National Aeronautics and Space Administration

Northern Lights and Solar Sprites

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National Aeronautics and
Space Administration

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Northern Lights and Solar Sprites

Exploring Solar Storms and Space Science
An Educator Guide with activities in space science

A product of Space Math @ NASA **http://spacemath.gsfc.nasa.gov**

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This resource was developed by the NASA Imager for Magnetopause-to-Auroral Global Exploration (IMAGE)

Information about the IMAGE Mission is available at:

http://image.gsfc.nasa.gov
http://pluto.space.swri.edu/IMAGE

Resources for teachers and students are available at:

http://image.gsfc.nasa.gov/poetry

National Aeronautics and
Space Administration
Goddard Space Flight Center

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Extending our Senses

How Scientists Work With Technology to Gather Data

Exploring a New Frontier of Knowledge

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Seeing the Invisible with NASA's IMAGE satellite.

How Scientists Use Technology to Explore the Unknown.

Coordination with Science Standards

Lesson	1	2	3	4	5	6	7	8	9	10	11	12	13
Science as Inquiry	x	x	x	x	x	x	x	x	x	x	x	x	x
Properties of Objects and Materials	x										x	x	x
Position and Motion of Objects											x	x	x
Motions and Forces			x			x	x		x		x	x	x
Light and Magnetism						x	x	x		x			
Transfer of Energy	x								x		x	x	x
Objects in the Sky					x			x					
Earth in the Solar System			x										
Abilities of Technological Design	x	x											x
Understanding Science and Technology	x	x	x	x	x						x	x	x
Science and Technology in Society	x	x	x	x							x	x	x
Science as a Human Endeavor	x	x									x	x	x

This book was designed to provide teachers with activities that allow students to explore topics related to the Sun-Earth Connection.

The units are designed for use in conjunction with your current curriculum as individual lessons or as a unit. The chart above is designed to assist teachers in integrating the activities contained with existing curricula and National Science Standards.

Throughout the lessons you will find activities that require the students to make observations, and record their findings. Observations can be recorded in Science Learning Logs, journals or by organization into charts or graphs.

Each topic has a culminating activity designed to help the students organize, summarize, and communicate the new knowledge gained.

Introduction

"Students should be actively engaged in learning to view the world scientifically. They should be encouraged to ask questions about nature and to seek answer, collect things, count and measure things, make qualitative observations, organize collections and observations and discuss findings."
(American Association for the Advancement of Science; Benchmarks for Science)

Scientists and young children share an active curiosity about the world. A true scientist maintains that inquisitive quality and continues to question, explore and investigate.

In developing this book, there is an attempt to stimulate an active curiosity about the Sun-Earth Connection. Scientists have been learning more about space science, and technology makes this information readily available to those who are interested. Activities in this book use images and data from satellites that were unheard of forty years ago.

"When students observe differences in the way things behave or get different results in repeated investigations, they should suspect that something differs from trial to trial, and try to find out what." (AAAS 'Benchmarks for Science Literacy, 1999)

Each lesson focuses upon a particular aspect of studying the Sun and the Earth as a system, and how scientists make the observations. Included in the procedure sections are questions that will further encourage scientific inquiry.

Each lesson begins with a description of the activities in which the students will participate, and provides general background information. The Objectives sections highlight the science process skills the students will develop while completing the activities. The Procedures sections are general, and can be adapted to meet the knowledge and developmental levels of the students.

Many lessons have extension activities designed to have the students apply the new knowledge in grade appropriate activities. Key terms are included to further enhance the teacher's comfort level with the material.

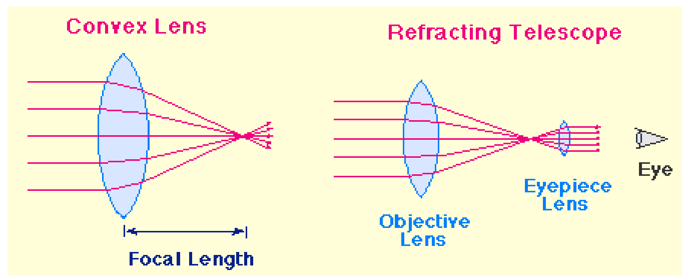
I...A Simple Magnifier.

Introduction

Why do scientists use instruments? To help students understand the world around them, scientists use instruments. These instruments are extensions of human tool-making abilities to extend our senses and often to greatly amplify them. A magnfiying glass is one simple instrument. High-tech satellites often contain more complex ones. Specific instruments are "fine tuned" by scientists to communicate only the information that is needed. This lesson will focus on why scientists needed to develop instruments through hands-on experiences making some basic scientific instruments. Throughout this unit the students will be completing activities that will provide models for the scientific instruments currently in use on the IMAGE satellite that was launched March 25, 2000.

Objectives

- The students will explore how a scientist develops tools in order to learn more about the world.
- The students will use hands on experiences to make scientific instruments and to alter them to "fine tune" what information the instrument can communicate.



Materials

3 x 5 index card with 1 inch hole cut out
Clear tape
Water
Clear glass bottles and jars
Old magazines or newspapers

Telescope materials -

Option 1: Two convex lenses- 38mm dia./(two different FL) DCX Lens work well (Edmund Scientific http://www.edsci.com)

Two mailing tubes (different diameters)
Manilla folder
Scissors

Option 2 Edmund Scientific has a Refractor Telescope Kit that includes lenses, tubes and everything else needed for $16.95 - if you order online, there is a discount for multiple items

Option 3 The Astronomical Society of the Pacific (1-800-335-2624) has a kit with 10 telescopes for $64.95 (KT 103) with all of the necessary parts for constructing simple refractors.

Procedure:

- In this activity the students will see that water, bottles, and jars can act as magnifiers. Sometimes instruments are developed by accidental discovery, to see how this happens, you will need to have a "accident" occur in the classroom. Have newspapers or magazines on a desk or table, and have an overhead film sheet on top. "Accidently" spill some water on the transparency sheet and see if any of the students can notice something that has ocurred. They should notice that where the water drops are, the print is slightly larger. The students should be able to reproduce this effect by placing a piece of clear tape across the hole in the index card. Students should have the newspaper or magazine on a flat surface and be holding the index card over it. Carefully place a drop of water on the tape, and have the students look down at the newspaper through the water. Does the print look different? The students should continue to experiment with the amount of water on the index card, the distance between the water and the print, and the distance the card is from the eye.

- Continue the "accident" approach by leaving a glass bottle close to the newspaper or magazine. Mention that you have noticed something else that is interesting, and see if the students can describe what they think is happening. Have the students explore on their own whether glass jars and bottles can also act as magnifiers. Direct the students to find out whether the shape of the glass influences the magnification, whether the distance between the glass and the print changes the magnification, and whether adding water to the jar or bottle would make a difference. The students should also explore how the print is changed with the different magnifiers. Then have a discussion to see why the water and some of the bottles were able to magnify the print.

- Now that the students have seen that glass bottles can act as magnifiers, initiate a discussion with the students about what scientific instruments they have seen that operate like the glass bottles. Hopefully the students will mention, magnifying glasses, microscopes, and telescopes. All of these instruments use glass lenses to help scientists see things that could not be seen in as much detail without these instruments. Continue the discussion to include why scientists had to "fine tune" basic instruments to find them useful. Use the example of why a scientist would need to develop a more convenient method of magnification, than carrying around a glass bottle, especially when viewing objects far away in the sky. The next activity is for the students to build a simple instrument, the telescope. There are three options on how to complete this project.

(Option 1 - Instructions) The students should take the lens that has the shortest focal length, and construct a manilla folder "frame" that will hold the lens inside the cardboard tube with the smallest diameter, this will be called the eyepiece lens. (The frame is a circle of folder that has its outside diameter the same as the diameter of the smaller cardboard tube, and its inside diameter the same as the diameter of the lens- it will look like a washer when completed.) Then construct a manilla folder frame that will hold the lens with the longer focal point inside the larger diameter cardboard tube for the objective lens. Slide the two tubes together. You can look through the eyepiece (smaller tube) and slide the tubes in and out until you have a clear image.

(Option 2 - Instructions) Use the directions in the Refractor Telescope Kit to construct your telescope.

(Option 3 - Instructions) The students should select a lens that is small, convex or concave with a short focal length to be the eyepiece lens. Next, the student should select a lens that is larger, convex and has a longer focal point to be the objective lens. The eyepiece lens should be placed close to one eye, without touching the eye while the objective lens should be placed right in front of the eyepiece lens. The student should look at a distant, well-lighted object and slowly move the objective lens away from the eyepiece lense until the object's edge is less blury and more sharply focused. If you have a good selection of lenses, the students can experiment by constructing different telescopes each time a pair of lenses is chosen. Some combinations of lenses may not work well, while others (such as a pair of double convex) may work well.

Conclusions:

The students will explore why scientists developed new instruments to learn more about the world. These early instruments were changed to allow the scientist to find out specific information in his or her field of study. The students will explore how a scientist needed to make modifications to these instruments as new information was needed.

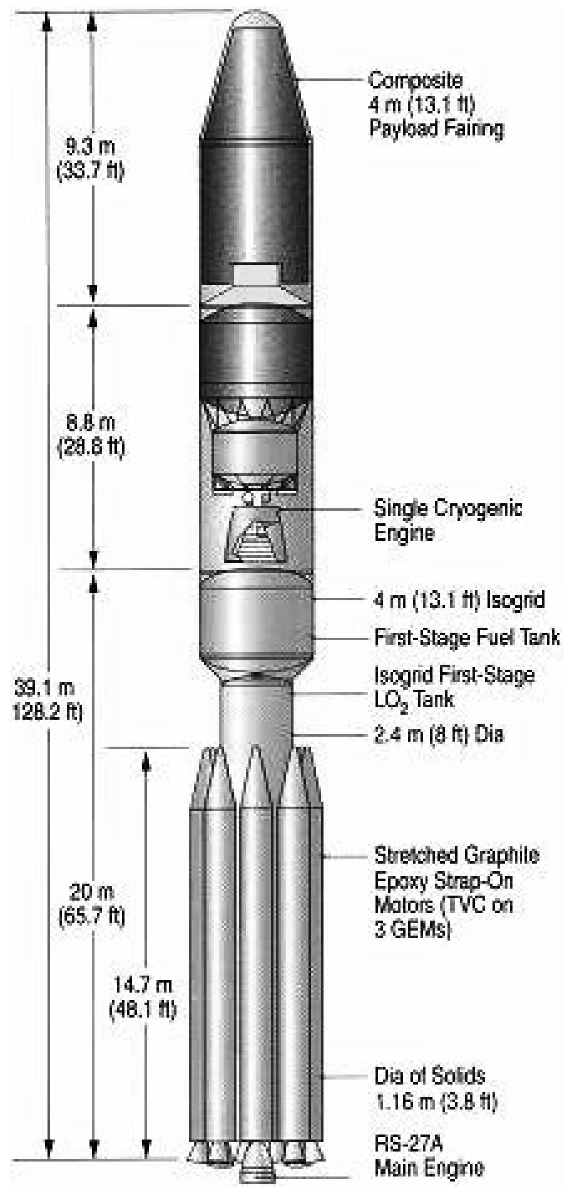
II...Design Your Own Research Satellite!

Introduction:

How do scientists design satellites? When scientists and engineers design research satellites, many different things have to be considered in order to accomplish the research they want to carry out. In this activity, students will design their own satellite. They will discover how the research goals of a satellite have to be balanced by the cost of the satellite and how much money the scientists would have to spend in order to conduct their research from space. The more you want the satellite to do for you, the heavier it will become, and the more it will cost to launch it!!

Objectives:

- The students will gain an understanding of how the research goals of a scientist have constraints such as weight, cost, materials and feasibility.
- The students will communicate their findings to classmates by drawing a picture or diagram of their research



Materials:

<u>Grades K-2</u>

Copies of four quadrant square

Pattern blocks

Copies of the IMAGE satellite outline

Copies of the IMAGE instruments

<u>Grades 2-6</u>

Copies of the Procedures for the students

Copies of the Student Cost Factor Sheet

Procedure: Grades K-2

- The students are going to design their own satellite that is shaped like a square. The students will have to think like a scientist by making sure that each of the four quadrants has an equal amount of weight in it. In this activity, pattern blocks will be used to represent weights, and the hexagon shape will represent 100 pounds. Give each student a copy of the four quadrant square and a supply of pattern blocks. (This activity can easily be completed in groups also). Allow the students time to explore the pattern blocks. Direct the students to find a yellow hexagon. Then ask the students to find the ways to make the hexagon shape using other pattern block pieces. Some of the younger students may need to "build" on top of the yellow hexagon in order to find all the possiblities. When the students finish, direct them to consider each "hexagon" shape to be equal to an instrument that weighs 100 pounds. As scientists, the students will need to make 100 pound "instruments" in each of the four quadrants. There are many different combinations of pattern blocks that the students can use. When the students have completed all four of their instruments, they can record the shapes used in chart form or by drawing or stamping them onto the four quadrant square.

- The students will be given an outline of the IMAGE satellite and its instruments. The students will need to place the instruments on the outline of the satellite to meet certain criteria that you will read to the students. Each instrument should touch the outside edge so that the instrument's name can be read from the inside out. Begin by giving each student a copy of the outline and the instruments. With the exception of the "deployers" (in this case, where the antenea are released from the satellite) all of the instrument names are acronyms, so you can just call out the letters for the students to find the correct instrument or if your students are not recognizing all their letters, write them on the board or put them on the overhead. Start to discuss the shape of the satellite, how many sides does it have? Review with the students what happens on a seesaw both ends do not have the same amount of weight on them. When placing the instruments on the outline, the students will have to remember to balance the instruments on each side so that the weight is evenly spread out.

Criteria for the instruments on the IMAGE satellite:

1. The four "deployers" must each be centered along the edge on different sides and no other instruments can be placed on the same side. They are the heaviest items on the satellite, remind the students that they have to be evenly distributed around the edge.
2. All of the instruments that have FUV (there are three- FUV-SI, FUV-GEO, and FUV-WIC) as a part of their name go along the same side of the satellite. No other instruments can go on this side of the satellite.
3. Have the students count how many sides do not have any instruments on them. There should be three sides left at this point that do not have instruments. The HENA, MENA, and LENA instruments each need to go on different sides.
4. Each of the remaining instruments, the RPI, CIDP, and EUV, can go on the same side as the HENA, MENA, and LENA. No instrument can be placed on top of or touching another instrument, so the students may need to do some rearranging as necessary. When you and the students feel that their satellite is "balanced" the instruments can be glued.

Conclusions:

The students will gain an understanding of the decision making process that scientists use when designing a satellite. This process is not always completed by one individual, but often by teams of scientists working in many locations. The students should be aware of the constraints on designing an instrument or research satellite.

Grade K-2: Satellite Design. Four Quadrant Square

Sample Layout for the IMAGE Satellite Experiments

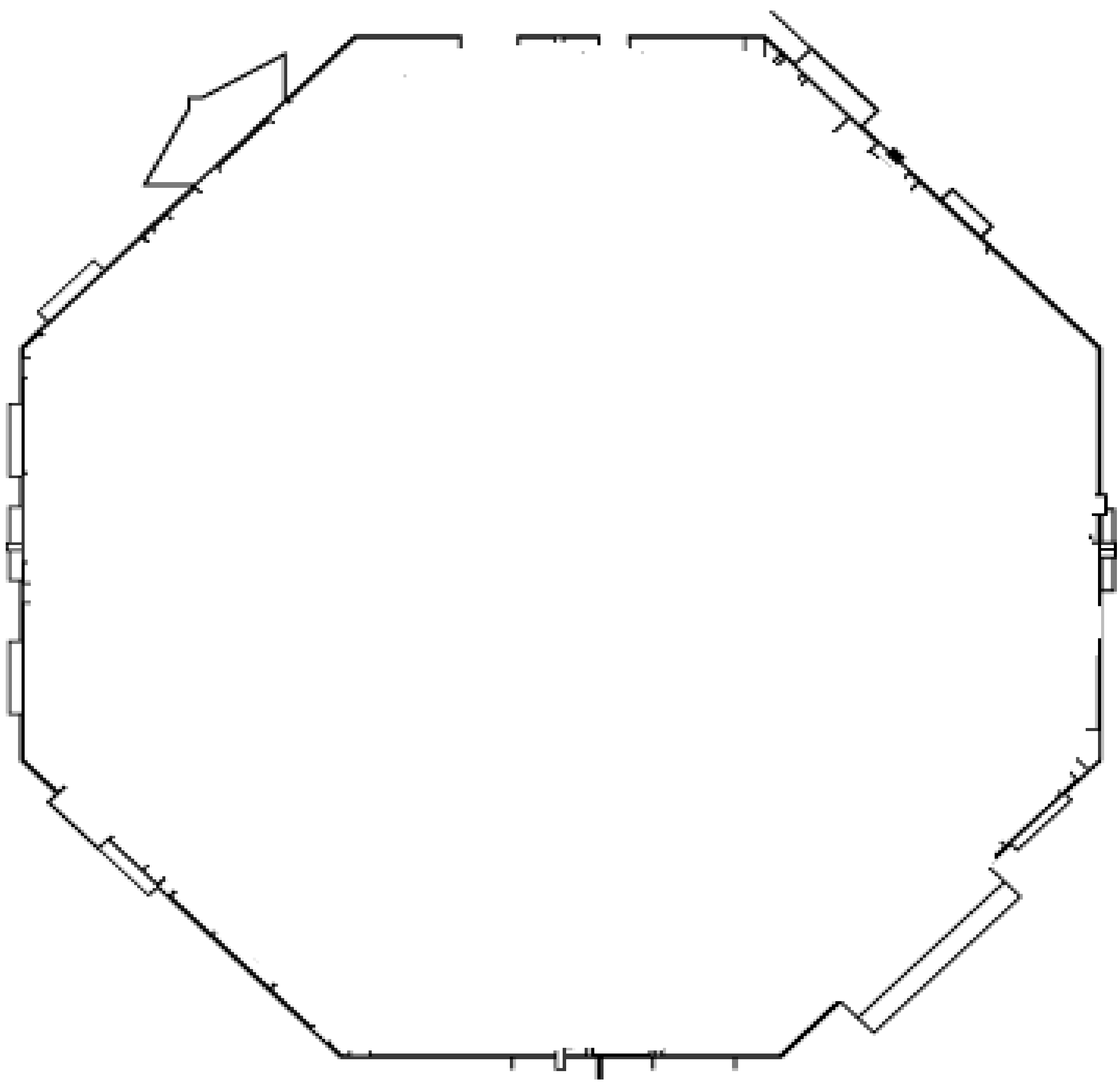
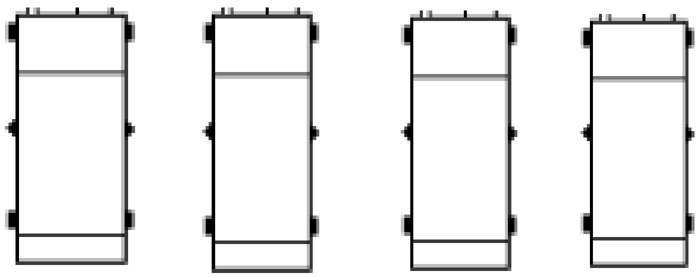
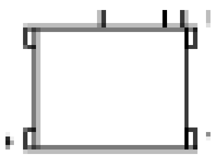


