Maynard F. Jordan Planetarium

Destination Pluto

Edited by Jenny Worster/Leisa Preble

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 – *Destination Pluto*

From the sun to the furthest planet, *Destination Pluto* is a journey of discovery for space travelers of all ages. New space exploration has reshaped our understanding of the planets and their origins, even to the point of changing the identity of little Pluto and limiting the planet family to eight members. Recently discovered moons and far flung mysterious ice worlds, rings around the largest planets, close-up views of alien landscapes and hazardous asteroids are all part of the adventure in *Destination Pluto*. This planetarium star show introduces young students to the wonders of the Sun's system and reviews the latest space news for the rest of the family.

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 *Destination Pluto*, 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 *Destination Pluto,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-5

Science and Technology –

B1. Skills and Traits of Scientific Inquiry

a. Pose investigable questions and seek answers from reliable sources of scientific information and from their own investigations.

c. Use simple equipment, tools, and appropriate metric units of measurement to gather data and extend the senses.

d. Use data to construct and support a reasonable explanation

B2. Skills and Traits of Technological Design

f. Modify Designs based on results of evaluations.

C1. Understandings of Inquiry

a. Describe how scientists answer questions by developing explanations based on observations, evidence, and knowledge of the natural world.

D1. Universe and Solar System

a. Show the locations of the sun, Earth, moon, and planets and their orbits.

D4. Force and Motion

a. Predict the effect of a given force on the motion of an object.

English / Language Arts –

E1. Listening
- b. Attend and respond appropriately to classmates and adults

E2. Speaking
- a. Explain ideas clearly and respond to questions with appropriate information

<u>Grades 6-8</u>

Science and Technology –

A2. Models

- b. Propose changes to models and explain how those changes may better reflect the real thing.

B1. Skills and Traits of Scientific Inquiry

- c. Use appropriate tools, metric units, and techniques to gather, analyze, and interpret data.
- d. Use mathematics to gather, organize, and present data and structure convincing explanations.
- e. Use logic, critical reasoning and evidence to develop descriptions, explanations, predictions, and *models.*
- f. Communicate, critique, and analyze their own scientific work and the work of other students.

B2. Skills and Traits of Technological Design

- c. Communicate a proposed design using drawings and simple *models*.

C4. History and Nature of Science

- b. Describe and provide examples that illustrate that science is a human endeavor that generates explanations based on verifiable evidence that are subject to change when new evidence does not match existing explanations.

D1. Universe and Solar System

- a.Describe the different kinds of objects in the solar system including planets, sun, moons, asteroids and comets.
- b. Explain the motions that cause days, years, phases of the moon, and eclipses.

D4. Force and Motion
- e. Describe and

Social Studies - History –

A. Chronology

2. Identify the sequence of major events and people in the history of Maine, the United States, and selected world civilizations.

9-D

Science and Technology -

B1. Skills and Traits of Scientific Inquiry

- c. Use statistics to summarize, describe, analyze, and interpret results.
- d. Formulate and revise scientific investigations and models using logic and evidence.
- e. Use a variety of tools and technologies to improve investigations and communications.
- g. Communicate and defend scientific ideas.

D4. Force and Motion

- b. Explain and apply the ideas of relative motion and frame of reference.

Performance Indicators Snapshot

The Show

Grades 3-5

Science and Technology
A4.a; B1.a, c, d, f; D1.a, b.
English Language Arts
E1.b; E2.a.

Grades 6-8

Science and Technology
C4.b; D4.e.

The Guide

Grades 3-5

Science and Technology.
B1.a, c, d; B2.f; C1.a; D1.a; D4.a.

Grades 6-8

Science and Technology.
A2.b; B1.c, d, e, f; C4.b; D1.a, b.
Social Studies – History
A.2

Secondary

Science and Technology
B1.c, d, e, g; D4.b.

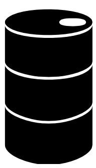
How Much Would a Can of Soda Weigh?

