Maynard F. Jordan Planetarium

RING WORLD

Edited by Leisa Preble

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Mission Statement:
The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

Cosmic Classroom

Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – *Ring World*

Its name is Cassini-Huygens. On October 15, 1997, it sailed out from the port of Earth on a seven year, two billion mile odyssey to the outer solar system. The size of a school bus with a total weight of over 12,000 pounds, and an array of 18 packages of scientific instruments, Cassini-Huygens represents the combined effort of scientists and engineers in 18 countries, and is one of the largest, heaviest, and most sophisticated interplanetary spacecraft ever launched. It's destination?... One of the most intriguing objects in the solar system -- a world of unparalleled beauty and the undisputed "Lord of the Rings" -- Saturn! Join us for this as we explore the history and scope of Saturn, its rings and its many moons on the Cassini-Huygens mission to Saturn and Titan.

We are very glad that you have chosen to visit our planetarium with your group. We hope that this guide either will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Ring World*, help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place which holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site at http://umainesky.com.

If used in its entirety and accompanied by the Planetarium visit this guide will help students to:

Become **a clear and effective communicator** through

A. oral expression such as class discussions, and written presentations
B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and life long learner** by

A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
B. encouraging students to go further into the study of the subject at hand, and explore the question of "what if?"
C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

A. asking students to observe phenomena and problems, and present solutions
B. urging students to ask extending questions and find answers to those questions
C. developing and applying problem solving techniques
D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

A. an understanding the teamwork necessary to complete tasks
B. applying that understanding and working effectively in their assigned groups
C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

A. applying concepts learned in one subject area to solve problems and answer questions in another
B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *Ring World,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-4

Science and Technology

I. Motion

#1. Describe the effects of different types of forces (e.g. mechanical, electrial, magnetic) on motion.

K. Scientific Reasoning

#4. Use various types of evidence (e.g., logical, quantitative) to support a claim.
#5. Demonstrate an understanding that ideas are more believable when supported by good reasons.

L. Communication

#1 Record results of experiment or activities and summarize and communicate what they have learned.
#2. Ask clarifying and extending questions.
#4. Make and/or use sketches, tables, graphs, physical representations, and manipulatives to explain procedures and ideas.
#7. Function effectively in groups within various assigned roles (e.g., reader, recorder).

Mathematics

C. Data Analysis and Statistics

#1. Make generalizations and draw conclusions using various types of graphs, charts, and tables.

J. Mathematical Reasoning

#1. Use simple tables and graphs to communicate ideas and information in presentations in a concise and clear manner.

Grades 5-8

Science and Technology

I. Motion

#1. Describe the motion of objects using knowledge of Newton's Laws.
#3. Describe and quantify the ways machines can provide mechanical advantages in producing motion.

J. Inquiry and Problem Solving

#1. Make accurate observations using appropriate tools and units of measure.
#2. Design and conduct scientific investigations which include controlled experiments and systematic observations. Collect and analyze data, and draw conclusions fairly.

K. Scientific Reasoning

#6. Support reasoning by using a variety of evidence.

L. Communication

#1. Discuss scientific and technological ideas and make conjectures and convincing arguments.
#4. Make and use scale drawing, maps, and three-dimensional models to represent real objects, find locations, and describe relationships.

Social Studies - Geography

A. Skills and Tools

#1. Visualize the globe and construct maps of the world and its sub-regions to identify major physical features.

Unveiling Titan's Surface

http://saturn.jpl.nasa.gov/education/pdfs/Topography.pdf

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to make accurate observations using appropriate tools and units of measure. (5-8. Science and Technology. J. #1.)
2. Learners will be able to design and conduct scientific investigations which include controlled experiments and systematic observations. (5-8. Science and Technology. J. #2)
3. Learners will be able to support reasoning by using a variety of evidence. (5-8. Science and Technology. K. #6.)
4. Learners will be able to develop maps, charts, models and databases to analyze geographical patterns on a planet. (5-8. Social Studies-Geography. A. #2)

The General Idea:

To make measurements of topographic features and to draw maps based on these data. This will be done in a way that is analogous to making radar measurements of topography through vegetation (on Earth) or through clouds (on Venus, Titan, and Earth).

Discussion:

Titan's visibly opaque atmosphere shrouds the satellite's surface from our eyes. When the two Voyager spacecraft imaged Titan during their 1980 and 1981 flybys, scientists saw only the haze and cloud tops of the moon's thick, nitrogen-rich atmosphere.

Unlike a photographic camera that needs an outside light source, radar provides its own illumination. Cassini's radar will project pulses of radar energy toward Titan to strike the surface and echo back to the instrument. The amount of energy received by the instrument dictates how bright the resulting image is and is a function of the type of surface being measured. The round trip travel time of each energy pulse determines the location of the echoing surface. This technique, called synthetic aperture radar (SAR), is used to capture images of surfaces that are cloud shrouded (e.g., Titan, Venus, and Earth) or dark (e.g., the night side of Earth). SAR can even detect structures shrouded by rain forest vegetation. By supplying its own illumination and operating at radio frequencies that can penetrate the atmosphere and clouds, a radar instrument can image Titan's surface.

