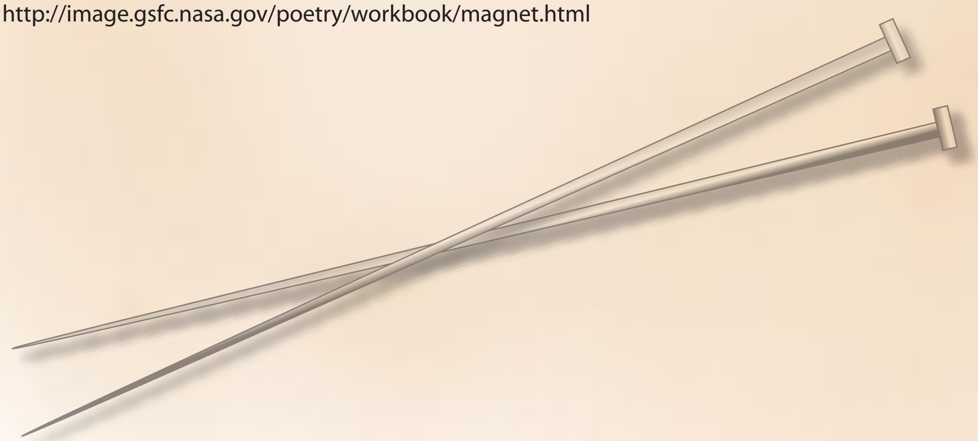


Diagram 3



Answer Key

Segment 4

Sunspot Pairs

1. Answers will vary but might include that solar flares and coronal mass ejections are created when energy is released from an entangled magnetic field.

What's the Delay?

1. Answers will vary.
2. Answers will vary.
3. If distance increases, travel time for the signal will increase. If distance decreases, travel time decreases.
4. With less travel time, the signals can be relayed faster.
5. The signals took longer to get to and from the astronaut and the satellite.
6. Answers will vary but should include that a geomagnetic storm occurred, causing disruption (delay) of the radio waves that were sending signals to the GPS receivers. The delay of the signals caused the satellites to send incorrect coordinates.
7. Answers will vary but should include that the tree house detectives were geocaching during a geomagnetic storm. The storm interacted with the ionosphere and caused a delay in the signal between the satellites and their GPS receiver. This delay gave the tree house detectives inaccurate coordinates.

How Many Spots Does the Sun Have?

1. 1991, 1995.
2. 10-15 sunspots in 2006 and 130-150 sunspots in 2012.
3. Answers will vary, but might include that there might be more geomagnetic storms causing more disruption to satellite transmissions and other electronic devices.

Plotting the Auroral Oval

1. You would travel to the northern reaches of North America such as Canada and Alaska.
2. The center of the auroral oval is located approximately at 270 degrees, 80 degrees.
3. Approximately 1200 km.
4. You would look directly up.

Making a Magnetometer

1. Answers will vary.