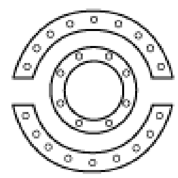
IMAGE Instrument Cutouts



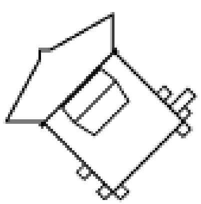
RPI Antenna Modules



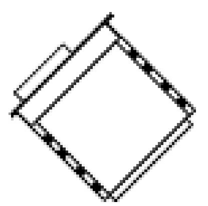
HENA Electronics



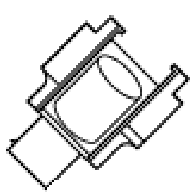
RPI Axial Antenna System



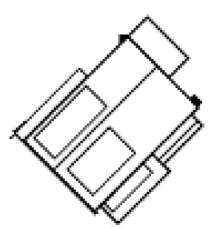
HENA Sensor Module



CIDP Satellite Electronics Module

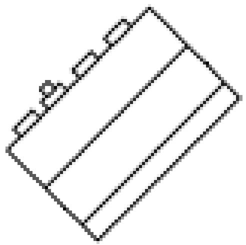


EUV Sensor Module

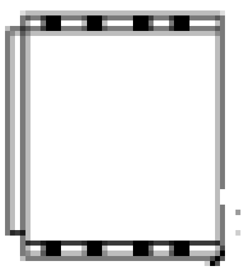


LENA Sensor Module

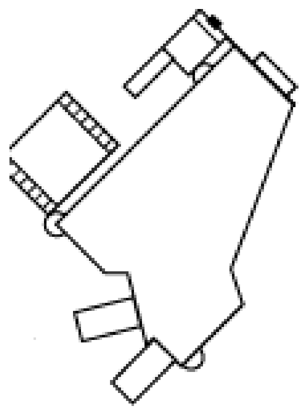
IMAGE Instrument Cutouts



MENA
Sensor
Module



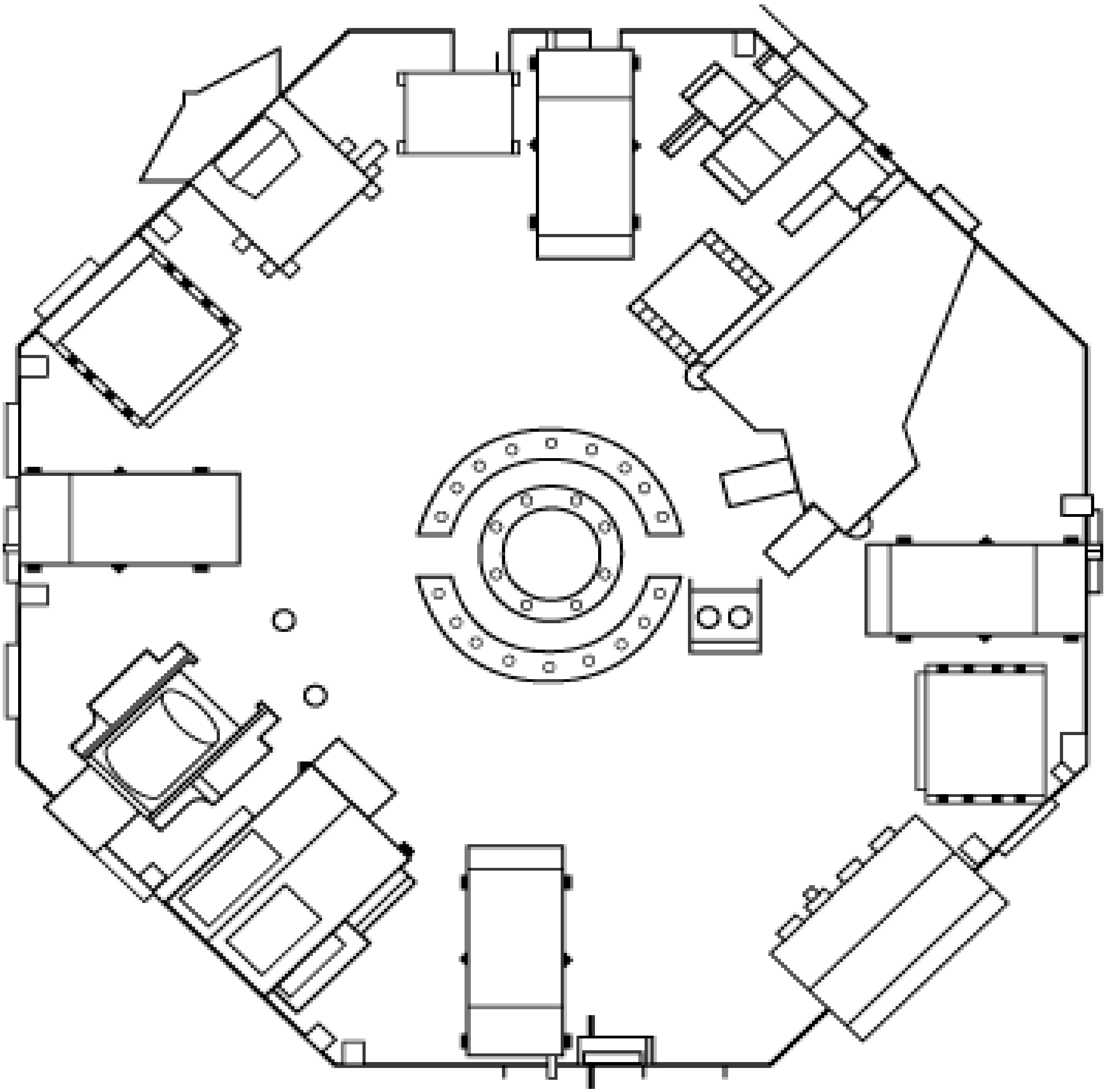
RPI
Electronics
Module

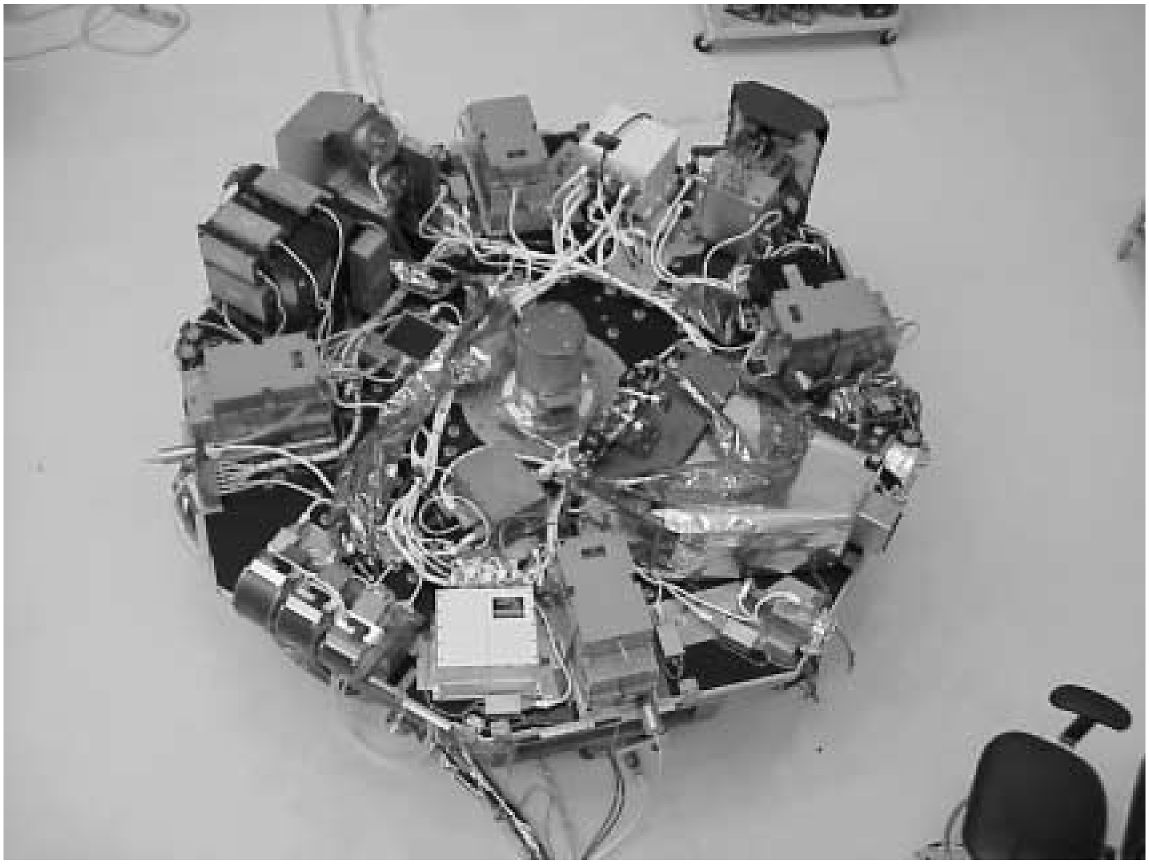


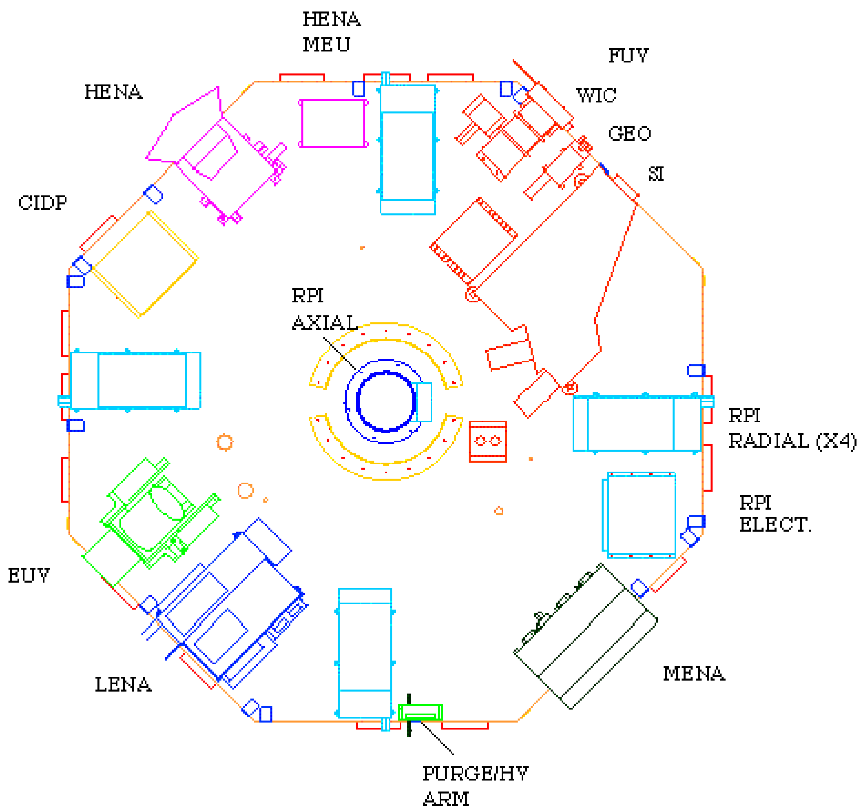
FUV
Spectroscopic
Imager
Module

FUV
Wide Field
Camera
Module

Actual Satellite Instrument Layout.






HENA
MEU
FUV
HENA
WIC
GEO
SI
CIDP
RPI
AXIAL
RPI
RADIAL (X4)
RPI
ELECT.
EUV
LENA
MENA
PURGE/HV
ARM

Procedure: Grades 2-6

Cost factors in building a satellite.

- Select the experiments that you would like the satellite to accomplish from Chart 1. Write down the mass needed for each of your chosen experiments then find the total mass needed. You will also need to write down the required power in watts you will need for all your experiments then find the total watts needed. For example, a scientist wants to study how aurora are produced by low energy particles so he selects a WIC instrument and a LENA instrument for his satellite.
- In designing a satellite, all of the instruments listed in Chart 2 are required. Once you have decided your specific instruments from Chart 1, you will need to find the total mass and power in watts for all of the instruments in Chart 2.
- Select the spacecraft mass from Chart 3 by using the number of experiments you have chosen to complete including all those from Chart 2. The more experiments you select, the bigger and heavier you have to make the satellite to hold them.
- By looking at Chart 4 find the watts needed to power your experiment, and the additional mass needed to transport the required power. Virtually all earth orbit satellites use a combination of batteries and solar power.
- To find the grand total mass needed to launch your satellite, add your total mass from Chart 1 and Chart 2, your mass to support experiments from Chart 3, and your mass to power your satellite from Chart 4. Find your grand total mass in Chart 5 to determine the appropriate launch vehicle and its cost. (Experiments mass + Spacecraft mass + Power mass = Grand total mass)

Students can continue to complete this activity as many times as they would like by simply choosing the different experiment or experiments that the satellite could accomplish. The students can also explore what happens when they propose to build and launch 2, 3, or more identical satellites with the same launch vehicle. In order to have more than one satellite launched at the same time, the students will need to find the grand total mass for all the desired satellites. (Each satellite's experiment mass + Each satellite's spacecraft mass + Each satellite's power mass = Grand total mass for all satellites) This final grand total mass for all the satellites is used in Chart 5 to determine the appropriate launch vehicle and its cost.

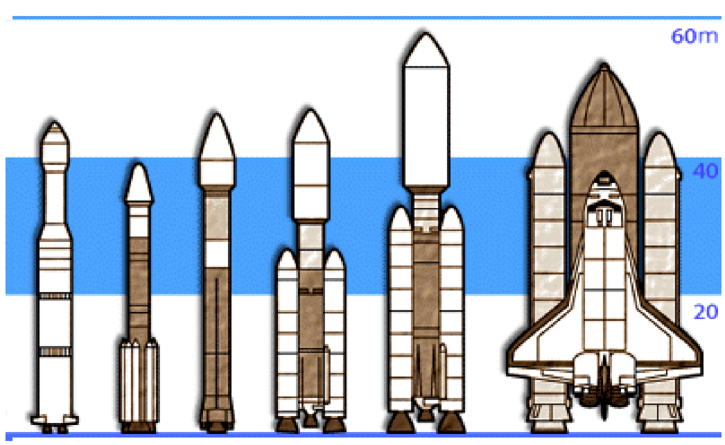


Chart 1. Select the experiments you want to use!

Instrument	Mass (kg)	Power (watts)	Experiment Function
High -Energy Neutral Atom Imager **(HENA)**	8.0	12.0	-detects and maps high-energy atoms in ring current, inner plasma sheet and substorm boundary
Medium- Energy Neutral Atom Imager **(MENA)**	7.0	7.0	-detects and maps medium-energy atoms in ring current, near-Earth plasma sheet and the nightside boundary
Low-Energy Neutral Atom Imager **(LENA)**	8.0	5.3	-detects and maps low-energy atoms from the polar ionsphere
Extreme Ultraviolet Camera (EUV)	15.6	15.5	- detects solar EUV photons in the Earth's plasmasphere
Spectrographic Imager **(SI)**	8.7	6.0	-identifies and produces images of the proton and electrons in aurora
Wideband Imaging Camera **(WIC)**	1.9	3.0	-produces images of auroral currents
Geocorona Photometers **(GEO)**	2.6	3.0	- detects light produced by hydrogen atoms.
Radio Plasma Imager (RPI)	49.8	30.8	-characterizes plasma clouds around earth using radio frequencies
Magnetometer	2.5	2.4	-measures direction strength of local magnetic field near spacecraft
Electric Field and Wave Sensor	15.5	8	-Measures electric fields near the spacecraft and detects their changes in time.
Solar Wind Plasma Analyzer	12.2	18	-composition of solar wind charged particles

Chart 2. Required components for each satellite

Instrument	Mass (kg)	Power (watts)	Experiment Function
Central Instrument Data Processor (CIDP)	11.0	11.8	-computer that processes the data from instruments
Antenna	14.4	4	- S band communication to ground
Telemetry Package	5.1	5.0	-transmits/receives data from ground
Spacecraft Electronics	18.0	18.5	-keeps spacecraft working in space
Attitude Torque Rods	15.4	5.3	-part of the spacecraft pointing system

Chart 3. Spacecraft mass to support the experiments.