Materials

- A sturdy cardboard shoe box, shipping carton with its top, or boot box
- Green styrofoam (commonly used in floral arrangements) cut to fit in the bottom of the box
- A tool for shaping the styrofoam (a large spoon will suffice)
- A sharpened pencil or similar object to punch holes in the box top
- A plastic coffee stirrer (about 5 inches long) or other long thin object like a bicycle spoke, a wooden kebab
- skewer, or a chopstick — to use as a depth gauge
- Adhesive tape and a ruler or tape measure
- A blank 3- by 5-inch index card
- Graph paper: several pieces with the same grid size

Procedure

1. Shape the styrofoam with mountains, valleys, craters, and other landforms, and then place it inside the box.
2. Tape graph paper over the box lid.
3. Using the pencil, punch holes in the box lid at the grid intersections of the graph paper.
4. Prepare the height code card by inserting the depth gauge into the box lid until it touches the bottom. This fixes an artificial "sea level" on a "planet" that has no ocean.
5. Place the index card next to the depth gauge and mark where the top of the gauge is on the card. Mark this as zero.
6. Beginning with the zero mark, measure off and mark 0.5-centimeter increments on the index card.
7. By following a systematic pattern across the box lid, measure the height of the depth gauge as it is inserted at different intersections across the box lid.
8. Record the data at the corresponding intersections on another piece of graph paper.
9. Using the graph paper with the recorded height values, draw lines connecting the points with the same height reading. How does the contour map compare with the measured surface? How could the map be improved to better match the actual surface?
10. What is the effect if the depth gauge is not vertical? The map will be the same if the angle and orientation of the gauge are the same for each measurement point. If the angle and orientation vary, the map will be distorted. Advanced students can perform an analysis using trigonometric functions.

Planetary Magnetic Fields

http://saturn.jpl.nasa.gov/education/pdfs/Planetary_Magnetics.pdf

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to describe the effects of different types of forces (e.g., mechanical, electrical, magnetic) on motion. (3-4. Science and Technology. I. #1)
2. Learners will be able to describe the motion of objects using knowledge of Newton's Laws. (5-8. Science and Technology. I. #1)
3. Learners will be able to demonstrate an understanding that good scientific explanations are based on evidence (observations) and scientific knowledge. (3-4. Science and Technology. K. #5)
4. Learners will be able to make accurate observations using appropriate tools and units of measure. (5-8. Science and Technology. J. #1)
5. Learners will be able to ask clarifying and extending questions. (3-4. Science and Technology. L. #2)

Objective

To demonstrate magnetism and its measurement and apply these concepts to understanding the structure of surrogate planets; to take three measurements with a magnetic compass and deduce the orientation of the magnetic fields in manufactured "planets."

Discussion

The interiors of planets may forever remain out of the realm of direct observation and measurement. Yet, by means of laboratory experimentation, theoretical studies, and external observations, scientists can infer many details about the conditions found deep inside a planet. One external observation directly related to conditions in the core of a planet is that of the shape and orientation of the planetary magnetic field.

Spacecraft carry instruments called magnetometers to measure the field strength and direction of planetary magnetic fields. These instruments are so sensitive that they must be mounted on long booms extending from the main body of the spacecraft. Otherwise they would pick up magnetic fields generated by flowing electrical currents and permanent magnets aboard the spacecraft.

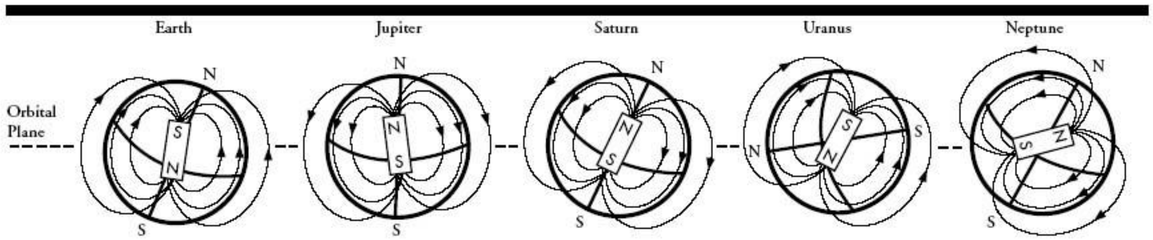
Earth, Jupiter, Saturn, Uranus, and Neptune all have magnetic fields that can be described as offset tilted dipoles. A dipole describes a system having two polarities such as the north and south of a bar magnet. "Tilted" refers to the alignment of the dipole with respect to the rotation axis of the planet, that is, how well the positions of the magnetic poles match the positions of the geographic poles. Offset describes the position of the dipole relative to the center of the planet. The center of the dipole may be shifted away from the planet's center both outward from the center and toward one of the geographic poles.

Planetologists believe that planetary magnetic fields are generated by a dynamo effect within the core of a planet. The dynamo effect occurs when moving electrical charges generate magnetic fields. Such processes are believed to occur deep inside some planets, based on the observation of their external magnetic fields. A spacecraft like Cassini can measure these magnetic fields, including their strength and direction, at a large number of places around Saturn, from the equator to near the poles and from nearby and far away. This allows detailed characterization of Saturn's magnetic field and permits the construction, within a computer, of good models of the generating source.

In this activity, students can observe the effects of a simulated planetary magnetic field and infer details about its source. The complexity of the planetary field can be specified by the instructor.

Materials

- Bar magnet(s) (available at toy, hardware, office supply or fabric store) or cow magnet(s) (available at veterinary or farm supply store); must be strong
- Rubber balls (approximately the size of a tennis ball)
- Pencil(s) or dowel(s)
- Magnetic compass(es), liquid-damped recommended



In this diagram of Earth, Jupiter, Saturn, Uranus, and Neptune (not to scale), the magnetic axes are shown by the bar magnets; the planet's orbital plane is the dotted line through the center of the diagram. This drawing also shows that a planet's rotational axis is not necessarily perpendicular to its orbital plane. Magnetic field lines extend into space and form a "cage" around the planet, trapping charged particles and sweeping them around in space as the planet rotates.

The teacher will construct some different "planets" for the experiment.

