Solar System—PART II

STARFINDER

PROGRAM 26

Instructional Objectives

After viewing the program and participating in accompanying activities, the student will be able to:

1. list planets that generate heat from within,
2. define Oort cloud,
3. explain why planets have rings and what the composition of the rings are, and
4. explain the process that would have to occur for Jupiter to become a star.

Synopsis

The show opens with Dr. Eric Chaisson and a discussion of the "HST Data Stream's" latest images and closes with an interview of Peg Stanley, Technical Manager at the Space Telescope Science Institute.

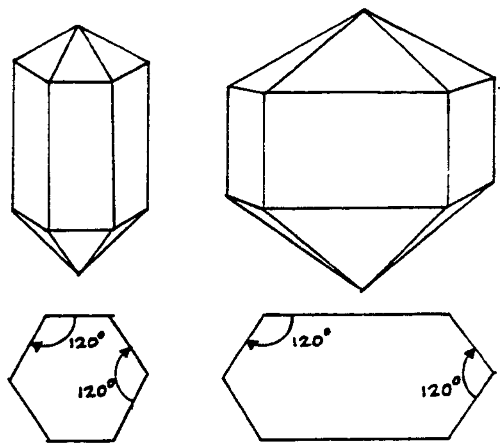
The "Science Links" segment discusses sources of heat on planets other than earth, using the sun, the source of nearly all of the heat on earth, as a reference point. Various theories describe how Jupiter and Saturn are able to generate their own heat. The formation of the rings of Jupiter, Saturn, Uranus and Neptune has also inspired various theories. The Oort cloud is defined in an effort to explain one of the theories. The relative massiveness of Jupiter is explained. Two-thirds of all solar system matter, excluding the sun, is part of Jupiter. Hypothetical scenarios describe how Jupiter could have become a star. The point of these scenarios is to show students that the solar system is not stagnant and that we are part of a much larger ever-changing universe.

Vocabulary

Composition - The nature of a chemical compound or mixture in terms of the kind and amounts of its constituents. This is often expressed with the percentage of each element present by weight.

Cosmological - Pertaining to the study of the origin and general structure of the universe.

Crystals - Solids with regular geometric shapes and smooth flat surfaces referred to as faces. Crystals are a common form of the minerals found in the earth's crust. Two crystals of a substance can look different, but the size of the angle separating the faces is always equal (see diagram).



Eccentricity - A measure of the amount an ellipse is elongated. When eccentricity is zero, the shape is a circle; the closer to 1 the eccentricity is, the more elongated the ellipse.

Friction - The act of rubbing one body against another with the result of resistance to the relative motion of one body. Friction can result from sliding, rolling, or flowing of one body over another.

Nuclear Fusion - A nuclear reaction in which nuclei combine to form more massive nuclei with the release of energy.

Oort Cloud - A vast cloud of ice, metal, and rock particles that surrounds the solar system.

Radioactivity - The process by which certain kinds of atomic nuclei naturally decompose with the spontaneous emission of subatomic particles and gamma rays. This process is sometimes called radioactive decay. The radioactive element decays, losing some energy and charged particles, to form another, more stable element. Uranium decays, forming lead in final form.

Previewing

Ask the students to bring in articles about the pictures taken by Voyager. Have the students describe what was discovered by scientists through these images.

Review the Doppler Effect (programs 4 and 28). The Doppler Effect is marked in the quasar that Dr. Chaisson discusses. The quasar is moving rapidly away from us, at about 80% the velocity of light. The farther away the quasar, the more it shifts into the red portion of the spectrum, where Hubble's spectrograph is able to pick it up.

Discuss some of the questions scientists are still asking about our solar system.

If possible, have a night session with the students to look at the visible planets through the telescope. Ask them to compare the images seen by Voyager and the image they saw in the telescope. Back in the classroom, ask them to talk about why non-manned space probes are of value to science.

Postviewing

Ask students to describe the effect on earth if Jupiter were to become a star. (Emphasize this as a hypothetical situation.)

Ask students to describe the Oort cloud and the possible reasons for its creation.

Have the students explain the relationship between the Oort cloud and the planets' rings.

Ask students to list the planets that generate heat from within themselves. Discuss the size of Jupiter. Have the students recount the hypothetical scenarios that could bring about Jupiter's rise as a young star.

Students should think of shows 25 and 26 together. Ask them to talk about the new pieces of information scientists have gathered through the recent space probes as well as ground-based studies.