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to demonstrate that gravity is what causes objects to have weight (3-5. Science and Technology. D4.a.).
2. Learners will be able to explain that the nine planets do not exert the same amount of gravitational force (6-8. Science and Technology. D4.c.).

The General Idea:

Weight is the name we give to the force acting in a direction toward the center of a planet. The pull of gravity is the natural force of attraction exerted by a planet upon objects at or near its surface. The force depends both on the mass of the planet and its diameter. (For example: a planet having twice the mass, but with the same diameter, of Mars would result in a surface gravity twice that of Mars). This activity will help students understand this concept by comparing the various relative weights of a can of soda if placed on the surface of each of the nine planets and our Moon.



Getting Ready:

- Mark each can with the name of one of the nine planets and our Moon.
- Place the number of pennies (from the chart below) in each can.

Planet	**Number of pennies**
Mercury	42
Venus	100
Earth	Full can of soda
Moon	18
Mars	42
Jupiter	275
Saturn	117
Uranus	99
Neptune	125
Pluto	7

What You Need:

10 clean, empty soft drink cans
approximately 850 pennies
a permanent marker

What To Do:

1. Allow each student to pick up and compare the weights of the cans

What To Discuss:

1. After the students have all had a chance to lift the cans and feel the differences in weight, ask students to discuss why they think the same can of soda would have different weights on different planets and our Moon.

Continuations/Extensions:

1. Place a half-gallon plastic milk jug upright and punch a small hole 2.5 cm (1") up from the bottom. Placing your finger over the hole, fill the jug with water. Go to a playground with a friend as an observer. Find a high place and make sure nobody is standing directly below. Take your finger off the hole and drop the jug. What does the observer see happening to the flow of water during the drop?
2. Does the weight of objects affect how fast they fall? Take 14 pennies. Make two piles of seven. Tape one pile together. Hold one pile in your right hand and the other in your left. Reach both hands up high and cleanly drop the two piles at the same time. The taped pile is at least seven times the weight of each penny in the other pile. Any conclusions?

3. How old would you be on another planet? If a year is described as the amount of time it takes for a planet to revolve around the Sun, for the Earth it's 365.25 days, then your age would be different on each planet. Use the chart below to figure out how old you would be.

Planet	**Number of days in a planetary year**	**Multiply your age by**
Mercury	87.97	4.152
Venus	224.7	1.626
Earth	365.25	1
Mars	687	.53
Jupiter	4,333	.084
Saturn	10,759	.034
Uranus	30,685	.012
Neptune	60,188	.006
Pluto	90,700	.004

There are now two ways for you to figure out your age. The first is to multiplying your age by 365 (to find the number of days) and then divide that number by the number in the middle column above to find out you age on that planet. For example, if you are 20 years old here on Earth and want to know your age on Jupiter, 20 X 365 = 7300 and then 7300X4900 = (approximately) 1.5. That means you'd be one and a half years old on Jupiter!

The second method is to multiply your age by the number in the right hand column. For example, if you are 20 and want to know your age on Neptune, 20 X .006 = .12 (years).

The Scaled Solar System

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to explain the scale of the solar system in terms of size and distance (3-5. Science and Technology. D1.a.) (6-8. Science and Technology. A2.a.)
2. Learners will be able to identify generalizations that people may have about the solar system and exceptions to those generalization (6-8. Science and Technology. B1.e.).
3. Learners will be able to reflect on and what they are learning in this activity (6-8. Science and Technology. B1.f.)

The General Idea:

Most of us have seen models of the solar system at some point. And most of those models placed planets the size of baseballs just a few inches apart. With models like these it's no wonder that students often understand the differences in size between the planets without actually understanding the scale of the solar system. This activity deals with relative sizes ***and*** distances in the Solar System.

What You Need:

index cards
Scale models for all the planets and the moon.

What To Do - Part I Relative Size:

1. On the front of each index card write the name of a planet, the moon, the Sun, etc.
2. On the back of each index card write the diameter of the object using the chart following this lesson.
3. Show the students the scale models you are using to represent the objects, but do not tell the students which models represent which objects.
4. "Deal" out the index cards and have each student in turn come up and pick a model that they think represents the object on their index card. (If a student cannot find a suitable model among those that are left s/he may take one from another student and that student can choose another object)
5. Stop the game when all the students have the correct models for the objects indicated on their index cards.