1. Place the compass on the edge of a horizontal nonmagnetic surface.
2. Hold the "planet" near the compass. The compass should be at the "planet's" equator.
3. Rotate the "planet" slowly. Observe the effect on the compass of the "planet" slowly rotating about its axis.
4. Move the "planet" above the compass and repeat.
5. Repeat the experiment by placing the "planet" below the compass.
6. Repeat with different "planets."
7. Observe how the compass behaves in each position.

Procedure

1. Test "planets" made from bar magnets and balls can be made as either demonstrators or mysteries for students to solve. The length of the magnet, compared to the diameter of the ball, may be the determining factor. The simplest construction method is to bore a hole in each ball and place a magnet inside, held either by friction or with rubber cement. The holes or protruding magnet ends will give away the orientation of the magnet.
2. Balls whose diameters exceed the lengths of the magnets can be cut in half. A section of one (for radial offset) or both hemispheres (for no or axial offset only) can be hollowed out. The magnet is placed in the hollow and the hemispheres are glued together again.
3. Make several "planets" and decide in advance on a prime meridian for each (draw a 0-degree longitude half-circle connecting the north and south geographic poles).
4. Construct "planets" with no offset or tilt, and others with different amounts of offset, tilt, and both.
5. More elaborate "planets" with more than one magnet can also be constructed (and have some similarity to the more complex magnetic fields of real planets).
6. Use a pencil or dowel jammed into one pole of each "planet" to mark the rotation axis and as a handhold for experiments. Each "planet" can have more than one pole and prime meridian; color code and number them. Thus, each "planet" becomes several "planets" for experimentation.

For demonstrations to the whole class, a large, transparent compass (available from sporting goods stores) can be placed on an overhead projector. The class can observe the projected motions of the compass needle as various "planets" are slowly rotated nearby. Alternatively, each student or group of students can make their own measurements. The compass should be placed on the edge of a nonmagnetic surface (ideally, each student's desk). Students should observe the effect of slowly rotating the "planet" about its axis from at least two positions of the compass. One position should be in the plane of the equator. The other should be near one pole. One can predict the idealized effect of the "planet" on the compass as follows:

No offset, no tilt — From both positions, the compass points towards the "planet," with no effects visible due to rotation.

Radial offset, no tilt — From both positions, the compass points towards the "planet," but rotation will cause the compass needle to be displaced a small amount in either direction from some zero-point.

Axial offset, no tilt — Three measurements, at the equator and near both poles, may distinguish a geographic offset. Otherwise, the compass will point towards the "planet," with no effects visible due to rotation. Additional measurements made at a different distance may help to indicate this offset.

No offset with small tilt — With an equatorial measurement, the compass will point towards the "planet," with no effects visible due to rotation. Polar measurements will show oscillating displacements with rotation. A different end of the needle will point towards either pole.

No offset with tilt near 90 degrees — The equatorial measurement shows the needle reversing direction; i.e., rotating in step with the rotation of the "planet." Polar measurements show little difference from the equator measurement.

Offset and tilt — Measurements at the equator and both poles and at two distances should allow the observer to distinguish the degrees of offset and tilt of the internal dipole. Similar measurements of "planets" with multiple dipoles can sort out their more complex magnetic fields.

Extension

Let students build their own "planets" by embedding a magnet and pencil in clay. They can then exchange "planets" and determine the orientation of the hidden magnet. Locate Earth's geomagnetic poles on a globe or world map. There is clearly a tilt; is there an offset?

Several vendors offer directional magnetic field sensors and software that allow data to be acquired, recorded, and plotted under computer control. Many spacecraft acquire all their data via computer control, and computerized data acquisition is common in many laboratories on Earth.

Questions

1. How did the different "planets" affect the compass differently?
2. How was the compass affected differently when the "planet" was placed above, below, and at the compass' level?
3. If you assume a simple bar magnet is hidden in each "planet," figure out how the magnet is oriented in each "planet."

Magic Wand

http://www.nasa.gov/pdf/58277main_Space.Based.Astronomy.pdf

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to describe and quantify the ways machines can provide mechanical advantages in producing motion. (5-8. Science & Technology. I. #3.)
2. Learners will be able to discuss scientific and technological ideas and make conjectures and convincing arguments. (5-8. Science and Technology. L. #1)
3. Learners will be able to support reasoning by using models, known facts, properties, or known relationships. (5-8. Mathematics. J. #1)

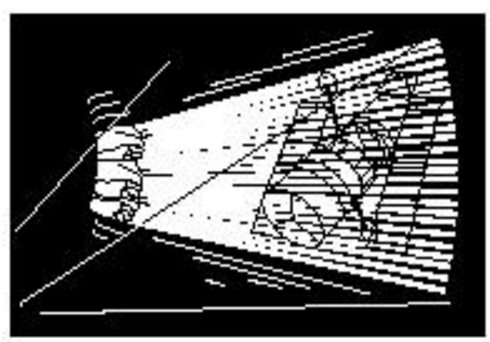
Description:
A recognizable image from a slide projector appears while a white rod moves rapidly across the projector's beam.

Objective:
To demonstrate how an image falling on a CCD array is divided into individual pieces.