Active Involvement

Have students view one or more of the following videos/films:

Mercury, Exploration of a Planet. NASA, 1976. An award-winning film using Mariner/O's close-up views of Mercury and Venus.

The Solar System. National Geographic Society Educational Services, 1980. Incorporates recent Voyager information to present a realistic view of the solar system.

Space Orbits. United States Air Force. Orbital patterns of the planets and the reason for those patterns is explained.

Have the students review where the Hubble Space Telescope has taken images. They can use a map of the sky to put markers on the parts of the universe the Hubble Space Telescope has observed.

Have the students create an informational bulletin board for the school on the Hubble Space Telescope Mission.

Students may write to Dr. Eric Chaisson at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218 with ideas on what other topics they would like him to explain in any follow-on series to *StarFinder.*

Bibliography

For high school readers:

Heppenheimer, T.A. *Colonies in Space.* New York: Holt, Rinehart and Winston, 1976.

Jackson, Joseph H. and John P. Baumert. *Pictorial Guide to the Planets.* New York: Harper and Row Publishers, 1981.

NASA, *Exploring the Universe with the Hubble Space Telescope.* Government Printing Office, Washington, D.C. 20402.

Weaver, H.A., and Laura Danly. *The Formation and Evolution of Planetary Systems.* Space Telescope Science Institute Symposium Series No. 3. New York: Cambridge University Press, 1989.

For middle school readers:

Asimov, Isaac. *Jupiter: The Largest Planet* (Revised edition). New York: Lothrop, Lee and Shepard Co., 1976.

Branley, Franklyn. *Saturn.* New York: Thomas Y. Crowell, 1983.

O'Donnell, James J. *Earthly Matters.* New York: Julian Messner, 1982.

Vogt, Gregory. *Halley's Comet.* New York: Franklin Watts, 1987.

See For Yourself: Experiments/Project

Changing Temperatures

▶ **PREPARATION:**

Blend the following mixture according to the directions provided.

- 1 cup sweet butter chopped
- 2 cups whole milk
- 2/3 cup sugar
- 1/2 cup semi-sweet chocolate chopped
- 1/4 teaspoon of vanilla extract

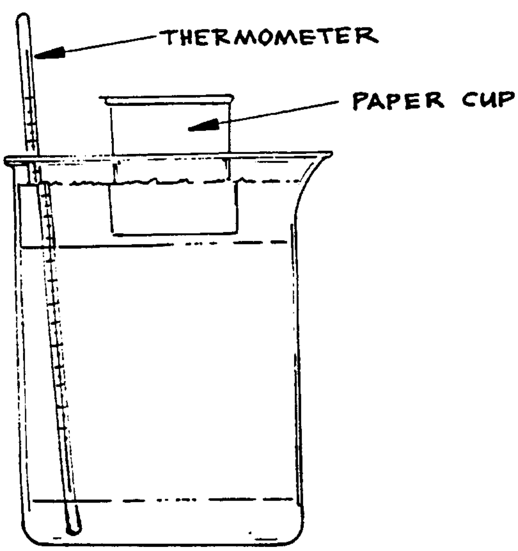
In a saucepan, melt butter, then add milk and sugar. Bring to boil. Pour mixture in blender and blend for 10 seconds. Pause and repeat twice. Add vanilla and chocolate and blend until smooth. Refrigerate for at least two hours.

▶ **MATERIALS**

- graph paper
- thermometer
- paper cup (waxed)
- tall slender bowl or beaker
- stirring rod or short dowel
- plastic spoons
- crushed ice
- rock salt

▶ **PROCEDURE:**

Fill the beaker one-fifth full of crushed ice. Then add rock salt and finally water. The water level should be 2 cm from the rim of the beaker (see diagram).



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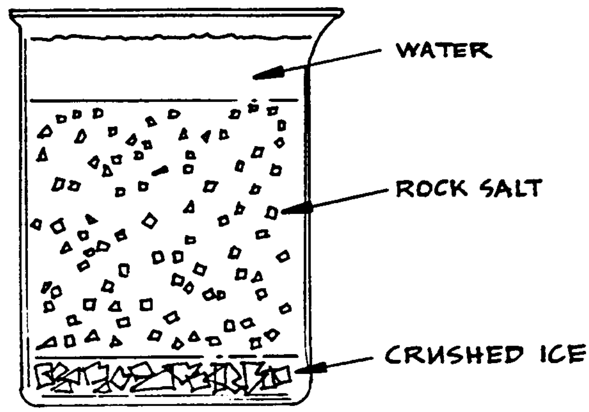


Add the paper cup to the beaker (see diagram). Add the mixture made in the preparation to the paper cup, leaving a little room.