What To Do - Part II Relative Size and Distance:

1. Using the objects from Part I, try scaling the distances in the Solar System to the same scale you used for size (see attached table). The idea is for the class to discover that this cannot be reasonably done because the bodies are very, very small compared to the distances between them. That is, the Solar System consists mostly of empty space.
2. Now, to scale these relative distances to size, we note that the Earth is 11,730 times its own diameter away from the Sun. So, for whatever size we have chosen for the Earth it would have to be placed nearly 12,000 times that distance from the Sun. Clearly we cannot easily represent our miniature Solar System model by tying distance to size.

What To Do - Part III Relative Distance:

1. To get a relative distance model, we will ignore size.
2. For this final part, the class will construct a relative distance model of the Solar System based on the Distance-Scale Chart listed in Part II. In this case, however, all bodies in the solar system will be considered the same size (even though we know from Part I that they truly are not). Ping pong balls, marbles, balloons, Styrofoam or metal balls could all be used. One could even use the models from Part 1, as long as it is made clear that the Earth-Sun distance is arbitrarily picked, and not in scale to the Earth-Sun sizes.
3. The Earth-Sun distance is again the standard, and it could be set at, say, 10 cm. This would place Mercury, the nearest planet to the Sun, at 4 cm, and Pluto out at 400 cm, or 4 m. This appears to be a reasonable range for the classroom. You might want to double these by making the Earth 20 cm from the Sun if you have a fairly large room. The planet, Sun and Moon models should be physically placed at their respective relative distances (on the floor) so a good general view of the spacing of the planets can be seen.
4. Note that even at a 20 cm Earth-Sun distance, the Earth-Moon distance would be only 0.6 mm (less than 1 mm) and so they would be virtually touching each other!

What To Discuss:

1. Which planet is the biggest? The smallest?
2. How many times larger is the biggest planet than the smallest?
3. Is the Sun bigger than the biggest planet?
4. Is the Moon smaller than the smallest planet?
5. If Saturn's rings are included in its size, how much bigger than Jupiter is it?
6. Which planet is closest to Earth in size?
7. Which planet's size would be hardest to determine? Why?
8. Place the bodies of the Solar System in 4 groups by matching up their relative sizes.
9. List the planets from smallest to largest, including Earth.
10. Which 2 planets are closest together? Farthest apart?
11. Which planet is closest to Earth?
12. Which body in the solar system is closest to Earth?
13. Which planet do you think is the hottest? (Discuss Mercury and Venus).
14. What does the Solar System mostly consist of? Think of when we tried to make the true model by tying distance to size.
15. How are the planets spaced from the Sun? Evenly?
16. What is true for the inner planets? Are they relatively close or far?
17. Neptune and Pluto actually switch their places sometimes. How can this be? Will they collide? Why or why not?
18. List the planets from closest to the Sun to farthest from the Sun, including the Earth.
19. How does the Earth-Moon distance compare to the planet distances?
20. Are the planets always in a straight line? If not, are they ever in a straight line?

Continuations/Extensions:

1. For a more advanced class, you could calculate the distance of the nearest star to the Sun, Alpha Centauri, in the scaled model. At 4.3 light years, which is about 25 trillion miles, it would be 27.2 km, or about 17 miles away for an Earth-Sun distance of 10 cm!
2. Take the activity outside and set up the models without putting the planets in a straight line. This helps the students avoid the “beads on a string” image that many of them may have.