Number of experiments	Mass (kg)
1-5	100
6-10	500
11-13	1000

Chart 4. Mass of the electrical power supply.

Watts needed	Mass
1-10	10 kg
11-20	25 kg
21-35	40 kg
36-55	50 kg
56-80	60 kg
81-100	70 kg
101-200	100 kg

Chart 5. Cost of launch vehicle for low earth orbit.

Grand Total Mass	Launch vehicle	Cost
450 kg	Pegasus	$90 Million
1100 kg	Delta II-8925	$115 Million
1800 kg	Delta II- 7925	$105 Million
3000 kg	Atlas II	$150 Million
4500 kg	Atlas III	$180 Million
8200 kg	Atlas V	$290 Million
15,600 kg	Titan IV	$400 Million

III...Getting a Satellite Into Space

Introduction:

How does a satellite get into space? Most students will know that to get something into space, you need a rocket, but they may not realize that rockets do not have to "push off" of the atmosphere to get into space. Also, you do not have to keep pushing a satellite to keep it moving in space because there is no friction in space to cause things to slow down. In this activity, students will learn how Newton's Laws of Motion can be applied to the launching of rockets: "Every action has an equal and opposite reaction." Students will explore how a satellite is placed in orbit. The students will explore how a satellite remains in orbit.

Objectives:

- Students will explore Newton's Laws of Motion and their application to rocket launching.
- Students will explore Newton's Laws of Motion and their application to satellite orbits.
- Students will develop an understanding of the decisions that a scientist makes when designing a satellite.

Materials:

Balloon (any size or style)

Glitter

Skateboard (optional)

Outdoor swing set

Books

Ball –tennis with a length of string attached
(a yo-yo works well too)

Several Balloons
(3 inches by 12-24 inches long)

Drinking straws

Tape

Nylon fishing line

Stopwatch or timer

Key Terms:

Newton's First Law of Motion - if an object is at rest, it takes unbalanced forces to make it move. Conversely, if an object is moving it takes an unbalanced force to make it change its direction or speed. *It is a common misconception among students and adults that you have to keep exerting a force on a body to maintain its speed. This is only true when friction is important.*

Newton's Third Law of Motion – for every action there is an opposite and equal reaction. *The exhaust gases are expelled and cause an opposite force which moves the rocket forward in the opposite direction.*

Procedure:

How does a satellite get into an orbit?

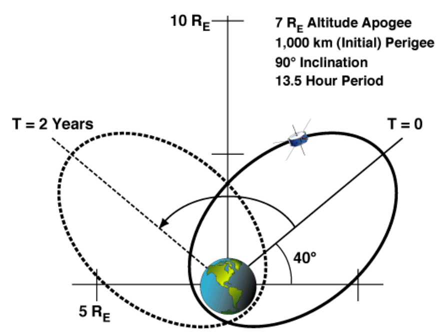
- Place some glitter inside a balloon. Blow up the balloon and hold the open end. The students should predict what would happen when the balloon is released. The children will need to observe carefully to see what happens when you let go. After the observation, discuss that the air being released was traced by the glitter that came out. The glitter went in one direction while the balloon went in the opposite direction. This is an example of Newton's Third Law of Motion.

- Have the students imagine that they are going to ride a skateboard or bring in one for a student demonstration. The skateboard and the rider are both still. The rider jumps off the skateboard, representing an action. The skateboard responds to this action by traveling in the opposite direction of the rider. This is another example of Newton's Third Law of Motion. When launching a rocket, the action is the expelling of gas out of the engine. This action or thrust must be stronger than the weight of the rocket to start it moving off the launch pad and into space. The Saturn V moon rocket had energy that provided a thrust of 6 million pounds to lift a rocket weighing a few hundred tons.

- If you have a set of swings available, you may use a swing to demonstrate that "for every action, there is an equal and opposite reaction." Have a student sit on the swing with his or her legs dangling free and not swinging, with one or two books in his or her lap. When the swing is still, have the student thrust the weight (books) forward. The students should discuss the action and reaction observed. The students can draw and write about their experiences in their learning logs.

How does a satellite stay up?

- Attach a ball to a string or use a yo-yo where the string has been tied tightly to the center of the yo-yo. Swing the ball around in a circle. Have the students observe that the path of the ball stays in a circular pattern and that the force on the string is the ball (centrifugal) has to be balanced by your tugging on it (gravity) to keep it going in a circle. This is the way that a satellite remains in orbit. A satellite has its forward thrust, which is offset by the pull of gravity towards the earth. This keeps the satellite circling in its orbit. Newton's First Law of Motion explains how the satellite remains in orbit.



Which Law of Motion is Being Applied?

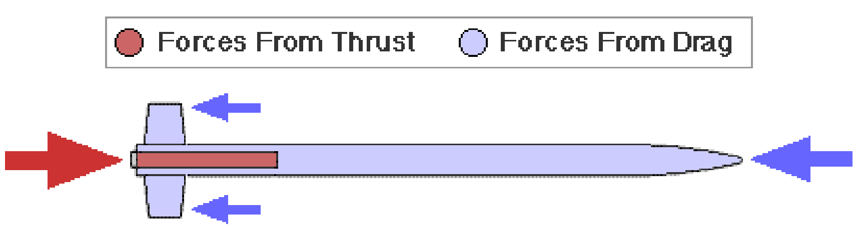
- The students should begin by tying one end of the nylon string to an anchored object in the room that is approximately four to five feet off the ground. Then a plastic straw should be threaded onto the string. Blow up the balloon 1/3 full of air, twist the end without tying it and carefully tape it to the straw so that the long side of the balloon is parallel to the straw and its head is pointed toward the anchored end of the string. A student will need to hold the other end of the string up so that it is taunt and at an even height across its length. Before the balloon is released, have a stopwatch ready to record the time and a meterstick ready to measure the distance traveled. Students can repeat the activity two more times so that an average time and distance can be obtained.

- The students should then inflate the balloon 2/3 full and repeat the activity three times to get the average time and distance. Then the students should inflate the balloon completely and repeat the activity three times to get the average time and distance.

- Have a class discussion about the data collected. Which balloon went the farthest and why? Why did the balloons stop moving? If there were no friction between the straw and the string and no wall in the way, how would the students expect the balloon to behave? If there were no friction between the straw and the string, no wall in the way and no air resistance against the deflating balloon how would the balloon behave when it ran out of fuel? Which Law(s) of Motion explains the results and why do the students feel this way?

Conclusions:

A rocket works by ejecting gas, and because of Newton's Third Law of Motion, this produces an equal and opposite force in the direction the rocket travels. Scientists, while designing satellites, have to be very careful of the total weight of the satellite. Heavy satellites may give the scientists more data, but they are are also much more expensive to place into orbit with a rocket.



IV...Sending Data from a Satellite Back to Ground

Introduction:

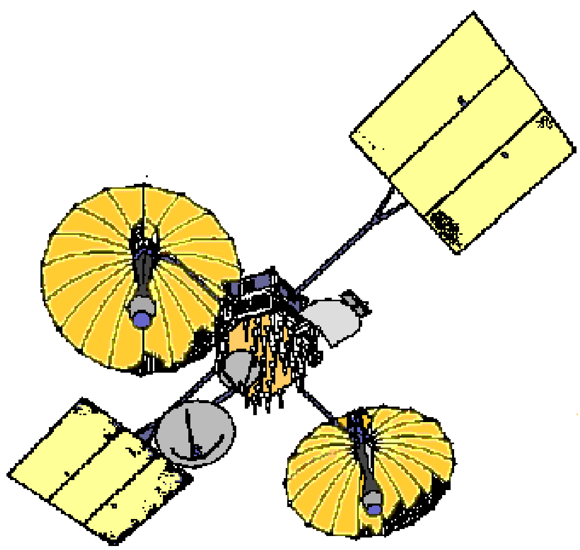
How does a satellite communicate with the Earth? Some military "spy" satellites take pictures with actual film. The film canisters are ejected back to earth and caught mid-air by waiting aircraft. Scientific research and weather satellites send their information back to earth in long strings of numbers. These numbers provide information about the brightness of millions of image "pixels" taken by satellite-borne, electronic cameras. In order for satellites to truly "communicate" information has to be sucessfully transmitted and received without any errors. The received information must also be clearly understood. In this activity, students will have hands on experiences in the communication processes of satellites.

Objectives:

- Students will learn that satellites use a transmitter and receiver system of sending information.
- Students will learn that communication requires that information be transmitted, received and understood or it is not considered communication.
- Students will learn how a satellite communicates the information it has gathered.

Materials:

- Flashlight
- Mirror
- Appropriate grade level grids
- Appropriate list of coordinates



Procedure:

- Darken the room, and shine the flashlight at the mirror. Have the students observe the path of the light. A satellite "sends" its data by reflecting it off mirrors and directing it to the satellite dish on the earth's surface at a distant point.

- Students should play the "gossip" game, where a message is repeated from student to student. The student is the "transmitter" when saying the message to a classmate, and is the "receiver" when hearing the message from a classmate. Start with small groups of children and increase the group size. Discuss with the students the success or "noncommunication" of information as the groups get larger. While some students are being the transmitters, make some background noise. Compare this to satellite interference which leads to "noncommunication" of information.

- When a satellite is communicating it does not speak in words, but in numbers. These numbers correspond to a location on the grid system. In many instances, the transmission of these numbers is done three times, once from each of the cameras. Each set of numbers transmitted refers to a color filter. When the completed filters are place on top of each other, the true colors in the image are seen. Some of the activities below use this grid system to transmit information from one student to another. For some other satellite transmissions, the information at each location refers to the number of times the corresponding location was hit by charged particles. Some of the activities below use this type of grid system to transmit information to the students.

Grade K -6 warm-up activity (Graph #1)

- The students will be "read" a set of numbers that correspond to a square on the grid. If a number one is "read" for a square, then the students should color in the corresponding square. If a number zero is "read" for a square, then the students should leave the square alone. When complete the grid should display a message.

Grades K-2 (Graph #2)

- The students will be "read" a set of numbers that correspond to the location on the grid. One student reading the information to the other student can accomplish this, or the teacher can read it to the class. The square at that location will be colored in the corresponding color. The students will be read three lists. The areas that are colored in will model the way a satellite creates an image when it transmits data.

Grades 1-3 (Graph #3)

- The students will "read" a pair of coordinates for a location on the coordinate graph and the number of hits that correspond to that location. The students will use the range of hits chart to color the square its corresponding color. After all the coordinants have been completed, the colors will form an image as a satellite does when it transmits data.

Grades 4-6 (Graphs #4 - 7)

- To prepare for this activity, make enough transparencies of graphs #4 - 7 for each student to have one. The students should work in groups of four for each of the graphs. Each student will be assigned a color for the graph that they are working on, and will "read" a pair of coordinates for a location on the coordinate graph and the number of hits that correspond to that location. Please note that the coordinate graph for these students is a 10 x 10 grid. The students will use the range of hits chart to color the corresponding squares for the assigned color. After all the coordinates have been completed, the four students should place their transparencies on top of each other so that the colors will form an image as a satellite does when it transmits data. When all students are finished, they will see that the four groups' grids will be put together at the end of the activity to form a large image. (Each of the four graphs will have four transparencies in a pile to show the layers of data that go into producing a single image.)
- The students will be comparing the completed four panel image with actual data from the IMAGE satellite's FUV instrument. This image may be found at http://image.gsfc.nasa.gov/poetry, find the link for live data for the most recent information.

Conclusions:

The students will learn how a satellite communicates information to the earth. Students will gain experience in two ways that data is transmitted, received and understood. The students will use "color" filters, and information based on the number of hits a location received to produce an image that models the way information, as images, is sent from a satellite

Extensions:

Grades 1 to 3 Students should draw a set of pictures with captions to show the sequence of data transmission from a satellite. They could make it in a sequence frame format or in story format.

Grades 4 to 6 Students should develop their "own" pictures to be transmitted via their classmates. They should write the coordinates keeping in mind that the three primary colors could be mixed to form other colors. They could then make a sequence frame to show the steps involved in satellite transmission.

Culminating Activity for Satellites:

Working in cooperative groups the students will complete a "life cycle" of a satellite in mural form. For the older students who designed a research satellite, the cycle begins with the decision process. For the younger students, the cycle begins with the launch of the satellite on the rocket. Each group's mural should include pictures and captions of how a satellite gets into and remains in orbit, and how a satellite communicates information. Students can use a long roll of paper or smaller papers attached together.

Graph #1 - Warm-up activity coordinates

If a "0" is transmitted, leave the square blank
If a "1" is transmitted, color in the square

#1	1	#11	1	#21	1
#2	0	#12	1	#22	0
#3	1	#13	1	#23	1
#4	0	#14	0	#24	0
#5	1	#15	1	#25	1
#6	1	#16	1		
#7	0	#17	0		
#8	1	#18	1		
#9	0	#19	0		
#10	1	#20	1		

Graph #1

21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	8	9	10
1	2	3	4	5

Graph # 2 Coordinates and Color Bar Table

(Please note that each square could be colored more that one color.)

Yellow: 1, 5, 7, 8, 9, 12, 14, 16, 17, 18, 19, 20, 21, 23, and 25
Red: 2, 3, 4, 6, 10, 11, 13, and 15
Blue: 2, 3, 4, 6, 10, 11, 15, 22, and 24

Graph 2

21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	8	9	10
1	2	3	4	5

Graph # 3 Coordinates and Color Bar Table

Location	# Hits	Location	# Hits	Location	# Hits
(1, 1)	23	(1, 3)	37	(1, 5)	25
(2, 1)	38	(2, 3)	7	(2, 5)	34
(3, 1)	32	(3, 3)	17	(3, 5)	38
(4, 1)	30	(4, 3)	2	(4, 5)	30
(5, 1)	25	(5, 3)	31	(5, 5)	21
(1, 2)	39	(1, 4)	36		
(2, 2)	26	(2, 4)	22		
(3, 2)	5	(3, 4)	4		
(4, 2)	28	(4, 4)	27		
(5, 2)	37	(5, 4)	39		

Number of Hits/Color Chart

#Hits Color

0-9	Blue
10-19	Green
20-29	Yellow
30-39	Red

Graph # 3

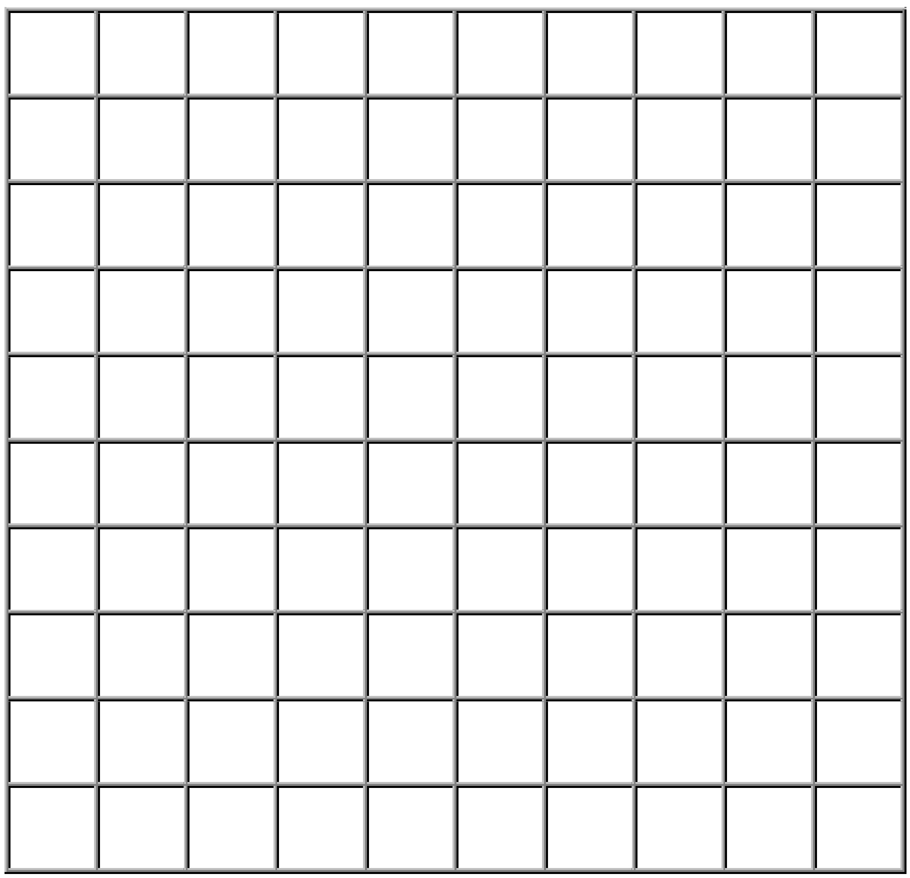
Graph #4, Coordinates and Color Bar Tables

Location	Hits	Location	Hits	Location	Hits	Location	Hits
(1, 1)	3	(6, 3)	19	(1, 6)	19	(6, 8)	29
(2, 1)	15	(7, 3)	15	(2, 6)	17	(7, 8)	11
(3, 1)	23	(8, 3)	11	(3, 6)	22	(8, 8)	19
(4, 1)	39	(9, 3)	19	(4, 6)	39	(9, 8)	22
(5, 1)	36	(10, 3)	17	(5, 6)	12	(10, 8)	29
(6, 1)	24	(1, 4)	17	(6, 6)	29	(1, 9)	10
(7, 1)	16	(2, 4)	14	(7, 6)	14	(2, 9)	10
(8, 1)	9	(3, 4)	28	(8, 6)	18	(3, 9)	13
(9, 1)	5	(4, 4)	29	(9, 6)	15	(4, 9)	18
(10, 1)	2	(5, 4)	12	(10, 6)	19	(5, 9)	19
(1, 2)	18	(6, 4)	21	(1, 7)	11	(6, 9)	22
(2, 2)	28	(7, 4)	12	(2, 7)	19	(7, 9)	29
(3, 2)	37	(8, 4)	19	(3, 7)	13	(8, 9)	27
(4, 2)	25	(9, 4)	18	(4, 7)	19	(9, 9)	25
(5, 2)	39	(10, 4)	15	(5, 7)	29	(10, 9)	28
(6, 2)	14	(1, 5)	14	(6, 7)	22	(1, 10)	10
(7, 2)	19	(2, 5)	19	(7, 7)	19	(2, 10)	10
(8, 2)	11	(3, 5)	25	(8, 7)	12	(3, 10)	10
(9, 2)	18	(4, 5)	39	(9, 7)	16	(4, 10)	12
(10, 2)	11	(5, 5)	15	(10, 7)	23	(5, 10)	15
(1, 3)	13	(6, 5)	27	(1, 8)	10	(6, 10)	18
(2, 3)	19	(7, 5)	14	(2, 8)	11	(7, 10)	29
(3, 3)	24	(8, 5)	9	(3, 8)	19	(8, 10)	26
(4, 3)	19	(9, 5)	19	(4, 8)	15	(9, 10)	16
(5, 3)	29	(10, 5)	11	(5, 8)	18	(10, 10)	29

Use this table to match the number of hits to a color so that you can create the image.