Materials:

- Slide projector
- Color slide of clearly defined object such as Saturn, a building, etc.
- 1/2-inch dowel (or white PVC pipe), 3 feet long
- Sheet of white paper
- White paint (flat finish)
- Dark room

Procedure:



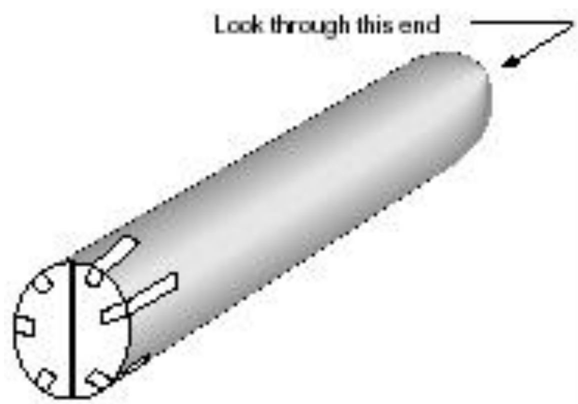
1. Paint the dowel white and permit it to dry. (A piece of 3/4-inch PVC water pipe from a hardware store can substitute for the dowel and white paint, and so can a painted meter stick.)
2. Set up the slide projector in the back of the classroom and focus the image of the slide at a distance of about 4 meters away from the projector.
3. Hold the sheet of paper in the beam at the proper distance for easy focusing. Be sure the focus point you select is in the middle of the room and not near a wall.
4. Arrange the students between the focus point and the projector. Darken the room.
5. Hold the dowel in one hand and slowly move it up and down through the projector beam at the focal point. Ask the students to try to identify the image that appears on the dowel.
6. Gradually, increase the speed of the dowel's movement.

Management and Tips:

By setting up the projector so that its projected image is focused in the middle of the room, the light from the image that falls on the far wall will be out of focus. This will make it more difficult for students to recognize the image until the dowel is passed through the light beam. Be sure to point out that the rod sends (“radios”) a fragment of the entire image. When the rod is moved, another image fragment is received. Challenge your students to memorize each fragment as they receive it. The fragments will be quickly forgotten as new fragments are added. It is only when the rod is moved very fast that they will be able to recognize the image. However, if the fragments were received by a computer in a digital form, each fragment would be recorded and an image would be built up at any speed.

Assessment:
Ask students to explain the imaging process as it is demonstrated here and use examples of images in other applications where the images consist of small parts that combine to make a whole.

Extensions:



1. How do television studios create and transmit pictures to home receivers?
2. How does a CCD work?
3. Project some slides. Magnify them as much as possible on a projection screen to see how the complete image consists of many discrete parts.
4. Construct a Persistence of Vision tube.
    a. Close off the end of a cardboard tube except for a narrow slit.
    b. While looking through the open end of the tube, wave the tube back and forth. A recognizable image will form at the other end of the tube.
    c. Use the tube to examine fluorescent lights.
5. Why do slightly darker bands appear across the lights?
   Hint: Fluorescent lights do not remain on continuously. The light turns on and off with the cycling of AC current.
6. Will using the tube to view an incandescent light have the same effect? Use the tube to examine the picture on a television screen. Why is the TV picture reduced to lines?
   Hint: Television pictures consist of scan lines.
7. A simpler version of the persistence of vision tube can be made with a 10 by 10-centimeter square of black construction paper.
    a. Fold the paper in half.
    b. Using scissors, cut a narrow slit from the middle of the fold.
    c. Open the square up and quickly pass the slit across one eye while looking at some distant objects.

Paint by the Numbers

http://www.nasa.gov/pdf/58277main_Space.Based.Astronomy.pdf, pp. 84-87

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to make generalizations and draw conclusions using various types of graphs. (3-4. Mathematics. C. #1)
2. Learners will be able to support reasoning by using models, known facts, properties, or known relationships. (3-4. Mathematics. J. #1)
3. Learners will be able to make accurate observations using appropriate tools and units of measure. (5-8. Science & Technology. J. #1)
4. Learners will be able to record results of experiments or activities and summarize and communicate what they have learned. (3-4. Science & Technology. L. #1)
5. Learners will be able to make and use scale drawings to represent real objects. (5-8. Science & Technology. L. #4)
6. Learners will be able to function effectively in groups within various assigned roles. (3-4. Science & Technology. L. #7)

Description:

A pencil and paper activity demonstrates how astronomical spacecraft and computers create images of objects in space.

Objective:

To simulate how light collected from a space object converts into binary data and reconverts into an image of the object.

Discussion:

This activity simulates the process by which an astronomy spacecraft such as the Hubble Space Telescope collects light from an astronomical object and converts the light into a digital form that can be displayed on Earth as an image of the object. The student with the transparent grid represents the spacecraft. The picture is the object the spacecraft is trying to collect from. The student with the paper grid represents the radio receiver on the ground and the image-processing computer that will assemble the image of the object. The image created with this activity is a crude representation of the original picture. The reason for this is that the initial grid contains only 64 squares (8 x 8). If there were many more squares, each square would be smaller and the image would show finer detail. You may wish to repeat this activity with a grid consisting of 256 squares (16 x 16). However, increasing the number of squares will require more class time. If you wish to do so, you can select a single student to represent the spacecraft and transmit the data to the rest of the class.

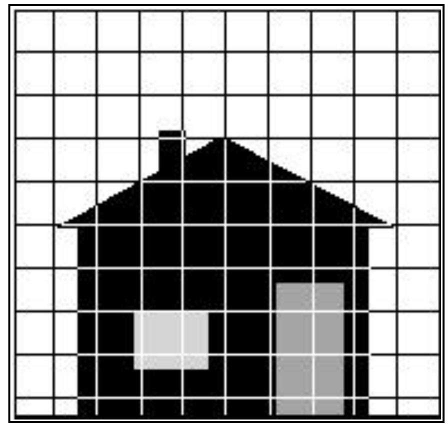
With the HST, the grid consists of more than 2.5 million pixels and they are shaded in 256 steps from black to white instead of just the 4 shades used here. Color images of an object are created by the HST with color filters. The spacecraft observes the object through a red filter, a blue filter, and then a green one. Each filter creates a separate image, containing different information. These images are then colored and combined in a process similar to color separations used for printing colored magazine pictures.