1. Using the thermometer, measure the temperature of the ice water. Record.
2. Wipe the thermometer clean. Measure the temperature of the mixture. Record.
3. Stir the ice water with the stirring rod and the other mixture with the plastic spoon.
4. Wait 5 minutes and repeat steps 1 and 2. Repeat steps 1 and 2 until the temperature of the two mixtures stabilizes and the mixture in the cup solidifies. You may add ice and rock salt as necessary. Graph your results.

Describe your observations with words. Discuss the temperature of the water which was still in liquid state. Discuss the solidified mixture. Why do the temperatures differ?

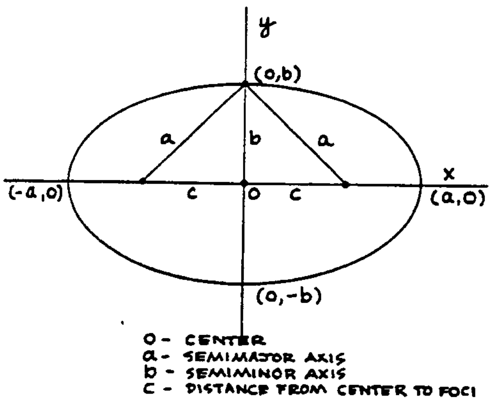
Relate your observations to the planets and the temperatures on the planets. Distance from the sun is not the only determining factor when discussing temperature. In your conclusions, explain what composition means.

You have created ice cream. If you would like, you may indulge yourself.

Elliptical Orbits

MATERIALS:

- graph paper
- straight edge
- calculator
- colored pencils (9)



PROCEDURE:

In this project, you will graph the elliptical orbits of the planets. Before you begin your own graphs, you should understand how to calculate the points to be plotted. We will use earth for our example.

This is the general shape of an ellipse. The general form of the equation of an ellipse is:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Eccentricity is equal to c/a.
To graph an ellipse, we need the value of b. Given eccentricity and a, we algebraically determine c and then use the relationship b = a - c to determine b.

Note: For ellipses, the letters represent different parts of the triangle, but it is still Pythagoras' Theorem.

For the earth, eccentricity (e) = .017 and the semimajor axis = 1 (by definition).

$e = c/a$

$.017 = c/1$

$\frac{.017}{1} = c$

$.017 = c$

$b^2 = a^2 - c^2$

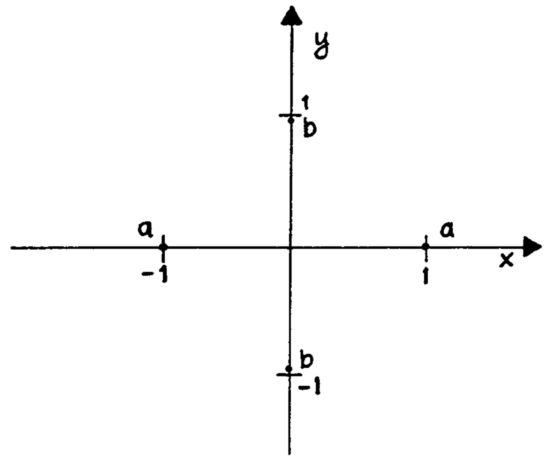
$b^2 = 1^2 - (.017)^2$

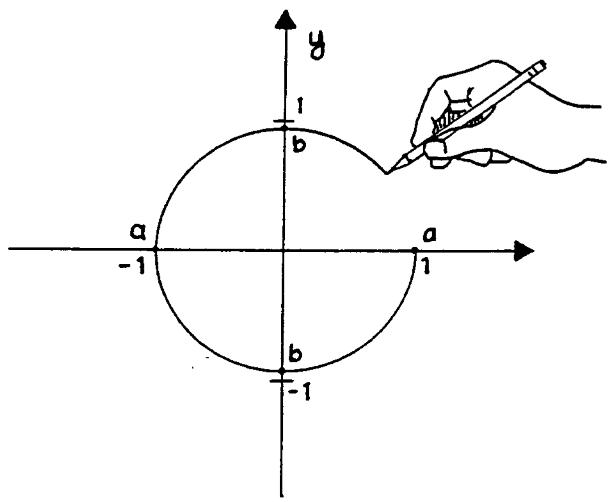
$b^2 = 1 - .00029$

$b^2 = .9997$

$|b| = .9998$

Now we use these values to graph on an x-y Cartesian coordinate system.





Do the same for the remaining planets. List all the planets on a single sheet of graph paper.