# Hits	Color
0-9	Blue
10-19	Green
20-29	Yellow
30-39	Red

Graph 4



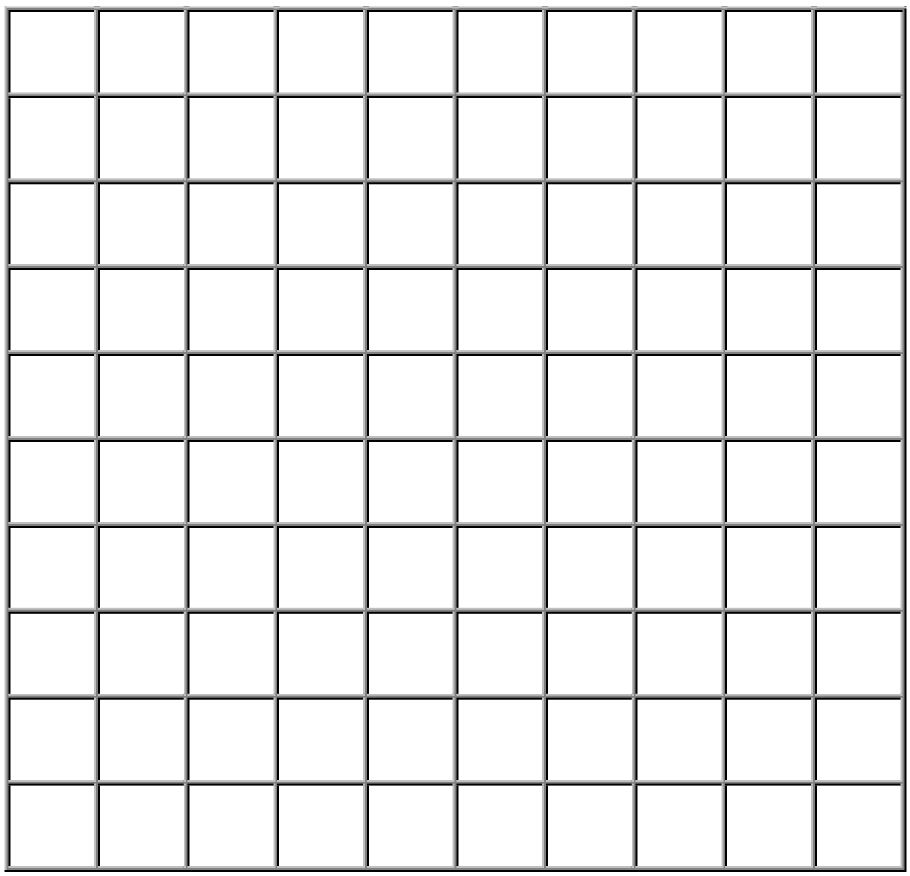
Graph 5: Coordinates and Color Table

Location	Hits	Location	Hits	Location	Hits	Location	Hits
(1, 1)	9	(6, 3)	17	(1, 6)	19	(6, 8)	33
(2, 1)	19	(7, 3)	14	(2, 6)	18	(7, 8)	28
(3, 1)	14	(8, 3)	28	(3, 6)	15	(8, 8)	22
(4, 1)	18	(9, 3)	37	(4, 6)	22	(9, 8)	24
(5, 1)	11	(10, 3)	11	(5, 6)	25	(10, 8)	26
(6, 1)	19	(1, 4)	19	(6, 6)	21	(1, 9)	29
(7, 1)	14	(2, 4)	12	(7, 6)	29	(2, 9)	27
(8, 1)	22	(3, 4)	15	(8, 6)	39	(3, 9)	34
(9, 1)	38	(4, 4)	17	(9, 6)	33	(4, 9)	36
(10, 1)	16	(5, 4)	14	(10, 6)	25	(5, 9)	22
(1, 2)	19	(6, 4)	11	(1, 7)	19	(6, 9)	28
(2, 2)	14	(7, 4)	19	(2, 7)	22	(7, 9)	24
(3, 2)	18	(8, 4)	25	(3, 7)	29	(8, 9)	25
(4, 2)	12	(9, 4)	39	(4, 7)	26	(9, 9)	27
(5, 2)	17	(10, 4)	28	(5, 7)	28	(10, 9)	29
(6, 2)	19	(1, 5)	11	(6, 7)	25	(1, 10)	29
(7, 2)	13	(2, 5)	19	(7, 7)	39	(2, 10)	21
(8, 2)	22	(3, 5)	17	(8, 7)	35	(3, 10)	26
(9, 2)	33	(4, 5)	15	(9, 7)	28	(4, 10)	28
(10, 2)	17	(5, 5)	13	(10, 7)	27	(5, 10)	29
(1, 3)	18	(6, 5)	14	(1, 8)	18	(6, 10)	24
(2, 3)	12	(7, 5)	29	(2, 8)	22	(7, 10)	27
(3, 3)	16	(8, 5)	38	(3, 8)	26	(8, 10)	28
(4, 3)	14	(9, 5)	33	(4, 8)	24	(9, 10)	23
(5, 3)	17	(10, 5)	29	(5, 8)	36	(10, 10)	22

Use this table to match the number of hits to a color so that you can create the image.

# Hits	Color
0-9	Blue
10-19	Green
20-29	Yellow
30-39	Red

Graph 5



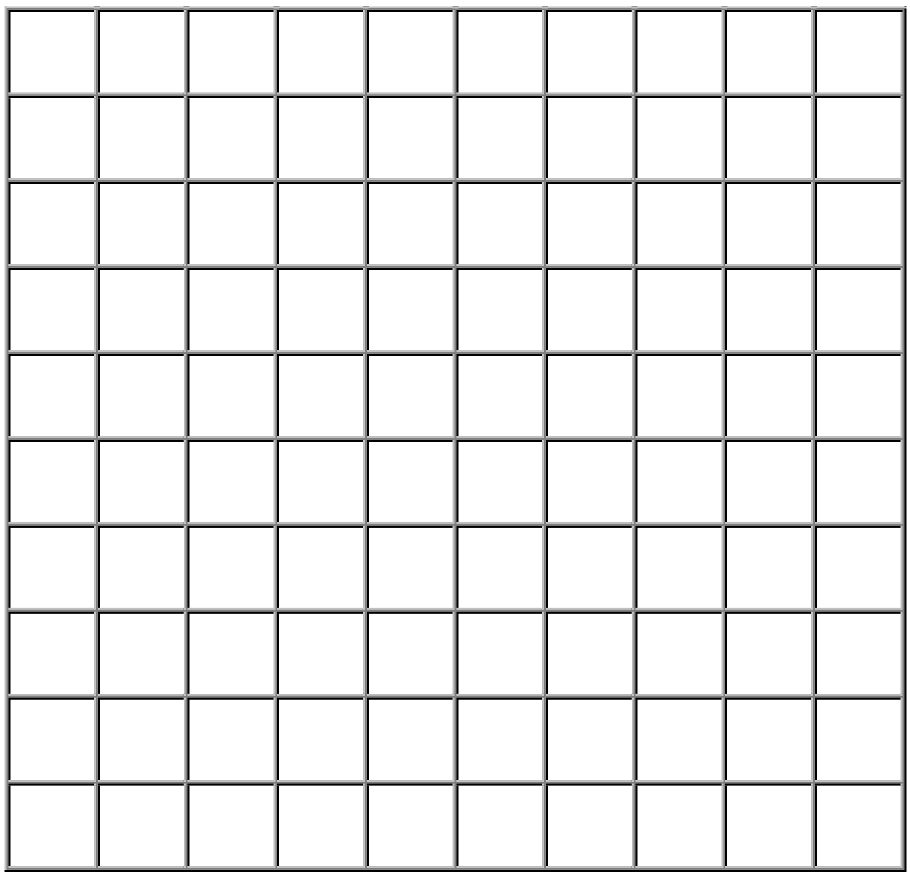
Graph 6: Coordinates and Color Table

Location	Hits	Location	Hits	Location	Hits	Location	Hits
(1, 1)	15	(6, 3)	29	(1, 6)	3	(6, 8)	25
(2, 1)	9	(7, 3)	17	(2, 6)	14	(7, 8)	18
(3, 1)	5	(8, 3)	14	(3, 6)	24	(8, 8)	4
(4, 1)	3	(9, 3)	16	(4, 6)	16	(9, 8)	9
(5, 1)	7	(10, 3)	15	(5, 6)	14	(10, 8)	3
(6, 1)	18	(1, 4)	9	(6, 6)	27	(1, 9)	7
(7, 1)	22	(2, 4)	4	(7, 6)	19	(2, 9)	17
(8, 1)	25	(3, 4)	8	(8, 6)	2	(3, 9)	26
(9, 1)	28	(4, 4)	11	(9, 6)	6	(4, 9)	24
(10, 1)	23	(5, 4)	21	(10, 6)	4	(5, 9)	28
(1, 2)	9	(6, 4)	28	(1, 7)	9	(6, 9)	25
(2, 2)	14	(7, 4)	25	(2, 7)	7	(7, 9)	19
(3, 2)	3	(8, 4)	19	(3, 7)	16	(8, 9)	4
(4, 2)	7	(9, 4)	17	(4, 7)	27	(9, 9)	7
(5, 2)	14	(10, 4)	11	(5, 7)	15	(10, 9)	3
(6, 2)	28	(1, 5)	3	(6, 7)	19	(1, 10)	9
(7, 2)	24	(2, 5)	6	(7, 7)	28	(2, 10)	18
(8, 2)	26	(3, 5)	18	(8, 7)	2	(3, 10)	26
(9, 2)	17	(4, 5)	25	(9, 7)	5	(4, 10)	31
(10, 2)	12	(5, 5)	19	(10, 7)	4	(5, 10)	27
(1, 3)	2	(6, 5)	28	(1, 8)	9	(6, 10)	18
(2, 3)	1	(7, 5)	18	(2, 8)	19	(7, 10)	8
(3, 3)	9	(8, 5)	9	(3, 8)	24	(8, 10)	3
(4, 3)	19	(9, 5)	11	(4, 8)	27	(9, 10)	9
(5, 3)	29	(10, 5)	19	(5, 8)	16	(10, 10)	2

Use this table to match the number of hits to a color so that you can create the image.

# Hits	Color
0-9	Blue
10-19	Green
20-29	Yellow
30-39	Red

Graph 6



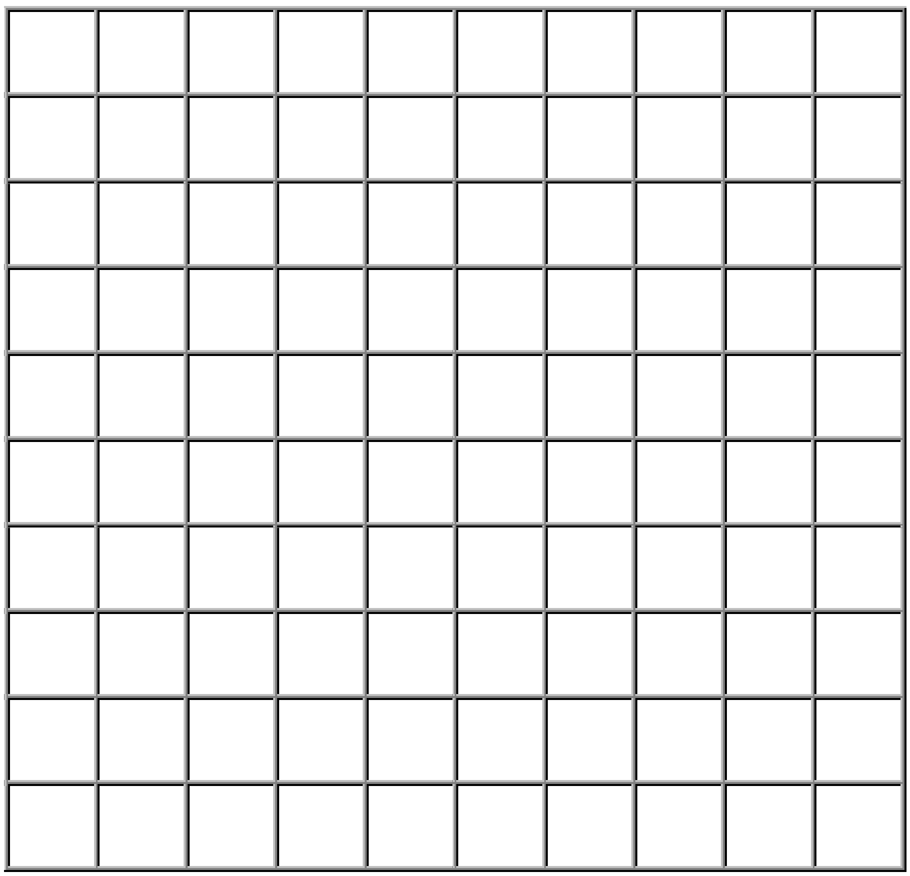
Graph 7: Coordinates and Color Table

Location	Hits	Location	Hits	Location	Hits	Location	Hits
(1, 1)	26	(6, 3)	22	(1, 6)	6	(6, 8)	11
(2, 1)	38	(7, 3)	11	(2, 6)	11	(7, 8)	15
(3, 1)	27	(8, 3)	8	(3, 6)	16	(8, 8)	27
(4, 1)	29	(9, 3)	6	(4, 6)	14	(9, 8)	31
(5, 1)	18	(10, 3)	9	(5, 6)	13	(10, 8)	19
(6, 1)	3	(1, 4)	12	(6, 6)	27	(1, 9)	5
(7, 1)	8	(2, 4)	15	(7, 6)	26	(2, 9)	7
(8, 1)	6	(3, 4)	22	(8, 6)	37	(3, 9)	9
(9, 1)	9	(4, 4)	28	(9, 6)	26	(4, 9)	6
(10, 1)	4	(5, 4)	26	(10, 6)	19	(5, 9)	8
(1, 2)	26	(6, 4)	34	(1, 7)	3	(6, 9)	18
(2, 2)	38	(7, 4)	28	(2, 7)	8	(7, 9)	16
(3, 2)	35	(8, 4)	15	(3, 7)	6	(8, 9)	26
(4, 2)	39	(9, 4)	3	(4, 7)	7	(9, 9)	36
(5, 2)	26	(10, 4)	8	(5, 7)	19	(10, 9)	19
(6, 2)	19	(1, 5)	11	(6, 7)	17	(1, 10)	8
(7, 2)	2	(2, 5)	16	(7, 7)	14	(2, 10)	6
(8, 2)	4	(3, 5)	14	(8, 7)	25	(3, 10)	2
(9, 2)	3	(4, 5)	16	(9, 7)	24	(4, 10)	7
(10, 2)	5	(5, 5)	22	(10, 7)	17	(5, 10)	4
(1, 3)	12	(6, 5)	27	(1, 8)	8	(6, 10)	18
(2, 3)	25	(7, 5)	37	(2, 8)	5	(7, 10)	15
(3, 3)	29	(8, 5)	26	(3, 8)	9	(8, 10)	24
(4, 3)	34	(9, 5)	16	(4, 8)	6	(9, 10)	31
(5, 3)	33	(10, 5)	8	(5, 8)	3	(10, 10)	19

Use this table to match the number of hits to a color so that you can create the image.

# Hits	Color
0-9	Blue
10-19	Green
20-29	Yellow
30-39	Red

Graph 7



V...How Your Location Changes What You See

Introduction:

How does your location change what you see? Students will use hands on experiences to develop an understanding of how the distance and location of the observer changes the appearance of a star and other objects in the sky. Although no two stars are exactly as powerful, it is still true that the farther away stars are, the fainter they will be. This follows a precise law called the Inverse Square Law, which the students will be exploring. The students will also explore how the observer's location changes the perception of what is seen by looking at auroras from two different perspectives; from space and from the ground.

Materials:

Seven Mini-Maglite flashlights (these flashlights were chosen specifically because the reflector mechanism may be removed easily by unscrewing the top of the flashlight off, making the flashlight work more like a candle without the dangers of flames) - or Glow-in-the-Dark stars of the same color (available at many stores)

Dark room or area - the darker the better!