Planet	Diameter	Scale size	Scale distance to Sun	Suggested objects
Mercury	3,005 miles	0.38 X Earth	0.39 AU	Small marble dried pea
Venus	6,406 miles	0.81 X Earth	0.72 AU	Large marble Round button
Earth	7,908 miles	1	1 AU *	Shooter marble Ping Pong ball
Moon	2,151 miles	0.272 X Earth		Dried pea Plastic bead
Mars	4,191 miles	0.53 X Earth	1.52 AU	Large marble Small rock
Jupiter	88,570 miles	11.2 X Earth	5.2 AU	Basket ball Small beach ball
Saturn	74,335 miles	9.4 X Earth	9.54 AU	Soccer ball Volley ball
Uranus	31,632 miles	4 X Earth	19.2 AU	Tennis ball Apple
Neptune	30,683 miles	3.88 X Earth	30.1 AU	Tennis ball Racket ball
Pluto	1,423 miles	0.18 X Earth	39.5 AU	Tiny bead Tiny pebble

*AU (Astronomical Unit) = The diameter of object being used to represent Earth / 11,730

Pluto a Planet No More

Article by Gary Hopkins
Education World®

http://www.education-world.com/a_lesson/newsforyou/newsforyou038.shtml

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to understand each planet’s place in the solar system. (3-5. Science & Technology. D1.a.)
2. Learners will be able to understand the history of space discoveries. (6-8. Science & Technology. C4.b.)
3. Learners will be able to understand the nature and history of science. (6-8. Science & Technology. C4.c.)
4. Learners will be able to understand the written word as it pertains to science. (3-5. Science & Technology. C1.a.)

The General Idea:

A group of scientists has decided that Pluto, which has been called a planet for 76 years, is not a planet after all. Scientists' new definition of a *planet* means Pluto is being demoted. Now we have only eight planets instead of nine. Discover new ways to remember the names of the planets, their order, and why astronomers now consider Pluto as a “dwarf planet”.

What You Need:

Enough copies of the news story, “Pluto a Planet No More” for everyone in the class.

What To Do:

Before reading, ask students to help you create a list of planets in the solar system. Are your students able to list all nine of the planets?

(Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto)

You might even see if your students can name all nine planets in order of their distance from the sun. If some students know the planet names in order, ask how they know them. Do they have a trick for remembering the planets' sequence?

Next, provide students with a copy of the news article, “Pluto a Planet No More”. (You could print copies for students or you could project a copy of the news story on a screen.) Some students might be aware already of the latest news -- that astronomers have removed Pluto from the list of planets.

Write the following news words on a board or chart: *astronomers, orbit, planet, solar system, distance.* Then read aloud each statement below. Ask students to use one of the News Words to complete each statement:

- All of the planets in our ____ orbit around the sun. *(solar system)*
- The planet Neptune is a long ____ away from Earth. *(distance)*
- Earth travels in a circular ____ around the sun. *(orbit)*
- Scientists who study the planets and stars are called ____. *(astronomers)*

Reading the News

You might use a variety of approaches to reading the news:

- Read aloud the attached news story, “Pluto, A Planet No More” to students as they follow along.
- Students might first read the news story to themselves; then call on individual students to read the news aloud for the class.
- Arrange students into small groups. Each student in the group will read a paragraph of the story. As that student reads, others might underline important information or write a note in the margin of the story. After each student finishes reading, others in the group might say something -- a comment, a question, a clarification -- about the text.

More Facts to Share

You might share these additional facts with students after they have read this week's news story.

- The decision to remove Pluto from the list of planets was not an easy one to make; it came at the end of a week of disagreements at a meeting of the International Astronomical Union. More than 2,500 astronomers from 75 countries were at the meeting.
- The decision established three categories for objects in space: planets, dwarf planets (or minor planets), and small solar system bodies (such as asteroids and comets).
- Pluto was discovered by Clyde Tombaugh in 1930. Tombaugh died in 1997, and some of his ashes are aboard the New Horizons spacecraft, which NASA launched earlier this year on a 9-1/2-year journey to Pluto. The spacecraft is expected to pass near Pluto around July 14, 2015.
- The new definition of a planet calls for it to "clear the neighborhood around its orbit." But the orbit of Pluto is *not* all its own. The orbits of Neptune and Pluto cross paths. There are actually times when Pluto is inside of Neptune's orbit and Neptune is farther from the sun than Pluto is.
- In 2003, Michael Brown of the California Institute of Technology discovered an icy object larger than Pluto that was once thought to be a new planet. Now that object, called UB313 (or Xena), will join Pluto as a dwarf planet. UB313 is the largest dwarf planet.
- Some science teachers found the news of Pluto's demotion exciting. "It's a chance to teach kids that this is the nature of science. Things are always changing," Arizona teacher Rich Hogen told CNN.