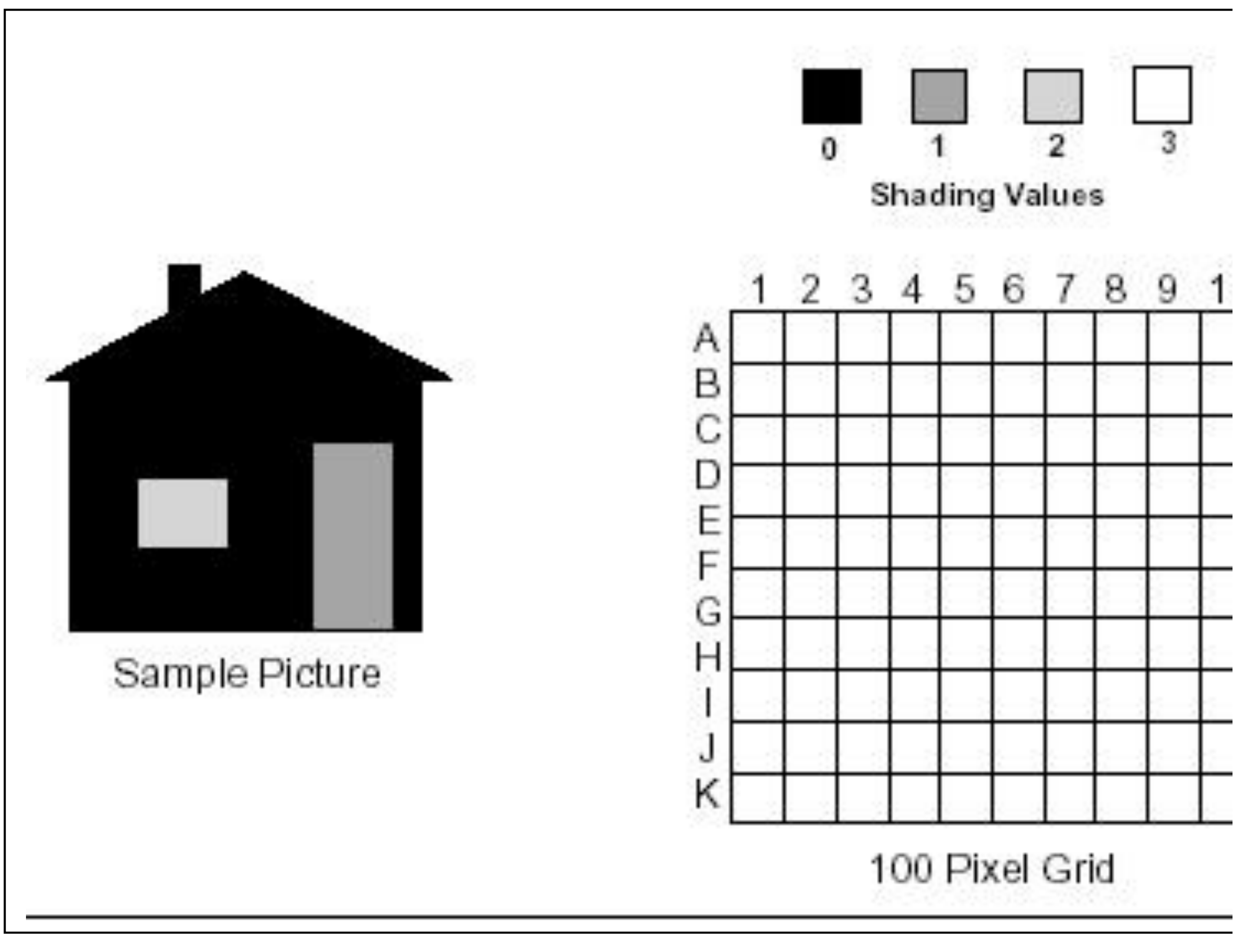
Materials: **(per group of two students)**

- Transparent grid
- Paper grid
- Picture of house
- Pencil

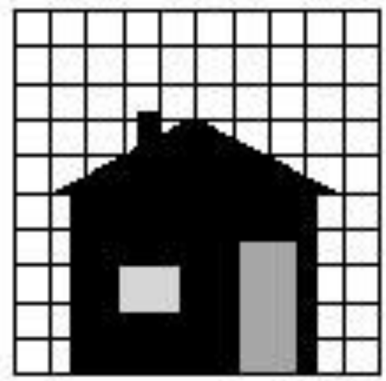
Procedure:

1. Divide students into pairs.
2. Give one student (A) in each pair the paper copy of the blank grid below. Give the other student (B) in each pair the picture of the house found below. Instruct student B not to reveal the picture to student A. Also give student B a copy of the transparent grid. (See notes about making student copies of the picture and grids on the next page.)
3. Explain that the picture is an object being observed at a great distance. It will be scanned by an optical device like those found on some astronomical satellites and an image will be created on the paper.
4. Have student B place the grid over the picture. Student B should look at the brightness of each square defined by the grid lines and assign it a number according to the chart above the picture. Student B will then call out the number to student A. If a particular square covers an area of the picture that is both light and dark, student B should estimate its average brightness and assign an intermediate value to the square such as a 1 or a 2.
   Note: The letters and numbers on two sides of the grid can assist the receiving student in finding the location of each square to be shaded.
5. After receiving a number from student B, student A will shade the corresponding square on the grid. If the number is 0, the square should be shaded black. If it is 3, the square should be left as it is.
6. Compare the original picture with the image sketched on the paper.