Cartoon copied onto colored paper

One Mini- Maglite flashlight (extension activity)

Index cards

Scissors

Graph paper with 1/2 inch squares (a stiff pad or clipboard is helpful)

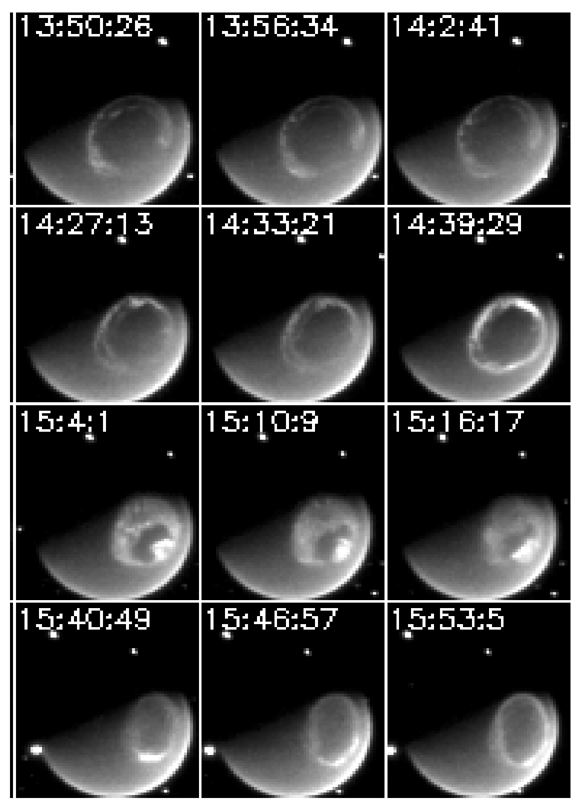
Pencil

Objectives:

- Students will make predictions about the influence distance has on appearance of an object.
- Students will explore the Inverse Square Law.
- Students will investigate the distance-perception relationship.
- Students will communicate observations to classmates.

Key Terms:

Inverse Square Law – states that for two identical lamps, the one that is twice as far from the observer will appear 1/4 as bright.



Aurora seen with IMAGE satellite

Procedure:

- Have three students stand approximately 10, 20 and 30 feet from the rest of the class, each holding a flashlight (with the reflector mechanism removed) or a Glow-in-the-Dark star. Darken the room and have the students turn on the flashlights or hold up the stars. Then have the rest of the class observe which light appears to be brighter. The class should discuss how this demonstration is related to the varying levels of brightness of the stars that we see. The darker the room/area, the more the students will have to look at the magnitude of the lights instead of where the flashlights are located.

- Have a student stand at the end of the hallway holding the cartoon with caption. The rest of the students should try to guess what that student is holding and if it has color. Have the student come toward the class slowly until the class can determine what is being held. The class can discuss how this demonstration is related to how distance changes the appearance of objects.

- Have seven students stand in a line with the Mini-Maglite flashlights (with the reflector mechanism removed) or the Glow-in-the-Dark stars. When the room is darkened, the students should turn on the flashlights or hold up the stars. Then the students should arrange themselves to look like a constellation such as the Big Dipper. Once they are arranged, assign them each a star number. (Some students could be sitting or kneeling on the floor). The rest of the class should walk around and observe the arrangement of student stars. Then ask the students who are star #1 and #6 to take four steps straight back. Student stars #3 and #7 should take 2 steps forward. Student star #2 should take one step back. Have the rest of the class walk around the newly arranged stars, and observe the changes. Discuss their observations. Does it still look like the Big Dipper from all sides? Compare this to observing the stars from different locations in space. The students should write about their observations in their learning logs.

- The students will need to have access to the internet to review sites that show images of auroras from the ground and from a satellite. Both images can be viewed at the same time if you go to: http://www.windows.umich.edu/spaceweather/sun_earth8.html A second site of interest can be found at http://www-istp.gsfc.nasa.gov/istp/outreach/coolpics.html This site has various images of auroras from the ground and from space as well as other information.

- Have the students discuss the differences in the appearance of the aurora. The students should record their observations in their learning logs. They should be able to conclude that although an aurora is actually a big circle (called an oval) small parts of it from the ground will look very different.

Grades 2-6

In this activity the students are going to explore the Inverse Square Law.

Procedure:

- The reflector mechanism needs to be removed from the flashlight. The students should cut a 1/2 inch by 1/2 inch square in the index card and attach it to the work surface one inch away from the modified Mini-Maglite. The students should place the graph paper against the index card, which means it is one inch away from the light source. Then the students should mark the number of squares that are illuminated on the graph paper and record the distance the graph paper was from the light source. The students should also note the intensity of the light on the graph paper.
- Now the students should move the graph paper to 2 inches away from the light source, illuminating a different area on the paper. Mark the squares that are illuminated, record the distance from light source and note the intensity of the light on the graph paper. Continue to move the graph paper away from the light source in inch increments, continue recording the distance from light source, the number of squares illuminated and the intensity of the light.
- The students should see a pattern of squares in the number of squares illuminated and the intensity of the light on the graph paper. When the graph paper was two inches away, there should have been four squares illuminated. When the graph paper was three inches away, there should have been nine squares illuminated.
- Discuss the students' observations and have the students record their observations in their science learning logs.

Conclusions:

The students will explore how the observer's location will change the appearance of stars and other objects in the sky. The students will learn that the distance between an observer and the object will change the object's appearance in size and brightness.

Extensions:

Grades 2- 3

- Students can predict whether all three children with flashlights would have to be exactly the same distance from the observers to have the lights appear to have the same brightness level. The students should design experiments to explore this further. Initiate a discussion about how stars in space are different distances from our view on earth.

Summary: The Inverse Square Law says that for two identical lamps, the one that is twice as far from the observer will appear 1/4 as bright.

Grades 4-6

- Students can predict the distance that the student holding the cartoon would have to move so that the observers could determine what was being held. The students should design a method for recording the distance the observer needs to be from the object being observed. Initiate a discussion about how stars in space are different distances from our view on earth. As the students saw from the demonstration with the cartoon, distance changes our perception of the stars.

Summary: The farther away an object is, the less detail the observer can see.

- To have students explore how the power of a star changes the distance – brightness relationship, students could use 25-watt & a 100-watt bulbs in lamps. As in the first activity listed here, the students should stand in different places in the hallway with the lamps. The students are exploring how a star that appears faint could actually be closer than a higher-powered star that is farther away.

VI...Playing with Magnetism

Introduction:

What is magnetism? We have all had the experience of using simple magnets to hold notes on surfaces such as refridgerator doors. Magnetism is the force produced by magnets which does all of the "holding". Magnetism is also a very important force in nature which can move hot gases in stars, and in the space around the earth. The students will investigate magnetism and magnetic forces. The students will explore the attracting and repelling properties of magnets through hands on experiences.

Objectives:

- The students will investigate that magnets are attracted to items, which contain metals such as iron.
- The students will experience that a magnetic force is an invisible force.
- The students will explore a magnet's attracting and repelling properties.

Materials:

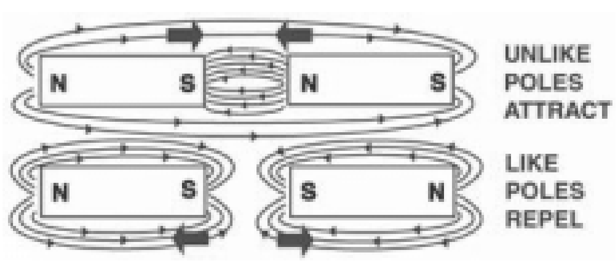
Magnets – enough for class

Paper clips

String

Books

Ruler

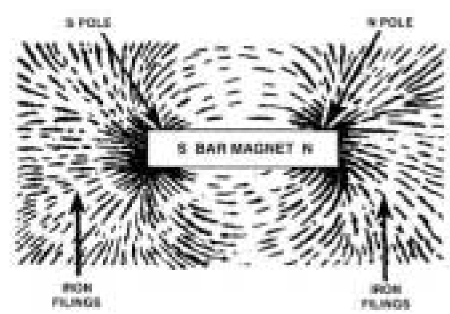


Key Terms:

Magnet - a metal that can attract certain other metals.

Magnetic Properties - refers to an item which can attract or repel items as a magnet does.

Poles - refers to the two areas of a magnet where the magnetic effects are the strongest. The poles are generally termed the north and south poles. Poles that are alike (both north or both south) will repel from each other, while poles that are different (one north, one south) will attract to each other.

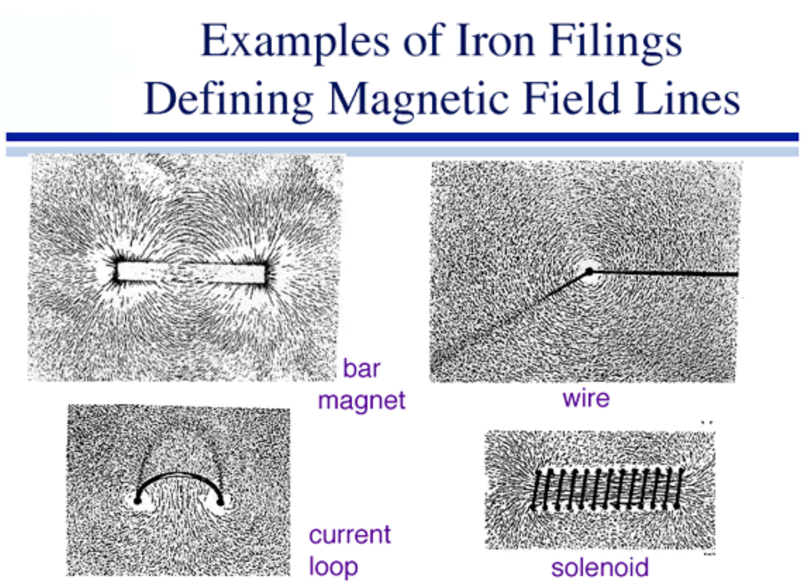


Procedure:

- Give each student a magnet. Have the students explore the objects that the magnet would be attracted to. The students should look at the objects and find common characteristics. The students should record their findings in a learning log.
- Tape one end of a piece of string to a desk; tie the other end onto a paper clip. Take a second piece of string and suspend the magnet from a ruler anchored with books. Adjust the level of books so that the distance between the magnet and the paper clip allows the clip to stand up without touching the magnet. The students should see that a magnetic force could be invisible. You can place pieces of paper or cloth between the clip and the magnet to show the strength of the magnetic force. Can the students find materials that block magnetic forces?
- With the string still attached, have the students try to raise the paper clip from the desk with a magnet. They should try to accomplish this without letting the magnet and paper clip touch. The students should keep a log of how they were able to accomplish this; what methods and strategies were used.
- Allow the students time to explore the attracting and repelling properties of magnets. They should be able to demonstrate that a magnet has two ends or poles that will attract or repel from other poles. Have the students observe what happens when two magnets are repelling from each other. The students should find a partner and discuss what they have seen and whether their classmate was able to discover the same properties.

Conclusions:

The students will learn the characteristics of magnetism. The students will demonstrate the attracting and repelling properties of magnets.



VII...Exploring Magnetic Fields

Introduction:

What are magnetic fields? In physical science, a "field of force " is a region or space in which an object can cause a push or pull. This field extends infinitely in all directions but gets weaker as you get farther from the source of the field. Magnetic lines of force show the strength and direction of this field. The students will explore the lines of force of magnets and compare them to the lines of force on the sun and the earth**.**

When the students are using the iron filings to define the magnetic lines of force, it is important to stress that the procedure must be done slowly and carefully to have the best effects.

Objectives:

- The students will explore the magnetic field lines of a magnet.
- The students will investigate the magnetic field lines between two attracting and two repelling magnetic poles.
- The students will learn that the earth and the sun have magnetic properties.

Materials:

Strong Magnets- enough for class or small groups

Plastic wrap

Iron filings

Plastic teaspoon

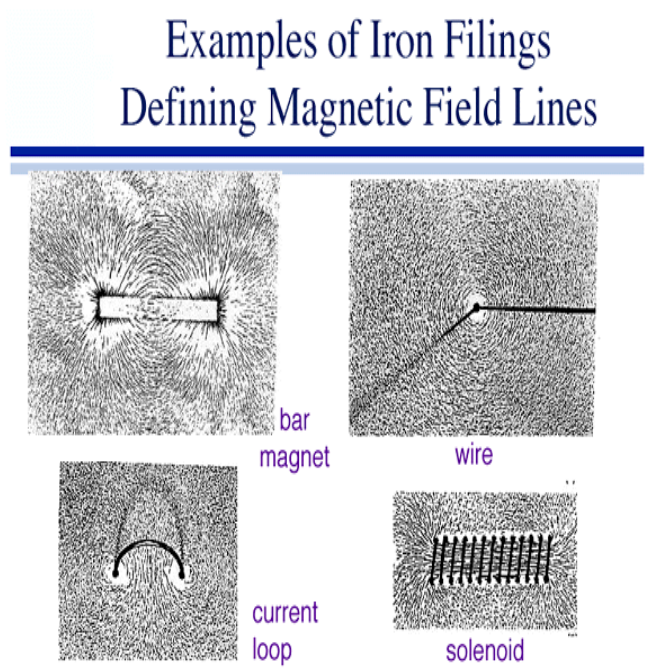
Paper- white

Plastic tray

Compass

Photograph of sunspot/magnetic loops on the sun

Also available through the TRACE satellite site at http://vestige.lmsal.com/TRACE/



Procedures:

*****Caution the students that the iron filings should not be eaten or blown into eyes. *****

- Cover the magnets with plastic wrap to keep the iron filings off them. Place the covered magnet in the plastic tray and place the paper on top. The students should carefully use the spoon to sprinkle a small amount of the iron filings on the paper. The iron filings will stay in a pattern that indicates the lines of force of that magnet. The students should draw their observations in their learning logs. After the students have completed their observations, the iron filings can be poured off the paper and the tray back into the container.

- Give each group of students a pair of covered magnets. Place the covered magnets about an inch apart in the plastic tray and place the paper on top. The students should carefully sprinkle a small amount of the iron filings on the paper. The iron filings will stay in a pattern that indicates the lines of force between the magnets. The students should look at the lines of force and determine whether the magnetic poles are alike or different. Have the students record their observations in their learning logs.

- Have the students repeat the activity of finding lines of force, but this time one of the magnets must be reversed so that its opposite pole is about an inch away from the other magnet. The students should look at the lines of force and determine whether the magnetic poles are alike or different. The students should record their observations in their learning logs.

- Display the photograph or the TRACE website of magnetic loops on the sun's surface without informing the students of the source. Question the students about what they observe in the photograph. The image should resemble the magnetic lines of force the students saw in the previous activity. The students, as scientists, should understand that they are seeing magnetic properties on the sun. Discuss with the students what other property the shapes on the sun need to share with a magnetic field if they are in fact, magnetic. Answer - They should display a definite North and South polarity as well as loops. Scientists have in fact confirmed this using other observations.

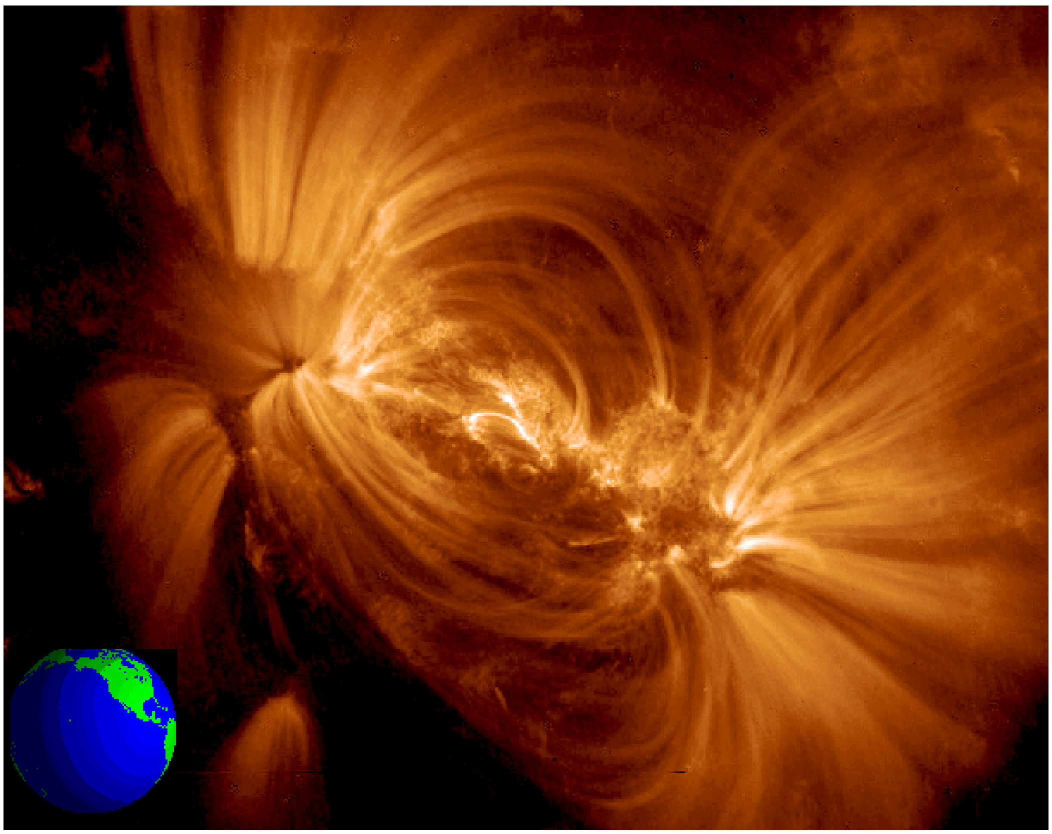
- Discuss the student's observations and update the K-W-L chart with new questions and information.

- Display a compass to the students. Explain that in the Northern Hemisphere the needle of the compass will point to the magnetic north because it is magnetized. When a compass is held on the earth, the earth's magnetic field exerts a force on the needle. This should help the students understand that the earth also has magnetic properties. If the "north" part of a compass is attracted to the magnetic north pole of the Earth, what is the polarity of the Earth's north magnetic pole? Answer - South!