<u>What To Discuss:</u>

Recalling Detail:

- How many of the nine planets can you name now that we have read the news story?
  (Are students able to name all of the planets?)
- For how long has Pluto been called a planet?
  (76 years)
- What are the rules that will help scientists determine in the future if a space object is a planet or not?
  (A planet must orbit the sun; be large enough to have almost a round shape; and have its own clear orbit.)
- Which planet is closest to Pluto?
  (Neptune)
- What new name have scientists given to space objects similar to Pluto?
  (dwarf planets)
- Who discovered Pluto?
  (Clyde Tombaugh)

Continuations/Extensions:

Critical Thinking.
Challenge your students to come up with a new mnemonic to help them learn the names of the eight planets in their correct sequence from the sun. In a news article on ABC.com, the following sentences were suggested as possibilities:

- My Very Extravagant Mother Just Sent Us Nachos.
- My Very Elderly Mother Just Sits Up Nights.
- Major Volcanoes Erupt, Making Jolts, Shaking, Unsteadying Nerves.
- Make Very Extraordinary Meals of Jell-O, Strawberries and Unsalted Nuts.
- Mary's Violet Eyes Make Jack Stare Until Noticed.

Note: Maybe your students can come up with an even better mnemonic. They might even be able to come up with a mnemonic that provides an easy way to remember which of the *M* planets -- Mercury or Mars -- is closest to the sun. For example the old mnemonic

Men Very Early Made Jars Serve Useful Needed Purposes

helps students remember that Mercury is closer to the sun because the word *Men* begins with the two letters *M-e,* which are also the first two letters of *Mercury*. The words *Made* begins with *M-a,* which are the first two letters of *Mars.*

Assessment

Use the Comprehension Check (above) as an assessment. Or have students work on their own (in their journals) or in their small groups to respond to the **Think About the News** questions on the printable news story page.

Pluto a Planet No More

Like a lot of kids, you might know the names of the nine planets in our solar system in order of their distance from the sun. Maybe you use the first letters of the words in a sentence such as "My Very Educated Mother Just Served Us Nine Pickles" to help you remember Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Now you will need to learn a new sentence to remember the planets. A group of scientists has decided that Pluto, which has been called a planet for 76 years, is not a planet after all. The scientists, called *astronomers*, wrote new rules to help them decide whether an object in space is a planet or something else. The new rules say a planet must

- orbit the sun,
- be large enough to have almost a round shape, and
- have its own clear orbit.

Pluto's orbit cuts into the orbit of the planet closest to it, Neptune, so the scientists say
Pluto cannot be a planet.

NEWS WORD BOX

astronomers orbit
planet solar system

MORE FACTS ABOUT PLUTO

- Scientists have tried for thousands of years to write rules to help them decide what is a planet.
- Pluto also is smaller than the eight planets, so scientists are calling it a *dwarf planet*. The other eight planets are called *classic planets.*
- Pluto was discovered in 1930 by a 24-year-old scientist named Clyde Tombaugh who lived in Arizona.

THINK ABOUT THE NEWS

Write a new sentence that kids can use to help them remember the names of the eight planets.

Modeling the Orbit of Planets

NEW HORIZONS: NASA's Pluto-Kuiper Belt Mission
http://pluto.jhuapl.edu/education/GrowthChartActivities/ModelingOrbitsPlanets/modelOrbits.html

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to explain the scale of the solar system in terms of size and distance (3-5. Science and Technology. D1.a., B1.d.)
2. Learners will be able to describe the unique properties of Pluto's orbit. (6-8. Science and Technology. D1.b.)
3. Learners will be able to make accurate observations using appropriate tools and units of measure (6-8. Science and Technology. B1.c.).