Name	Semimajor Axis(a)	Eccentricity	c^2	c	b^2	b
Mercury	.3871	.206				
Venus	.7233	.007				
Mars	1.5237	.093				
Jupiter	5.2026	.048				
Saturn	9.5547	.056				
Uranus	19.2181	.046				
Neptune	30.1096	.009				
Pluto	39.4387	.246				

1. Describe the variations in the planets' orbits.
2. What is the relationship of eccentricity to the final orbit you drew?
3. The planets do not all lie in the same planes. Research how astronomers measure the angle of each plane of orbit. Design a means of diagramming the different planes.

Science Career Profile

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PROGRAM 26

PEG STANLEY

Technical Manager
Space Telescope Science Institute, Science Programs Division
Education: B.S. Computer Sciences

Chief Responsibilities

As a Technical Manager in the Science Programs Division of the Space Telescope Science Institute, Peg Stanley's responsibilities are two-fold. She is providing oversight and management of the current day-to-day Hubble Space Telescope activities, plus she is looking to the future needs of the HST.

Like a television that occasionally needs fine tuning or a camera that needs adjustment of focus, the Hubble Space Telescope periodically requires fine tuning and adjustment, an operation referred to as calibration. Since deployment, most of the telescope time is being spent performing the Science Verification program, a detailed check out and calibration of the science instruments on board the HST. These calibration activities start out on paper as proposals from the instrument developers, and are processed through several systems and organizations. They end up as a series of commands to be transmitted to the HST. Peg is involved all along the way. Her duties include scheduling processes and solving all the many problems that a proposal can run into—from the time it is written on paper until its final transmission to the on-board HST computers.

Peg's secondary role as the Technical Manager of the Telescope and Instrument Branch at the Science Institute is to prepare for the future calibration requirements of the HST. The current Science Verification program is unique because its development has been a joint effort of the science instrument developers, the Goddard Space Flight Center, and the Space Telescope Science Institute. But calibration of the instruments will continue for the life of the HST mission and will eventually be handled by the Space Telescope Science Institute's Telescope and Instrument Branch alone. There are routine calibrations that serve to continually fine tune the operation of the instruments and process data. There are also calibrations that must be made as mechanical and electronic components change due to the wear and tear of operations. Peg makes sure that the programs can be put into use within the required time frame.

A Typical Day

As the focal point for operational planning problems, Peg finds her schedule and her "to do list" change rapidly. A typical day starts early and might go like this:

The first item of the morning is to log onto the computer and read the variety of electronic mail messages received overnight. On an average day, Peg receives about 25-30 mail messages dealing with HST activities. After the morning mail is read, printed, and responded to as needed, Peg prepares for her daily status meeting by determining how the previous day's (and night's) observations went. During this status meeting, which is chaired by Peg and referred to as "the 9 o'clock," the group looks at the immediate schedule plus the status of the schedules for the next four to six weeks. There are usually lots of problems for Peg to investigate. Luckily, she is not required to fix all of the problems herself, but she is responsible for making sure they are taken care of before the observations are attempted by the HST. A few times each week, Goddard Space Flight Center personnel teleconference in to "the 9 o'clock." On those mornings, Peg uses a box on the table to talk to NASA management and bring them up to date on the progress of the planning and scheduling process. Following the meeting, Peg updates the data base to reflect the current, and ever changing, status of proposals and schedules.

The rest of the morning and much of the afternoon is spent handling problem cases. Peg labels her office a "crisis center," as she must constantly deal with problems brought to her attention through phone calls, electronic mail messages, and personal visits. Trouble shooting this variety of problems requires Peg to investigate the details of the scientific observations in order to determine solutions. This might be accomplished by examining reports and printouts, or speaking with the original observation proposers.

Many afternoons are spent in meetings. The meetings include a weekly assessment of HST's performance and progress of the Science Verification program. Every other week, she attends meetings that review possible problems for observations planned beyond the next six weeks. They hope to catch them early enough to avoid a last minute crisis. When not in meetings, Peg spends afternoons documenting procedures for handling problems and updating plans and schedules for the long term calibration programs.

Career Viewpoint

Peg is in the middle of the mission right now, and although it is often hectic and stressful, she wouldn't have it any other way. She enjoys knowing her contribution to the program is meaningful, and her knack for organizing and keeping things straight is being put to good use. However, she is looking forward to the time when the HST mission isn't quite so hectic and more things are going along as planned. She hopes she can then put more time and effort into long term calibration and help bring new HST science instruments into operation.

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