Conclusions:

The students will gain an understanding of the presence of magnetic fields around magnets, the sun and the earth. The students will learn that the magnetic poles attract when they are different and repel when they are the same.

Sunspots also have magnetic fields, and they look a lot like the kind you see with a bar magnet. This view (note the earth for scale) is provided by the NASA, TRACE satellite shows million-degree gases flowing along the lines of magnetism an illuminating them. How does the pattern compare to the iron filings near a bar magnet?



VIII...Solar Activity and Energy

Introduction:

Why is the surface of the Sun so stormy? Most of the activity we see on the sun is caused by magnetic fields getting tangled-up and pulled into complex shapes. Enormous amounts of energy can be release when magnetic fields "un-kink". The students will use various activities to model the magnetic fields around the sun. The students will see how changes in this magnetic field cause phenomena like coronal mass ejections, filaments, sunspots, and magnetic loops on the sun. Students will use photographs of coronal mass ejections and magnetic loops to determine the speed of this phenomenon.

Materials:

String - precut into 2 foot lengths

Students

Balloons

Glitter

Photographs of phenomena on the sun Images can be found at SOHO Satellite site's gallery

http://sohowww.nascom.nasa.gov/gallery/bestofsoho/

or TRACE Satellite site's gallery

http://vestige.lmsal.com/TRACE/Public/Gallery/Images/

Objectives:

- The students will use a model to demonstrate the restructuring of the magnetic fields on the sun's surface.
- The students will use a model to demonstrate how magnetic field restructuring can cause phenomena like coronal mass ejection, filaments, sunspots, and magnetic loops.
- The students will use photographs of the sun's surface to determine the speed of the phenomena.

Key Terms:

Coronal Mass Ejection – a blast of particles from the sun that occurs when the magnetic forces on the sun restructure and break.

Magnetic Loop – eruptions of the plasma of the sun that occur when the magnetic fields are twisted.

Solar Prominence- An arch-like filament of gas that extends high up from the surface and looks like a horseshoe.

Sunspots – a cooler area of the sun's plasma that occurs when there is a concentration of the sun's magnetic field lines.

Filament- small eruption on the sun's surface that occurs when the magnetic field is twisted.

Procedure:

- In this activity the students will use string as a model for the magnetic fields on the surface of the sun. They will see how these magnetic fields undergo restructuring over time. Have the students pair up and form a line across the room, all facing the same way. Give each pair of students a piece of the precut string, with each person holding an end. Every other pair should tie the ends of their string to both of their neighbor's and then step away from the line. The remaining students should hold on to the longer strands of string. Now, have every other remaining pair attach tie their ends to both of their neighbors and step away. Continue to repeat the activity until there are just a few students left holding the string. Do the students think that the resulting magnetic fields are going to be stronger or weaker? Do the students think the resulting magnetic fields will take up the same amount of area on the sun? Have the students discuss the changes in the magnetic field and record observations in their learning logs.

- In this activity the students will become the sun's magnetic field. The students should gather randomly in an open space in the classroom with about an arm's length between them. Each student will become an active part of the magnetic field, their left arm will have north polarity and their right arm will have south polarity. Use Post-it notes with N or S on them, or of different colors, to provide a visual aid for younger students. When the students are ready they should raise their arms to the side. You will be asking them to "attract" or "repel" to the other student's poles that are the closest. The students should not move their feet, but simply become the magnetic force with their arms. For example, if two same "poles" were closest together, the students' arms would move away from each. If two different "poles" were closest together, the students' arms would attach to each other at the wrists. Both of the student's "poles" can be attached to different "poles". Have the students look at what student configurations were formed.

The following list is meant to be a guideline to describe to the students what the student configurations could model.

- If a circular group of about eight students formed, they could be considered a candidate for Coronal Mass Ejection. A CME is formed when the magnetic field has been stretched and breaks away from the sun's surface.

- If a loop of about five students formed, they could be considered a candidate for a Magnetic Loop. A Magnetic Loop stretches away from the sun's surface, but remains attached at its ends. These might represent solar prominences.

- If a string of about three students formed, they could be considered a candidate for a Filament. A Filament is a short magnetic cloud that sticks out from the sun's surface.

- If a group of two students form a closed figure, they could be considered a candidate for a sunspot. A sunspot is an area on the sun's surface where the magnetic field is more concentrated, and can cause solar flares to form.

You can repeat the activity as many times as you would like, the students will make many new configurations with each repetition. Stress to the students that these new magnetic field configurations occur repeatedly on the surface of the sun. Scientists are just now studying these configurations to see if there are patterns in where they occur, how often they occur and the ramifications of the occurrences.

- To demonstrate the force of a CME, place some glitter in a balloon. Begin to blow up the balloon, reminding the students to observe the stretching of the balloon. The outside of the balloon models the magnetic forces of the sun that are being stretched. When the balloon is fully stretched, move it away from your face and pop it. This demonstration shows the students that the magnetic field on the sun will break away when it becomes stretched too far. The glitter represents the charged plasma that shoots away from the sun's surface when the magnetic fields break up.
- Discuss the students' observations and update the K-W-L chart with the new information.

Conclusions:

The students will gain an understanding of how the restructuring of the magnetic field of the sun can cause a variety of seemingly unrelated shapes and phenomena. Scientists have been able to learn more about the sun's surface as new information is received from satellites that have been launched in recent years.

Extensions:

Grades 1-6

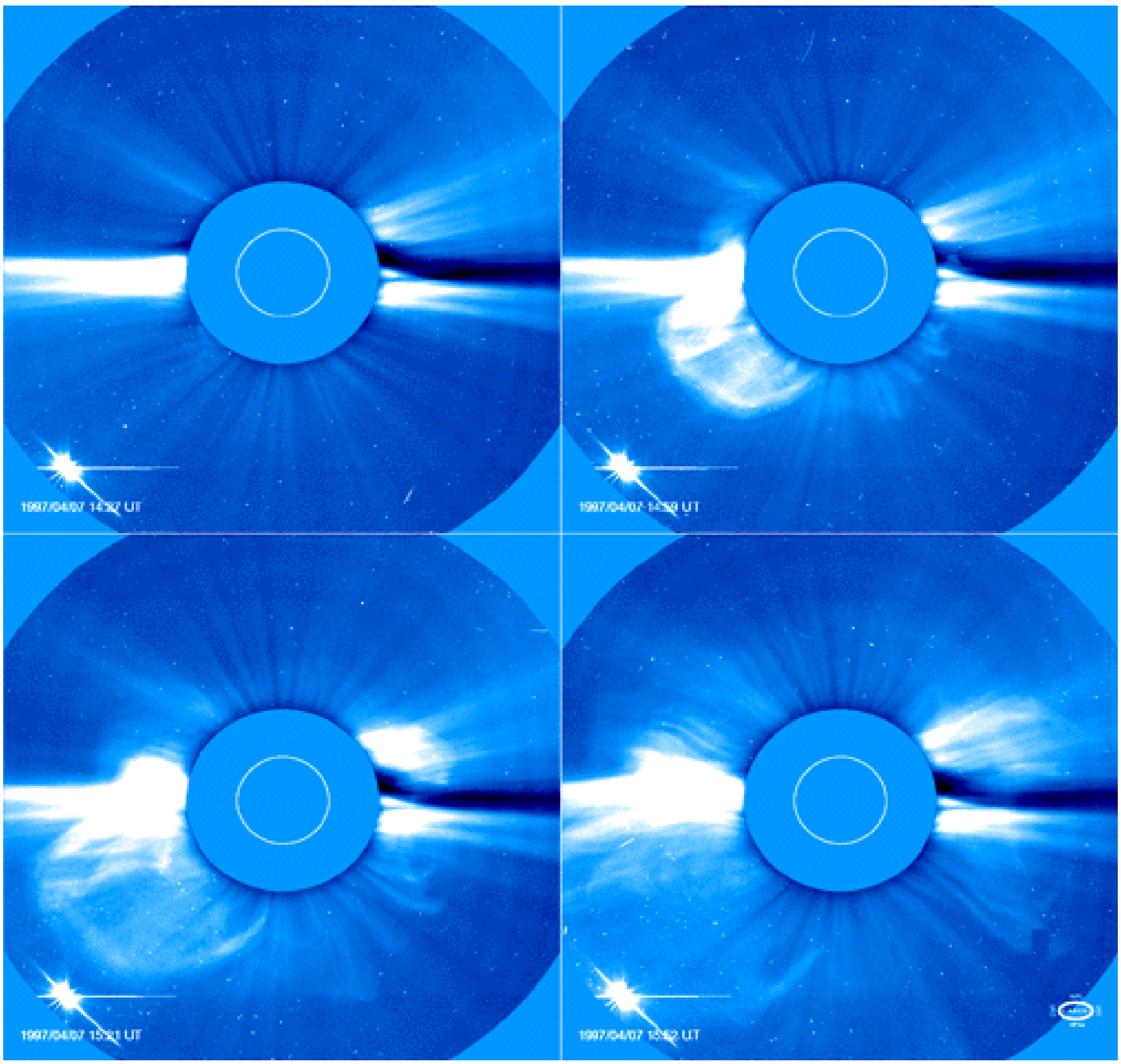
- Students could make a flipbook of a phenomenon of the sun as it moves. Included in the workbook are some photographs of CMEs and magnetic loops to help the students visualize what they look like. Give each student 10 sheets of 3 x 3 inch paper (a post- it – pad works well for this). The students should draw the sequence of the phenomenon one step at a time on each piece of paper. When all the steps are drawn, the papers should be placed in order and stapled together at one edge. The student holds the stapled edge in one hand and "flips" the other pages to make the image move.

Grades 4 - 6

- Students will look at photographs of a CME and of a magnetic loop and determine the speed using the formula below.

$$\text{Speed of Motion} = \frac{\text{Distance Traveled by the Feature}}{\text{Time of Travel}}$$

This series of four images taken with the NASA, SOHO satellite shows a giant cloud of gas, called a Coronal Mass Ejection, leaving the Sun on April 7, 1997. The time between the first frame (upper left) and the last frame (lower right) is about two hours. The diameter of the circle at the center is equal to the Sun's diameter. Use the Sun's size as a scale to measure how far the cloud traveled in each frame, and from the 30-minute interval between frames, estimate how fast the cloud was traveling.



IX...Transfering Energy from the Sun to the Earth

Introduction:

What is the solar wind? Because the surface of the sun is very active, gases are constantly being ejected into space. This "wind" rushes out from the surface at nearly a million miles per hour and travels to the orbit of Pluto and beyond. The amount of gas expelled in this wind is so small that fewer than 30 atoms per cubic inch are present as it speeds out from the solar surface and crosses the orbit of the Earth. Yet, this wind is more than enough to affect the tails of comets and to upset the magnetic field of the earth causing powerful storms in space and aurora. Students will make a model of the solar wind. They will use both individual and group activities to explore the solar wind.

Objectives:

- The students will explore a model of the solar wind.
- The students will communicate their findings to classmates.

Materials:

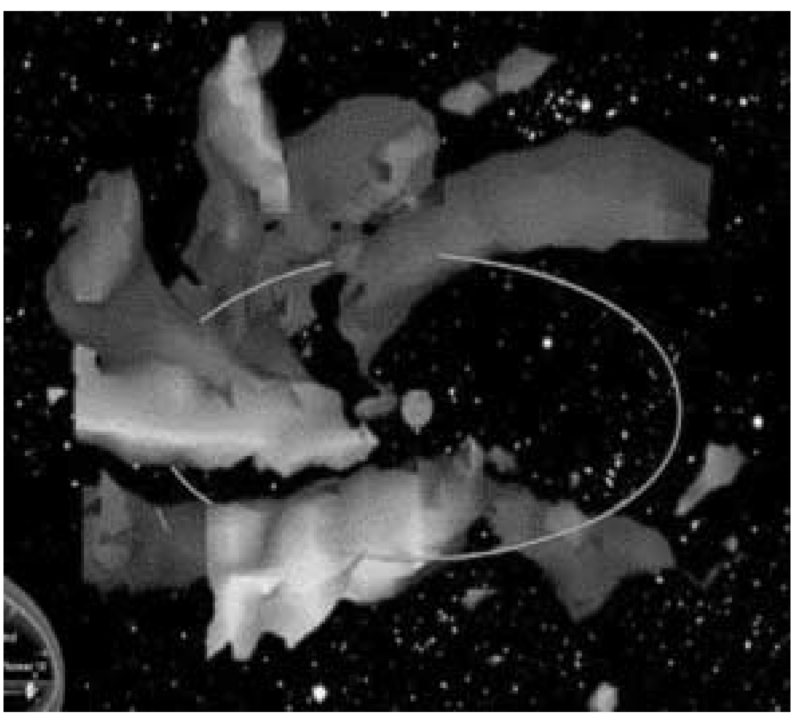
Puffed rice cereal

Students

Large non-windy area

There are many visual aids for the Solar Wind at The University of Michigan's "Windows to the Universe" Site - (access basic facts from this site)

http://windows.engin.umich.edu/spaceweather/



The pin wheel arms of the solar wind fill much of the solar system. This view shows the arms as they cross the Earth's orbit indicated by the green circle. The Sun is the red disk at the center.

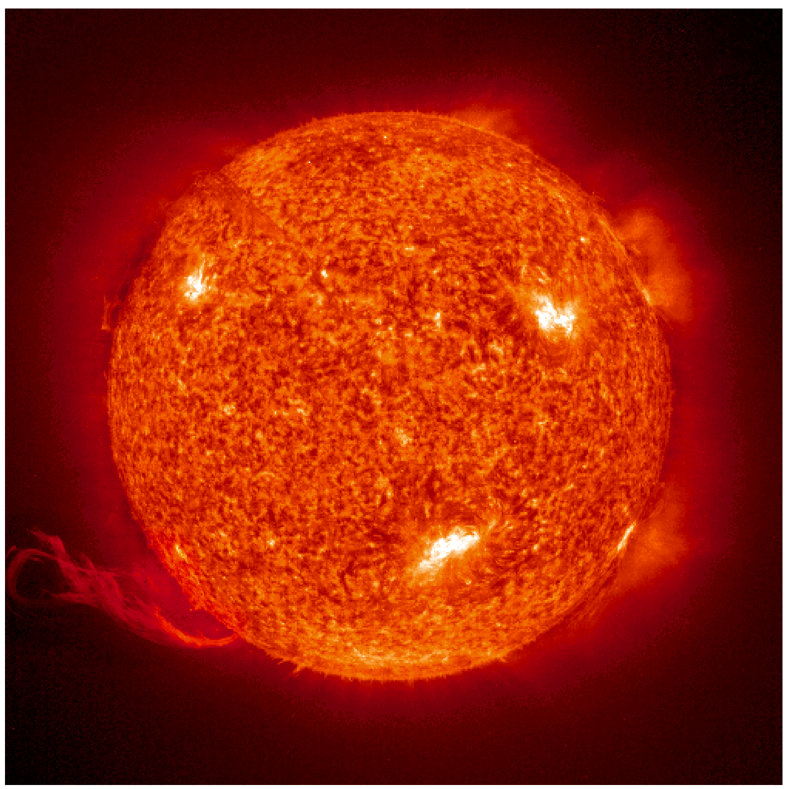
Procedure:

- The surface of the sun is very active and "boils" like a pot of water as heat rises from deep inside to the surface. This activity causes a flow of gas, containing charged particles, into space called the solar wind. Each student will become a convection cell on the sun’s surface. Each student should blow the puffed rice cereal off their hand and observe what happens. This represents what happens when one convection cell bursts at the surface of the sun.
- Students will need to form concentric circles facing out. Children will blow the puffed rice cereal off their hands at the same time. They should observe that some of the cereal will join into larger concentrations and that there is a much stronger flow. This example represents what happens when many convection cells burst at the surface of the sun.
- Discuss the student’s observations about the solar wind and update the K-W-L chart.

Conclusions:

The students will gain an understanding of how the solar wind is formed. The constant explosive activity on the Sun’s surface ejects gas into space. This activity is driven by the powerful, and ever-changing, magnetic fields on its surface which short-circuit and heat the gases to millions of degrees. Not even the Sun, with its powerful gravity can hold onto these hot gases for very long.

The Sun is a stormy star that constantly throws out gases from its surface. Some of these continue on into the solar system to become the solar wind.



X...The Earth as a Magnet

Introduction:

What is the Earth's magnetosphere? Scientists call the region surronding the Earth where its magnetic field is located, the Magnetosphere. When the solar wind sends its streams of hot gases (plasma) towards the Earth, the magnetosphere deflects most of this gas. Students will use hands-on experiences to learn about the magnetosphere (the magnetic field surrounding the earth). They will learn how the solar wind (the stream of electrically conducting plasma emitted by the sun) interacts with the magnetosphere. There is a wonderful animated graphic available for this in the Blackout! Video (information available through the IMAGE/POETRY site at http://image.gsfc.nasa.gov/poetry/

or at the Windows on the Universe site at www.windows.umich.edu/spaceweather/mag_

Objectives:

- The students will use models to learn about the earth's magnetosphere.
- The students will use models to learn how the solar wind interacts with the magnetosphere.

Key Terms:

Magnetosphere – magnetic cavity carved out of the solar wind by virtue of the magnetic field surrounding earth.