The General Idea:

The term Outer Planets refers to the five planets that orbit the Sun beyond the Asteroid Belt. The Outer Planets include: Jupiter, Saturn, Uranus, Neptune, and Pluto. The Inner Planets are: Mercury, Venus, Earth, and Mars. The planets are known to travel around the Sun along **elliptical orbits**—a term that simply means that the shape they trace out as they go around the Sun is an **ellipse**. (See Figure 1.) An ellipse is similar to a circle, but it is elongated along one axis. The circle is a special case of an ellipse in which the distance from the center to the edge in any direction is the same. The more elongated an ellipse is, the higher its **eccentricity**. An eccentricity of 0 is the special case of a circle, while eccentricities near 1 describe extremely elongated ellipses.

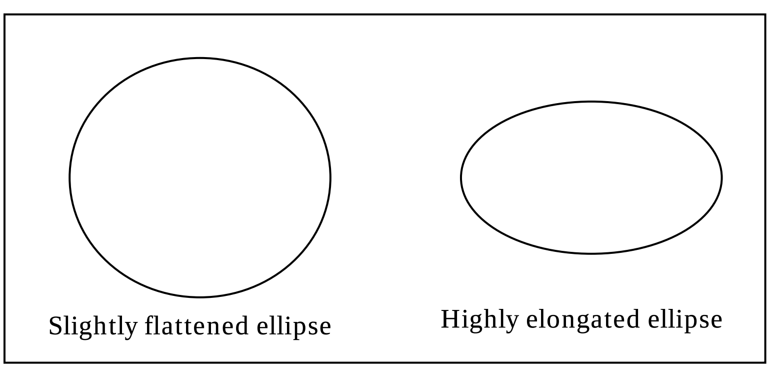
What You Need:

- 1 paper clip
- Scissors
- Glue, glue stick, or tape
- Pencil and crayons or markers
- Student sheets copied onto cardstock (if possible, but paper is ok!)

Overview:

If it were possible to look down on the orbits of the planets from above Earth's North Pole, the planets would be moving in a counterclockwise direction. The planets are locked into orbits around the Sun because of the gravitational force the Sun exerts on the planets. If we were able to somehow turn off the Sun's gravity, the planets would cease traveling along elliptical paths around the Sun, and instead continue along straight line paths in the direction they were just moving!

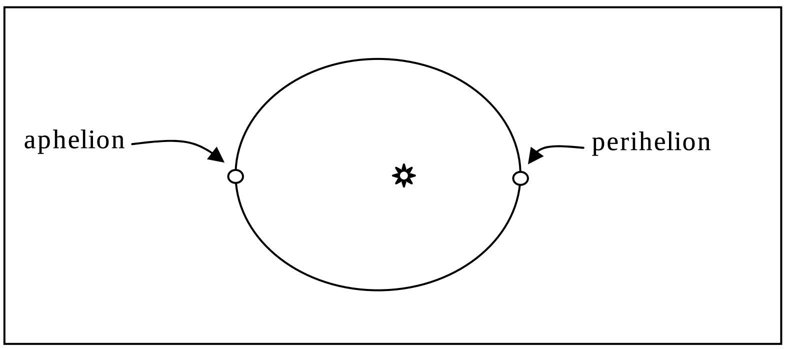
Figure 1



What's special about Pluto? The orbits of all the planets are elliptical, but they are close to being circular and are not very elongated. Pluto's orbit is the most elongated of all! Note, however, that although Pluto's orbit is the most elongated, it still appears relatively circular.
Since the planets have elliptical and not circular orbits, they are not always the same distance away from the Sun. At one point in their orbit, they are at **perihelion**, their point of closest approach to the Sun, and at another point, they are at **aphelion**, the point farthest from the Sun. (See Figure 2.) The more circular an orbit is, the more similar the distances are between the Sun and planet at perihelion and aphelion. If an orbit were circular, the perihelion and aphelion distances of the planets would be equal.