Management and Tips:
Students can provide their own pictures for this activity. It is important for the pictures to show strong contrast. The smaller the grid squares, the more detail that will appear in the image. However, simply going from a grid of 10 x 10 to a grid of 20 x 20 will quadruple the length of time it takes to complete the image.

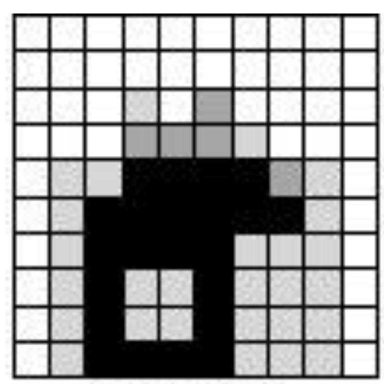


100 Pixel Grid Over House

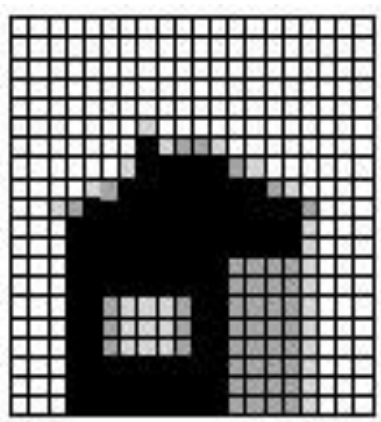
Assessment:
Collect the pictures of the house drawn by the student receivers. Compare the original drawing with the student images. Discuss with your students possible strategies for improving the detail of the images.

Extensions:

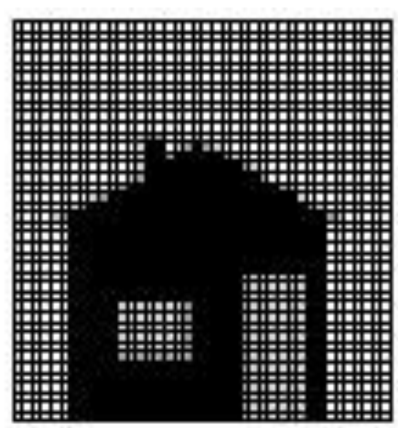
- Transmit and reconstruct the image of Saturn shown on the next page. This more advanced picture uses six shades and smaller grid squares.
- Examine printed copies of drawings made with a computer art program. Notice how the pictures are constructed of individual points. Also notice how the size of the points contributes to the fineness of detail in the picture.
- Examine pictures drawn on a computer. Use the magnifying tool to move to the maximum magnification possible. Compare the two views.
- Obtain Hubble Space Telescope images from the Internet sites given in Unit 5. Examine them closely for the pixel structure. Alternately enlarge and reduce the image size on your computer screen to see the effect on the fineness of detail.



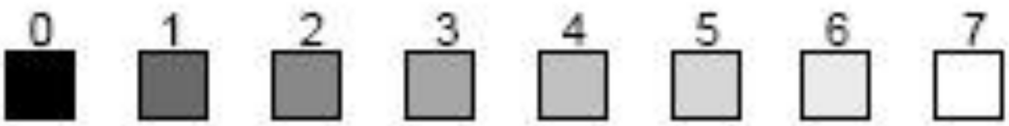
100 Pixel Grid



400 Pixel Grid



1,600 Pixel Grid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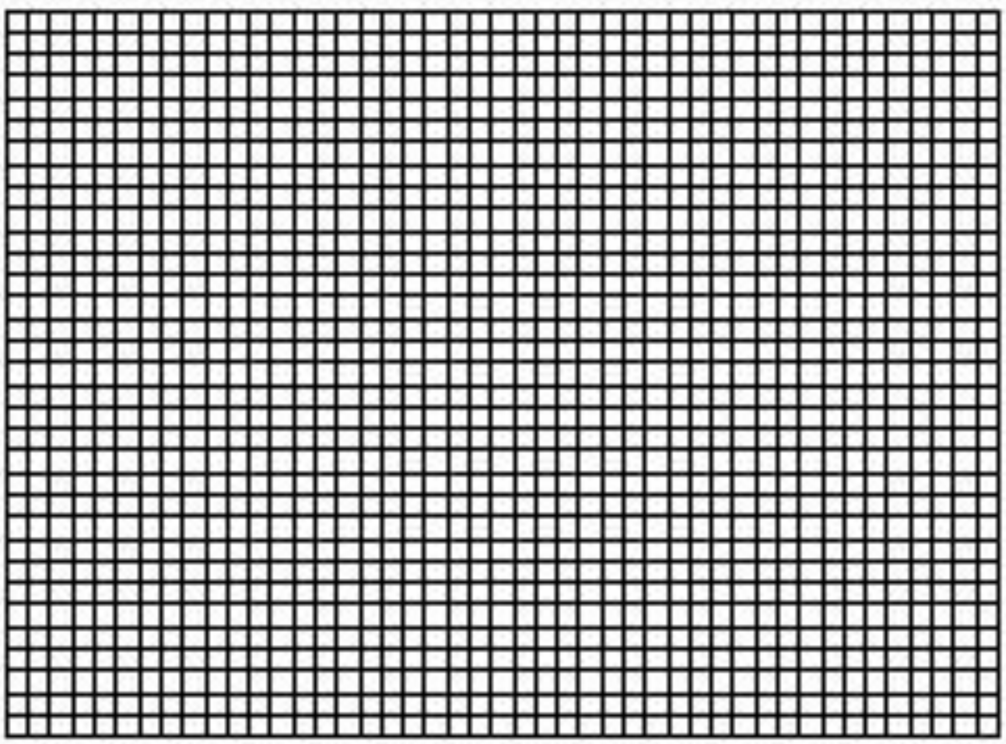