Materials:

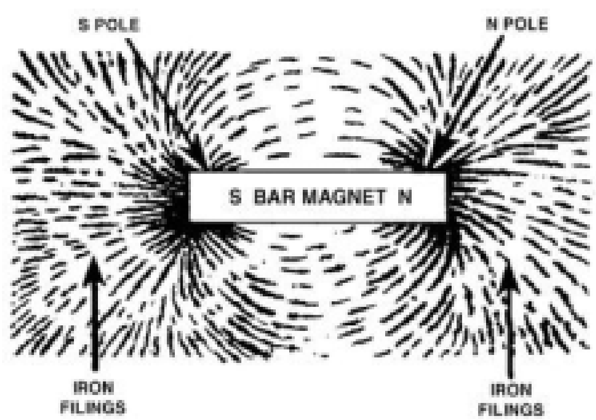
Magnets– strong polarity bar magnet (enough for groups if possible)

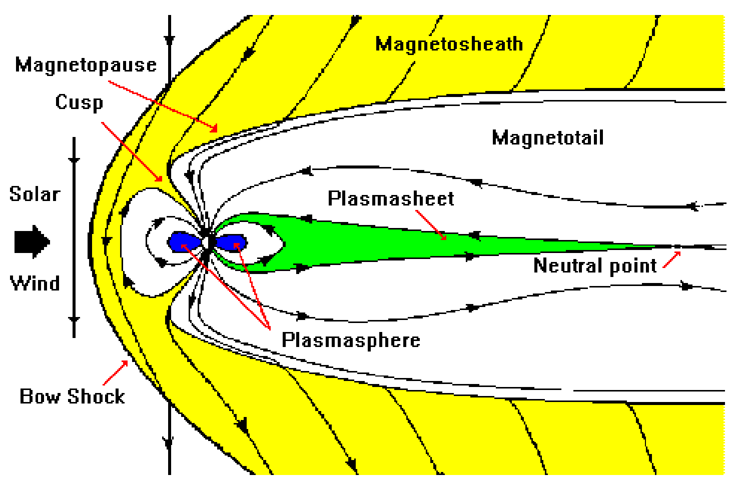
Plastic wrap

Iron filings

Plastic salad tray or aluminum tray

Straws





Procedure:

What protects the earth?

- The earth has a protective cover called the magnetosphere. It works as skin does on your body to keep out harmful things. Students can observe a model of the magnetosphere using magnets and iron filings. To keep your bar magnet clean, wrap it in plastic wrap with tape around it, or put contact paper around it. Place a bar magnet under a plastic salad tray or aluminum tray. Sprinkle some iron filings onto the tray from a distance of about 10 inches. Observe the pattern made by the iron filings held in place by the forces between the opposite poles of the magnets. The earth's magnetosphere can be modeled by blowing softly through a straw towards the magnetic field lines. A squishing of the field lines on one side of the model shows how the earth's magnetosphere looks. Have the students draw the model of the earth's magnetosphere in their learning logs.

What happens when the solar wind approaches the earth's magnetosphere?

- Students can observe the way water flows around a stone as a pattern of the solar wind as it flows around the earth.
- Place the bar magnet under a plastic tray or aluminum tray. Place a small button directly above the center of the magnet to model the earth. Sprinkle the iron filings along the edge of one side of the tray covering the magnet. Softly blow the filings toward the button through a straw. Caution the students to blow carefully so that no iron filings get into eyes or mouth! Depending on the force used in blowing, the filings will be trapped in the magnetic lines of force. Compare this to the trapping of the solar particles by the Earth's magnetosphere. Have the students draw the model of the effects of the solar wind on the earth's magnetosphere.

Conclusions:

The students will gain an understanding of the earth's protective region, called the magnetosphere. The students will gain an understanding of how the earth's magnetosphere interacts with the charged plasma sent from the sun in solar wind and CMEs.

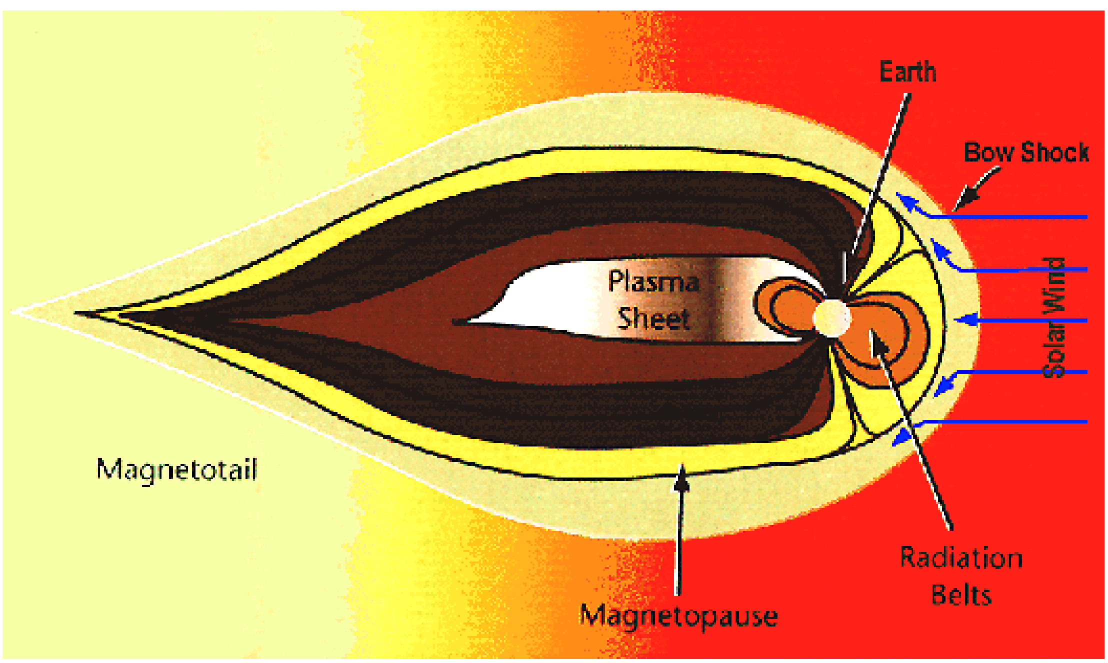
Culminating Activity :

Grades K-2

The students will work as a class or in groups with an adult to write the story of a charged particle in the plasma of the sun as it makes its way to the earth. The story could be written on chart paper or made into a book with student illustrations. Story events should include, coming from activity on the sun's surface, being organized with other particles in the magnetic fields of the sun, and the type of phenomena that took the particle away from the sun.

Grades 3 - 6

The students will work as a class, individually, or in-groups to write a story or rap song about a charged particle in the plasma of the sun. Story events should include; coming from activity on the sun's surface, being organized with other particles in the magnetic fiels of the sun, the type of phenomenon that took the particle away from the sun and what occurred when the plasma approached the earth's magnetosphere.



XI...Interplanetary Pool Games

Introduction:

What does the Neutral Atom Imager on the IMAGE satellite do? The Neutral Atom Imager on the IMAGE satellite uses remote sensing to find out more information about the clouds of charged particles (plasma) that surround the Earth. When some of the particles in the plasma are collected by the Neutral Atom Imager, they are measured. Scientists can determine the composition of these particles, their energy, and from what direction they came. Once all this information has been collected, the scientists can make pictures of where in space the particles came from. The students will make a simple "collector" of information, in this case, film similar to that used in a camera. Then the students will explore a model of how the Neutral Atom Imager collects and measures (counts) these particles.

Objectives:

- The students will explore how a scientist uses an instrument as a collector of information.
- The students will explore how a scientist measures (counts) and records the information collected.
- The students will explore a model to see how the Neutral Atom Imager collects and measures particles in the plasma surrounding the Earth.

Materials:

Sun sensitive paper - Two possible brands available are listed below (there are others)

Nature Print Paper - available at hobby stores or from Insectlore at
http://www.insectlore.com/activitykits.html

Sunprint Paper - available at hobby stores or from Quincy Arts and Crafts at
http://www.quincyshop.com/craftkits/html

(1-800-231-0874)

Cardboard or clipboards for groups

Index cards (size is dependant of the size of your print paper)

Tape

Access to water (sink or tray full)

Balls

Grades K-6 -

- You need four different colors of the same types of balls - for example if you were using foam balls, you would need five blue, two red, four green and six purple. The number of each color of balls can be different - it's the different colors that are important.

Grades 5-6- (Extension activity)

- You need four different colored balls, but three different types of balls for each color -for example, blue foam balls, blue tennis balls, and blue lacrosse balls.

Procedure:

- Scientists use remote sensing to collect information about things that are not always visible. Take for example, the sun. Scientists and teachers know that we can not see the sun's light energy on Earth. We can see the results of the sun's light energy in a sunburn we receive, or when we touch a hot car that has been sitting in the sun. The students will use paper that is similar to film in a camera to collect the sun's light energy. Place one sheet of Natureprint or Sunprint paper outside the classroom with a leaf on it. The paper will absorb or "collect" the sun's light energy by changing the color of the paper except in the area where the leaf sat, when developed in water. Scientists use instruments with more sensitive collection mechanisms on satellites.

- The students will now use the Natureprint or Sunprint paper to make an exposure frame that will measure how much of the sun's light energy was absorbed. Each student group will need a piece of cardboard or a clipboard, an index card slightly larger than the print paper, a piece of print paper and of course, sun! The students should tape just the corners of the print paper onto the cardboard or clipboard. Then the students should cut the index card almost all the way across four times. The result should be a hinged flap sheet. Label the flaps with 1, 2, 3 and 4 minutes, which will represent the exposure time for each portion of the print paper. The flap sheet should be placed on top of the print paper prior to going outside. Have the students place the print paper and flap sheet in a sunny area closeby to the timer. The students should lift flap one for a timed one minute interval, then place the flap back over it. Next, flap two should be lifted for a two minute interval, and covered after its exposure. Continue this way for flaps three and four. Take the exposure frame inside, but do <u>not</u> develop it with water. The students should be able to see varying shades of color on the print paper. If you go back and look at your print paper later, you will notice that there will no longer be varying shades of color because the print paper will continue to absorb light energy, even inside. The NAI uses a more complex method of measuring energy.

- How does the Neutral Atom Imager (NAI) collect and measure (count) the particles in the plasma? Let's use the game of baseball as an example; the catcher can model the collector, the field can model the plasma surrounding the Earth, and the balls thrown into the catcher can model the charged particles that the NAI collects, which are mainly hydrogen, nitrogen and oxygen. The field is going to be divided into four quadrants which are familiar to those who play the game. These will be left outfield, right outfield, left infield and right infield with the infield ending on the dirt area on the outside of the bases. Each of the quadrants will have a specific color ball assigned to it that will be thrown to the "collector", for example all balls from the left outfield would be blue. Send one student into each of the four quadrants with the assigned bucket of balls and one to be the catcher (with a mitt of course!) The NAI is now ready for operation. Have the students begin to throw their balls into the catcher, who will place all the balls into one big bucket. When all the balls have been thrown, the students will be constructing a scattergram by counting and plotting the balls by color on the attached graph. A scattergram is a graphic that displays how many times something occurred within a specific area. You may have seen these during broadcasts of football and baseball. In football, they are used to show where the quarterback has thrown to his receivers. In baseball they are used to show where a player has hit the ball or where the pitcher has placed each pitch in relation to homeplate. The NAI collects the particles and records the direction they were received from.

Extensions:

Grades 5-6

- With a slight variation in the baseball model above, older students can gain an understanding of how the NAI also collects and measures particles based on composition. Each of the quadrants will need to have specific ball colors, but now will need to have different types of balls that match the color. For example, if the left outfield balls are blue, this time you would need to have blue lacrosse, tennis, and baseballs. Each type of ball represents the different elements that are most commonly found in the plasma; nitrogen, oxygen and hydrogen. It is important to note, that each quadrant would have a trend or pattern as to the makeup of its particles. For example, the right outfield would have mostly hydrogen with some nitrogen and oxygen. The assignment of types of balls per quadrant should not be random.

Conclusions:

The students will gain an understanding of how scientists use instruments to collect, and measure information. The students will understand that scientists have adapted instruments to collect information about items in space that we can not always see through the use of remote sensing. The Neutral Atom Imager is an example of an instrument that collects and measures particles that are not visible to us on earth.

Scattergram # 1

Directions: The students should make a dot in each quadrant for each of the balls that was thrown into the catcher from that direction.

Left outfield	Right outfield
Left infield	Right infield

Scattergram #2

Directions: The students will make a dot in each quadrant for each of the balls that was thrown into the catcher from that direction. There will be three scattergrams completed, one for each of the compostions represented by the different types of balls.

Left outfield	Right outfield
Left infield	Right infield

Left outfield	Right outfield
Left infield	Right infield

Left outfield	Right outfield
Left infield	Right infield

XII...Seeing Auroral Lights from Space

Introduction:

What does the Ultraviolet Imager on the IMAGE satellite do? Do you remember using a "magic decoder " to find hidden messages? These decoders worked by having you look through a colored filter to reveal the hidden message. Your decoder absorbed the parts of the picture in your color and only the other colors were visible. In these lessons, the students will experiment with using color filters. Then the students will see how the sun's light can be broken into many colors through the use of a spectrograph. The students will learn that some light is not visible to our eyes, but could be ultraviolet. It is ultraviolet light that is used in satellites to make images of things we can not normally see. The Extreme Ultraviolet Imager (EUV) and the Far Ultraviolet Imager (FUV) are both highly specialized cameras that filter out extraneous light, recording images only through specific light energy.

Objectives:

- The students will explore how the use of filters can change what you see.
- The students will explore that visible light can be divided into a spectrum of colors.
- The students will explore that not all light is visible, for example ultraviolet.
- The students will explore that instruments like the FUV and EUV use ultraviolet light to make images of items in space.

Materials:

Crayola crayons
Paper- white
Red Cellophane- Available at Michael's Craft stores (store locations at http://www.michaels.com/craft/online/home) or Ben Franklin Craft Stores (store locations at http://www.benfranklinstores.com/newpage/bfcrafts.htm)

Diffraction grating - (can be ordered from Arbor Scientific - use lens of Rainbow glasses; or Edmund Scientific (1-800-728-6999 or http://www.edsci.com)

Shoe box with lid
Index cards (3x5)
Scissors
Tape
Rubber bands

Prism - Equilateral (can be ordered from Arbor Scientific)

UV Beads - these are beads that change color in the presence of Ultra Violet light and are available from Arbor Scientific at (1-800-367-6695 or http://www.arborsci.com/catalog.htm)

- bag of 200 beads for $5.95

Procedure:

- The students will be creating their own magic decoders. Each student will need to write a message in blue or purple crayon very lightly on a 3x5 index card. Then each student will need to color over the message using red, orange and yellow crayons to hide their message. Have the students exchange messages and give them a decoder (red cellophane) to find the message on their new paper. If the hidden messages are done carefully, the messages should be hard to decode without the filter. The FUV and EUV instruments use this same filtering mechanism when collecting information in space.

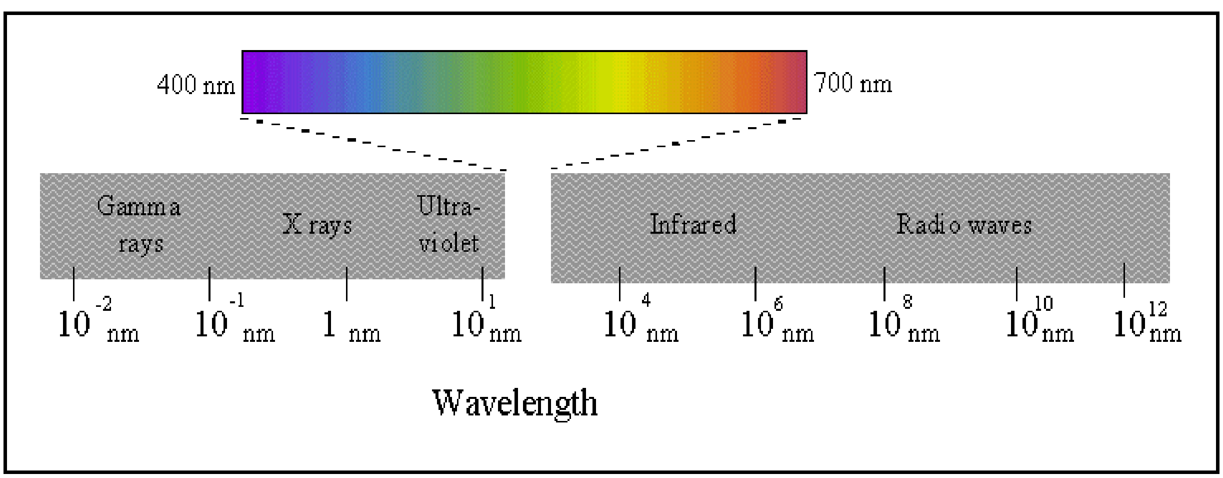
- <u>What does a spectroscope do?</u> A spectroscope demonstrates white light split into its component colors. The students will need to cut an opening at each end of the box the same size as the rainbow glass lens or the diffraction grating. Next, cut an index card in half, and tape the two halves over one cut opening creating a vertical slit (about 3/16" wide). Cover the other opening by taping the lens of the rainbow glasses or the diffraction grating on. (The students may find that they need to rotate the diffraction grating so that the spectrum extends in both directions from the slit.) Place the lid on the box and use rubber bands to hold the lid on. The students will need to point the box at a light source (never the sun!) and look through the diffraction grating to see the spectrum of colors, which should be displayed on the side of the box. Can the students see seven separate colors or do some blend together? Have the students draw and label the colors of the spectrum observed, in the center of a piece of white paper. Then students can hold their spectroscopes up to other light sources, draw the observed spectrum, and compare the results.