What's special about Pluto? The elliptical orbit of Pluto is flattened enough so that at some points in its orbit it is not the farthest planet! For approximately 20 years out of Pluto's 249 year trip around the Sun, Pluto is actually closer to the Sun than Neptune. But don't worry, the two planets will never crash because whenever Pluto crosses Neptune's orbit, Neptune is on the other side of the Sun.

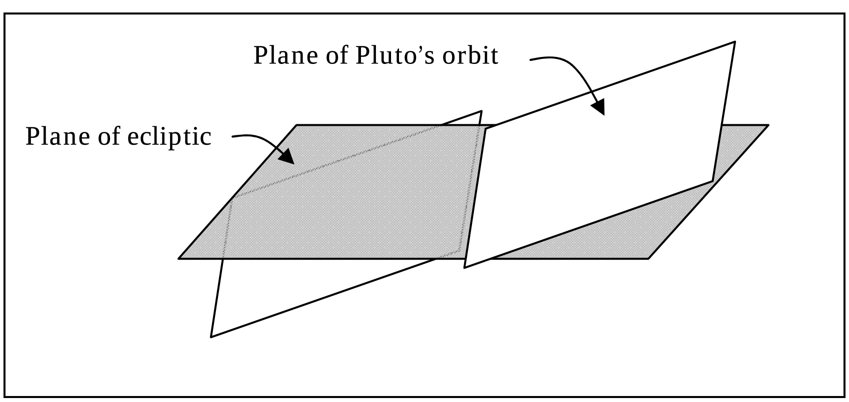
Figure 2.



All of the planets, except for Pluto, orbit the Sun approximately in a plane, called the **plane of the ecliptic**. A simple way of envisioning this is to imagine the Sun and planets (except for Pluto) as balls. If the ball representing the Sun were placed on a table, and the balls representing the planets (except for Pluto) were rolled around the Sun on the table, all of the balls, and hence, all of the planets (except for Pluto) would be orbiting the Sun on a plane. The ball representing Pluto would travel around the Sun too, but sometimes it would be above the table, and then dip down below the table before coming above the table again.

What's special about Pluto? Pluto does not orbit the Sun on the same plane as all the other planets. Its orbit is inclined, or tilted, by 17°. Because of this tilt, Pluto is located above the plane of the ecliptic for part of its orbit and below the ecliptic for the remainder of the time.

Figure 3.



What To Do:

1. Have students color the planets before cutting them out.
2. Ask students to cut all the shapes following the instructions on the Student Activity Sheets.
3. Glue planets onto the edge of the correct planet's orbital disk.
4. Have students unbend one end of their paperclip.
5. Using this end of the paperclip, have students poke a hole through the point marked "Sun" on each of the orbital disks. Work from the outer planets, inward (i.e. first poke hole through Pluto's orbital disk, next through Neptune's, etc.).
6. Ask students to bend the long end of the paperclip back into place so the planets' orbital disks don't fall off.