Which Way Should I Point?

http://saturn.jpl.nasa.gov/education/pdfs/Which_Way_to_Point.pdf

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to make accurate observations using appropriate tools and units of measure. (5-8. Science & Technology. J. #1)
2. Learners will be able to design and conduct scientific investigations which include controlled experiments and systematic observations. (5-8. Science & Technology. J. #2)
3. Learners will be able to use various types of evidence to support a claim. (3-4. Science & Technology. K. #4)
4. Learners will be able to verify and evaluate scientific investigations and use the results in a purposeful way. (5-8. Science & Technology. J. #3)

Objective:

To illustrate the need for cooperation among competing interests to make scientific measurements of planetary phenomena using "body-fixed" instruments.

Discussion:

The Voyager and Galileo spacecraft had some instruments mounted on a scan platform. This scan platform is a platform that can move independently from the rest of the spacecraft, something like a robotic arm. Cassini, in contrast, does not have a scan platform. All of Cassini's science instruments are attached directly to the main body of the spacecraft. As a result, in order to orient an instrument to point at Saturn (or any other target), the entire spacecraft must move. This means that while the camera is taking a picture of Saturn, all of the other instruments must look in their pre-defined directions, which may not be parallel to the camera's direction. This makes coordinating observations and data collection using the 12 instruments very difficult.

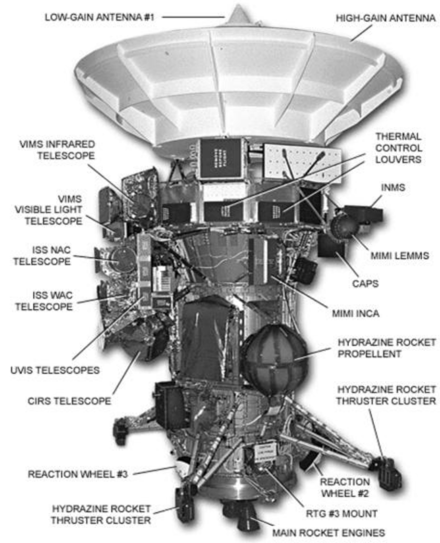
Materials:

- A desk chair that swivels
- A board that is wide and thick enough to support three people
- A brimmed hat, preferably a cowboy or outback hat
- One small toy telescope
- One pair of binoculars
- A broom handle (available at hardware stores or large wholesale kitchen supply stores)
- Three student volunteers
- An image or drawing of Saturn: this can be a photograph, a store-bought cut-out, or a download from the Internet (http://saturn.jpl.nasa.gov/multimedia/images/index.cfm)

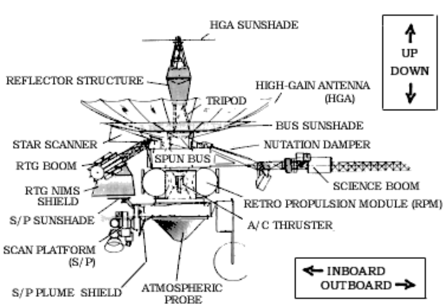
Procedure:

1. Mount the image of Saturn somewhere in the classroom.
2. Place the board on the swivel chair.
3. Have the first student volunteer sit on the center of the board and have the student hold the hat upside-down on top of his/her head. The hat represents Cassini's high-gain antenna (the main communication antenna for the spacecraft).
4. Give the student the small toy telescope and instruct him/her that the telescope can only move up and down. The telescope represents the Magnetospheric Imaging Instrument (MIMI).

5. With someone holding one end of the board so that it does not tip over, place the second student volunteer on the other end of the board with his/her back to the person in the center.
6. Give the second student the binoculars. These binoculars represent the Imaging Science Subsystem (the cameras, ISS). One lens of the binoculars is the wide-angle camera and the other lens is the narrow-angle camera. Instruct the student that he/ she can only look straight ahead.
7. Place the third student volunteer on the other end of the board with his/her back toward the person in the center. Give the third student the broom handle and instruct him/her to hold it out in front. The broom handle represents the Magnetometer (MAG).
8. Now that all three of the students are in position, it's time to acquire some data about Saturn, which is mounted somewhere in the classroom (first procedure step). Let's try to collect some data. The magnetometer (MAG) is collecting data on Saturn's magnetic field. Therefore, as long as the instrument is turned on, it does not need to point in any particular direction (for the purpose of this demonstration). The Magnetospheric Imaging Instrument (MIMI) and Imaging Science Subsystem (ISS) are a whole different story. Since both ISS and MIMI need to actually look (point) at Saturn to collect data, it's obvious that they cannot collect data at the same time. In real mission planning, there is a sequence of events that is predefined wherein one of these instruments collects data, and then the other has a chance. The discussion comes when both science teams want to collect data at the same time. The mission planning team then needs to negotiate a bargain between the two teams. Remember that this demonstration only uses three of Cassini's 12 instruments!



<u>Extension</u>



Demonstrate the difference between a body-mounted-instrument spacecraft like Cassini and a spacecraft with a scan platform like Galileo. This illustrates the difficulties presented to the Cassini science and engineering teams when they plan data collection using multiple instruments.

Now let's examine how Galileo works. The Galileo spacecraft is somewhat similar in design to Cassini. Galileo has a main antenna at the top of the spacecraft, a central core of electronics, and a main engine at the bottom of the spacecraft. Science instruments are mounted on the outside of the central core. A major difference between Galileo and Cassini is the movable scan platform that allows Galileo's remote sensing instruments (cameras and others) to be positioned to take data almost independent of the spacecraft's orientation.