- <u>How does the visible light split into colors?</u> To demonstrate this, you will be modifying the spectrograph made in the previous activity. Carefully remove the rainbow glasses or diffraction grating, this opening will now become the viewing opening. Move one of the index cards at the other end to widen the slit for the sun's light to enter. This next part gets tricky and takes a lot of adjustments, but it makes it easier for group demonstrations and longevity of the equipment. Locate the approximate mid-point of the inside of the lid, and using long pieces of tape suspend the prism so that it hangs down low enough to be visible through the slit in the side. You made need to put the lid on the box and make adjustments to the location and rotation of the prism several times until the spectrum is visible on the inside of the lid, close to the viewing opening. Once you have the prism set, add extra tape to hold it securely. This instrument operates by pointing the side of the box with the slit (or the lens) toward the sun, looking through the viewing opening toward the lid and by making simple changes in the angle of the box toward the sun until you see the spectrum.

- Initiate a discussion with the students about what they observed. The students should now realize that visible light is divided into a spectrum of color by using a scientific instrument. Explain to the students that there are more non-visible lights that exist. Again with slight modifications to the spectrograph, the presence of non-visible light, namely ultraviolet can be demonstrated. The UV beads are very sensitive to UV light from sunlight, so you will need to do the next few parts inside. String 8-10 UV Beads onto a pipe cleaner or a rubber band having the students note the color. Then tape the strand of UV Beads to the inside of the lid where the spectrum is displayed. Take the box back outside, adjust the angle of the box so that the spectrum is on the beads. The beads will appear to be lit up by the spectrum, after a few minutes, carefully hold the box up over the students heads and lift the lid just enough for the students to see the UV Beads. They should see that some of the beads are now different colors. What made only these beads change color and not all of them? Explain to the students that the color components of light have different wavelengths. You can demonstrate wavelengths on the board by drawing two different sets of waves. One of the waves peaks will be further apart that the other. The colors of the spectrum and ultra violet light have different wavelengths, which affects our ability to see them. Take some of the UV Beads outside and allow the students to watch them change color. Why was the color change more dramatic without the prism and box? Why would a scientist want to use an ultra violet filter when making observations in space?

Conclusions:

The students will develop and modify an instrument that will help them understand how scientist use filters to remove extraneous light in order to focus on specific information.



XIII...How to Catch a Speeding Cloud in Space

Introduction:

What does the Radio Plasma Imager on the IMAGE satellite do? Scientists can not go into all areas of space to collect information, so a process called remote sensing is used. Remote sensing is defined as collecting information about an object without touching that object. Remote sensing is also used frequently here on Earth. When a traffic officer wants to determine the speed of a car, a radar gun is aimed at the vehicle. The radar sends radio waves to the car, which are reflected off the metal in the car, and sent back to the radar gun's receiver. The radar gun then figures out the distance the car has traveled and the speed of the car. The IMAGE satellite's Radio Plasma Imager (RPI) calculates the distance and velocity of electrically charged clouds (called plasmas) and their densities (how many particles) in much the same way. The activities below begin to explore how radar works through echoes, wave patterns, and finally how the data is collected and organized to form images.

Materials:

Slinky - (two of the same size)
Stopwatch
Meter stick or measuring tape
Clear dish or plastic bowl
Water
Clay
BB, ball bearing or rock
Hot plate or overhead projector
Students

Objectives:

- The students will explore how waves move away from, and then bounce back to the source, in the form of echoes.
- The students will explore how the elapsed time of the echo waves can be used to determine distance.
- The students will explore how scientists use this information to produce images that represent the distances of things in space.

Key Terms:

Magnetopause- The boundary of a region surrounding the Earth where the pressure from the solar wind is just as strong as the pressure of the Earth's magnetic field.

Plasmapause- The boundary of a region surrounding the Earth in the shape of a donut with the Earth in the center. This region contains fast moving atoms trapped in the Earth's magnetic field, that rotate with the Earth every 24 hours.

Note to Teacher:

Always make it very clear to students that sound waves and light waves are ***not*** *physically the same. Sound waves are created by pressure changes in a gas and travel at the speed of sound. Light waves and radio are caused by changes in electric and magnetic fields and travel at the speed of light. It is very common for students and adults to think of these as the same phenomena.*

Procedures:

- The students are going to participate in a game where the use of echoes will help them determine another child's location. Choose one student to be the "bat" and the rest of the students will be the "insects". Set up a perimeter boundary to limit the distance the bat and the insects will be from each other. Place a blindfold on the bat and have the insects select a spot within the boundaries to stand still. The bat will begin to "chirp" and the insects will "buzz". Each time the bat makes its chirping noise, the insects must respond by buzzing. Direct the bat to find his meal of an insect by moving in the direction of a buzz. The students should be discouraged from harming each other. Allow several students to be the bats, saving time for discussion at the end. How were the bats able to find the insects without seeing them? The students should be able to explain how they followed the sounds they heard to the location of the "insects".

- To further the students experiences with echolocation and remote sensing go to the "Echo the Bat" site at http://imagers.gsfc.nasa.gov//index.html . This site offers a story of a bat that uses echolocation to find his food. This site also has the students go on an interactive journey to find Echo, who can not find the cave with the rest of his family. During the journey to find the cave, the students use radar images of the ground and learn to identify geographic features from these satellite pictures.

- How do the sounds get from one place to another? Have two students kneel on the ground facing each other. It is best if it is a bare floor - no carpeting. (The distance will depend on the length of the slinky that you are using.) The slinky should be stretched out on the floor between the two students, but not so taunt that it doesn't have flexibility. Have one student gently start to move his arm back and forth parallel to the floor creating waves in the slinky. Help the students see that this "wave" motion represents how sound moves from one place to another. When the students were playing the bat and insect game, they were able to hear the insects because the sound traveled in waves to the bat. Since the sound waves traveled in a straight path, the bat could determine what direction the insects' sounds were coming from and move toward the food. As a further example of waves moving in straight lines, place some water in a clear glass or plastic dish. Place the dish on an overhead projector, allowing the water to become calm. Drop a BB or rock into the water, and have the students observe the path of the waves. How do the waves move? What is the path that they take?

- When scientists are using remote sensing to explore areas in space, they need to "fine tune" the use of echolocation to include speed, distance and elapsed time. The students will use the slinky to determine how the elapsed time in which a wave travels gives some information about the distance the wave has traveled. Once again, the two students will need to kneel apart, keeping the slinky taunt. One student will need to begin a single wave that can travel across the slinky, bounce off the other student and return to the originating student. This time the students will need to time how long it takes for the wave to travel from one student to the other and back to the originating student. What would the students' predictions be if the ends of the slinky were farther apart or closer together? The students should be made to see that the distance is covered in half the round trip time.

- So how does the Radio Plasma Imager really use this echolocation to study distant locations within the Earth's magnetosphere? The students will use the slinky in the same way again. This time, have a student grab the slinky (without picking it up) at midpoint and allow the wave to bounce back from that point to the originating student. The students should record the time it takes for the wave to bounce back to the originating student. Did this take more or less time than having the wave move across the length of the slinky? Have the students repeat this part of the activity creating a new "object" for the wave to bounce off of by grabbing the slinky at different places. The students should still be recording the elapsed time. Initiate a discussion with the children about what they have seen; what would happen if there were no "object" where the wave was sent, would there be an echo? The students should gain an understanding that the closer the object is, the quicker the echo wave can return. Conversely if an object were further away, the echo wave would need more time to reach you. The satellite knows how fast the radar signal travels in space, so if we time how long takes for the signal to return, we can figure out how far it traveled and use this information to get a image of the object. The RPI instrument is constantly sending out waves and receiving echoes. From the return of the echoes, it can determine where specific clouds of particles are located in the magnetosphere and how many particles are in a certain area.

- When the RPI is sending out its waves, the waves are sent in all directions. Sometimes, there may be multiple boundaries of particles that will send echoes back from two different directions. Both of the waves will bounce back in straight lines, to the original transmitter. This can be demonstrated by using a clear glass or plastic dish, overhead, BB's, clay and water. Set up the dish with water in it, but place two clumps of clay that will remain stationary. Drop the ball bearing into the water so that it is not equidistant from both clumps of clay, and have the students carefully watch the first wave to move out. The waves circling out from the BB's will bounce off the clay and move back to the source, but they will not reach it at the same time.

- Students should report their findings in their Science Learning Logs. The students may find it helpful to draw pictures of what they observed.

Extensions: (Grades 3-6)

- When the RPI instrument sends out waves, it looks at location plots as well as the number of particles within an area (density). Have four students each grab an end of a slinky. Then have the students stretch the slinkys out to two different lengths, each group making waves at the same time and compare the apparent speeds of the wave. The more stretched out slinky can represent a less dense area of plasma, while the less stretched out area can represent a more dense area of plasma. Radio waves travel at slower speeds through dense plasmas than through less dense ones.

- In order to demonstrate to the students how the RPI makes use of multiple echoes, the students will pretend they are the boundaries of a plasma cloud, the RPI instrument and its waves. Have the students form two ovals one inside the other, facing each other. Assign one student to become the RPI instrument, and to stand between the two ovals, but not centered between the two groups. Two more students will need to be the waves that will be sent out from the RPI. The waves should stand on either side of the RPI, and when the instrument is ready, the waves should move away from the RPI and toward the other students. Since waves move in straight lines, the student waves should only bounce back if there is a student there to bounce off of. Allow the rest of the class to witness that when the RPI's wave hits an object that is close-by, the echo will return sooner than the echo that bounced off the student who was further away.

- By plotting the echoes you can build up a map of what is around you. A student can play the role of the RPI instrument by standing in the middle of a coordinate graph. You will need to make a coordinate graph using cardinal directions on the floor with masking tape (or purchase a shower curtain liner, make your coordinate graph on it with tape - fold up and save when done!) The student standing at the center of the graph will receive the echoes as listed in the attached chart. Then the student plots the echo points on the coordinate graph using objects that are placed on the coordinate graph. When all the echoes have been recorded, a string or yarn can be wrapped around objects to show the boundaries of the area being studied.

<u>What does the RPI's data tell us?</u>

- When the RPI is sending out sound waves, there would only be a returning echo if there were something in that part of space to bounce the wave back. In this next activity, the students will be using two different models of the Earth, its magnetopause and its plasmapause to demonstrate how the RPI's data would reflect the effects of a solar storm. We are going to suppose that the orbit of the IMAGE satellite will be slightly altered for the purposes of this demonstration. Display the normal model of the earth on the overhead. Have students pretend to become the boundaries for the magnetopause and the plasmapause as shown on the model (remind the students to stay where they were placed). Three students will pretend to be the IMAGE satellite at its three locations on the orbit. Select six students to be the sound waves that will be sent from the satellite at each location on its orbit. Begin with location A, have the sound waves move away from the satellite and move toward the boundaries, and carefully bounce back to the satellite. The students should notice that one wave returned to the satellite in a shorter amount of time. Have the wave that returned first hold up a colored sheet of paper. All three of the students need to stay in their locations while the other waves are sent from the other satellite locations. Repeat the activity for the other two satellite locations. The students must remain in their locations for the second half of the activity.

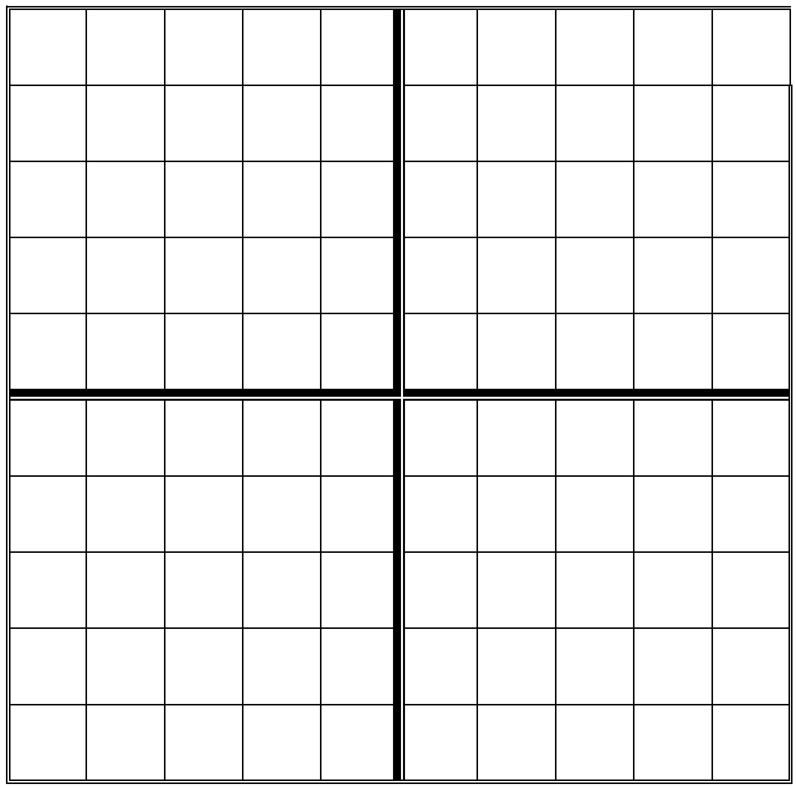
- Align a second group of students to show the boundaries of the magnetopause and the plasmapause. This time, the teacher will become the solar wind and "reshape" the boundaries as shown in the "storm" model. Have the students repeat the wave and echo directions for the three satellite locations in the new model, noting which wave arrived back at the satellite first. Keep the students in their spots while you discuss what they have seen. Show the amplitude/time charts and have the students discuss how the information in these charts was modeled by the students.

Grades 4-6

- Go back and look at the amplitude/time plot charts with the students, are they able to notice a pattern? Why does the order of the waves fom the magnetopause or plasmapause change or overlap? How can the elapsed time of the echo wave be used to determine the distance of the boundary? If given other amplitude/time plot charts could the students predict the boundaries of the magnetopause and the plasmapause?

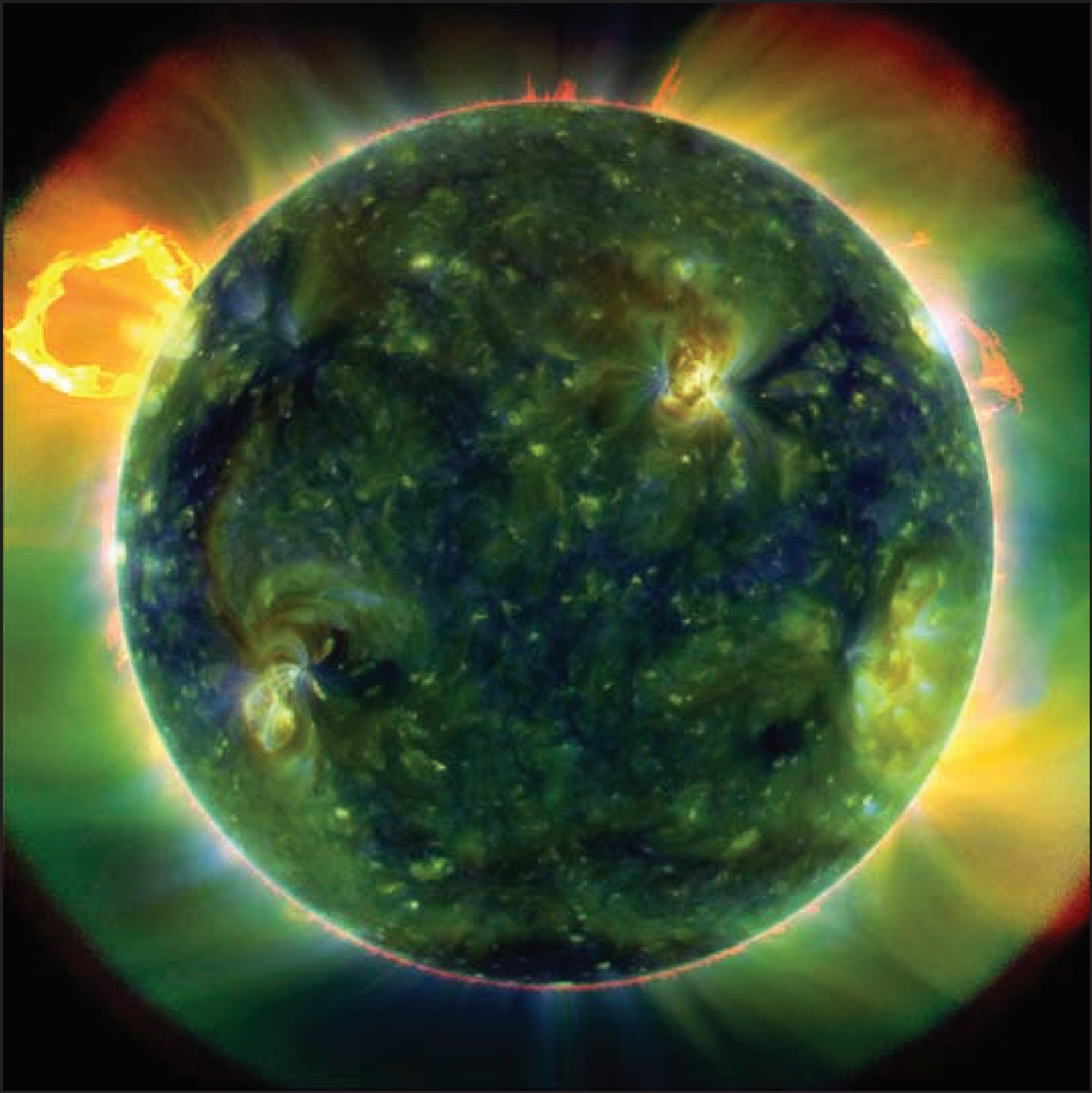
Conclusions:

The students will use hands-on experiences to determine how radio waves and echoes can be used to calculate distances. Students will then see how a scientist uses this information to produce an image that represents what is seen through remote sensing.



Sample data for plot of echo points.

Direction	Distance
S	4
SW	2
W	3
NW	3
N	4
NE	3
N	3
NW	2
W	2
SW	1
S	3



Solar Dynamics Observatory - First Light image of the active sun

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