On the Galileo spacecraft, your student camera (the student with the binoculars) is now free to move his binoculars in order to capture a target. Repeat the procedure used for Cassini, but as you slowly rotate the chair, allow the "camera" to stay pointed at Saturn until the chair is rotated so much that the "camera" is on the other side of the spacecraft from Saturn. For more information about how Galileo's science instruments work, go to http://www2.jpl.nasa.gov/galileo/. For more activities based on the Galileo Project, go to http://www2.jpl.nasa.gov/galileo/education/activities.html.

Vocabulary List

Aperture	The opening in a photographic lens that admits the light.
Axis	A straight line about which a body or geometrical object rotates or may be conceived to rotate.
Compass	A device used to determine geographical direction, usually consisting of a magnetic needle or needles horizontally mounted or suspended and free to pivot until aligned with the magnetic field of the earth.
Contour Map	A map showing elevations and surface configuration by means of contour lines.
Dipole	A pair of electric charges or magnetic poles, of equal magnitude but of opposite sign or polarity, separated by a small distance.
Field of View	The usually circular area in which the image is rendered by the lens system of an optical instrument.
Geomagnetic Field	The magnetic field of the earth, having a determinable value at every point in the region.
Imaging	T o create a representation of; *also* **:** to form an image of **b :** to represent symbolically
Magnet	An object that is surrounded by a magnetic field and that has the property, either natural or induced, of attracting iron or steel.
Magnetometer	An instrument for measuring the magnitude and direction of a magnetic field.
Orbital Plane	The path of a celestial body or manmade satellite as it revolves around another body relative to that second body.
Orientation	Location or position relative to the points of the compass.
Planet	A nonluminous celestial body larger than an asteroid or comet, illuminated by light from a star, such as the sun, around which it revolves.
Planetary field	A region or space around a planet in which a given effect (as magnetism) exists
Radar	A method of detecting distant objects and determining their position, velocity, or other characteristics by analysis of very high frequency radio waves reflected from their surfaces.
Relief	The variations in elevation of an area of the earth's surface.
Rotation	Motion in which the path of every point in the moving object is a circle or circular arc centered on a specific internal axis.
Simulation	Examination of a problem often not subject to direct experimentation.
Synthetic	Devised, arranged, or fabricated for special situations to imitate or replace usual realities.
Topography	Detailed and precise description of a place or region.

Some good books to use with *Ring World*

The Cambridge Photographic Atlas of the Planets
Briggs, G. & Taylor, F. , 2nd ed. 1986, Cambridge U. Press.
Has many high quality photographs.

The Grand Tour: A Traveler's Guide to the Solar System
Miller, R. & Hartmann, W. 1981, Workman.
A beautiful primer.

The Hubble Space Telescope
Vogt, G. 1992, The Millbrook Press, Brookfield, CT.

Rings
Elliot, J. & Kerr, R. 1984, MIT Press.
Guide to our discovery & current knowledge of rings around the outer planets.

Our Solar System
Simon, Seymour. 1992, Morrow Junior Books

Traveler's Guide to the Solar System
Barnes-Svarney, Patricia. 1993, Sterling Publishing Company

Saturn: A Spectacular Planet
Branley, F. 1983, Crowell.

Some good web sites to use with *Ring World*

space.jpl.nasa.gov
NASA's Jet Propulsion Laboratory web site

http://spaceplace.nasa.gov/en/kids/
A web site that offers ways to get involved in learning about space science and exploration. The Space Place is one of JPL's many successful education and outreach efforts.

http://quest.arc.nasa.gov/
Ames Research Center. NASA's K-12 Internet Initiative. This is a highly interactive site that features chats with scientists, video feeds to the Space Shuttle and much more.

http://tes.asu.edu/dsn_solarsyst.html
An astronomy information page compiled by Ken Edgett, Arizona State University

www.nineplanets.org
A Multimedia Tour of the Solar System from the Students for the Exploration and Development of Space

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

http://saturn.jpl.nasa.gov/education/edu-58-kitchen.cfm
Classroom activities created by the Cassini Outreach Team that teach students about the science and engineering behind the Cassini Mission to Saturn. Called "Saturn in Your Kitchen and Backyard," these activities are designed with cost in mind.

http://saturn.jpl.nasa.gov/education/edu-classroom.cfm
Check out these sites to further bring the wonders of space science to the classroom

btc.montana.edu/ceres
Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

spaceplace.jpl.nasa.gov/en/kids/index.shtml
This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities .

http://school.discovery.com/curriculumcenter/
This Discovery Channel education site allows teachers to search for science lesson plans by grade and subjects.

http://www.eduref.org/
Lesson plans based of the popular PBS series, Newton's Apple

www.thegateway.org
Sponsored by The U.S. Department of Education's National Library of Education and ERIC Clearinghouse on Information & Technology, this site offers lesson plans for all subjects and all grades.

www.thursdaysclassroom.com
Lesson plans, activities, and teacher resources presented from Science@NASA

Astronomy Web Sites Worth a Visit

umainesky.com
The Maynard F. Jordan Planetarium and Observatory home page.

hawastsoc.org
The Hawaiian Astronomical Society's home page

www.calacademy.org/planetarium
Alexander F. Morrison Planetarium home page

www.nss.org
The National Space Society web site

stardate.org

Learn what's going on TODAY in astronomy on the "Star Date" web page, maintained by the University of Texas' McDonald Observatory

http://domeofthesky.com/clicks/constlist.html

Find out the names of each constellation and the stories behind those names

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.