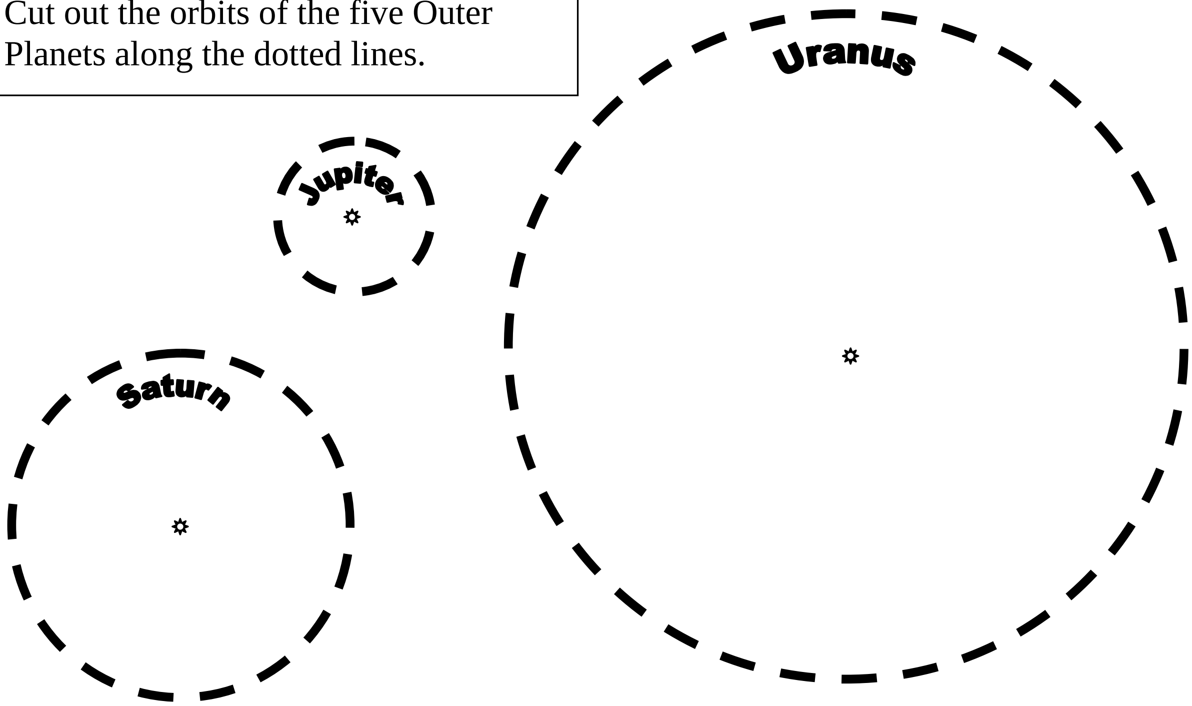
What To Discuss:

As students are finishing up, watch how they play with their model. Consider asking some of the following questions.

1. Q: I notice that <<student's name>> is spinning the planets around the Sun (paper-clip) on the model. How does that model what is happening out in space?
   a. The planets orbit around the Sun.
2. Q: Assume that Earth's North Pole is up. Which direction are you spinning the planets around the Sun? Which way models what happens in our Solar System? Clockwise or Counterclockwise?
   a. When viewed from above Earth's North Pole, the planets move in a counterclockwise direction. See animation: http://pluto.jhuapl.edu/common/content/videos/animations/PKB_MissionTrajectory.mov
3. Q: On your model, where would the orbits of Mercury, Venus, Earth, and Mars be located? What is different about the sizes of these inner planets' orbits compared to the orbits of the outer planets?
   a. Mercury, Venus, Earth, and Mars would be drawn inside the orbit of Jupiter, with Mercury closest to the Sun and the rest of the planets with slightly larger orbits, respectively. Their orbits are so small on the model, and they are very small in comparison to the orbits of the outer planets (Jupiter and beyond) in the Solar System.
4. Q: Can you use your model (and the special hole you cut out in Pluto's orbit) to show how Pluto's orbit is tilted in comparison with the orbits of the other planets?
   a. Pluto's orbit is inclined, or tilted, with respect to the orbits of the other planets by about 17°. This is a moderate amount that you will have to show students.
5. Q: Using our models, let's write on the chalkboard the order of the planets, from closest to the Sun to farthest.
   a. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto
   b. Some students may recall or see that sometimes Neptune is farther from the Sun than Pluto—if this comes up discuss it. If not, ask about it.
6. Q: Use your model and spin the orbit of Pluto until Pluto is at perihelion (the point closest to the Sun). Now, show Pluto at aphelion (the point farthest from the Sun).
7. Q: Did you know that spacecraft have traveled to all the planets except for one? Which one do you think has not been visited?
   a. Pluto!
8. Q: A space mission called New Horizons will launch (or has launched!) from Earth in 2006 heading for Pluto. How long do you think it will take for it to get there? What grade will you be in?
   a. The trip will take between 9 and 14 years, depending on the launch date. See real-time progress of New Horizons at: http://pluto.jhuapl.edu

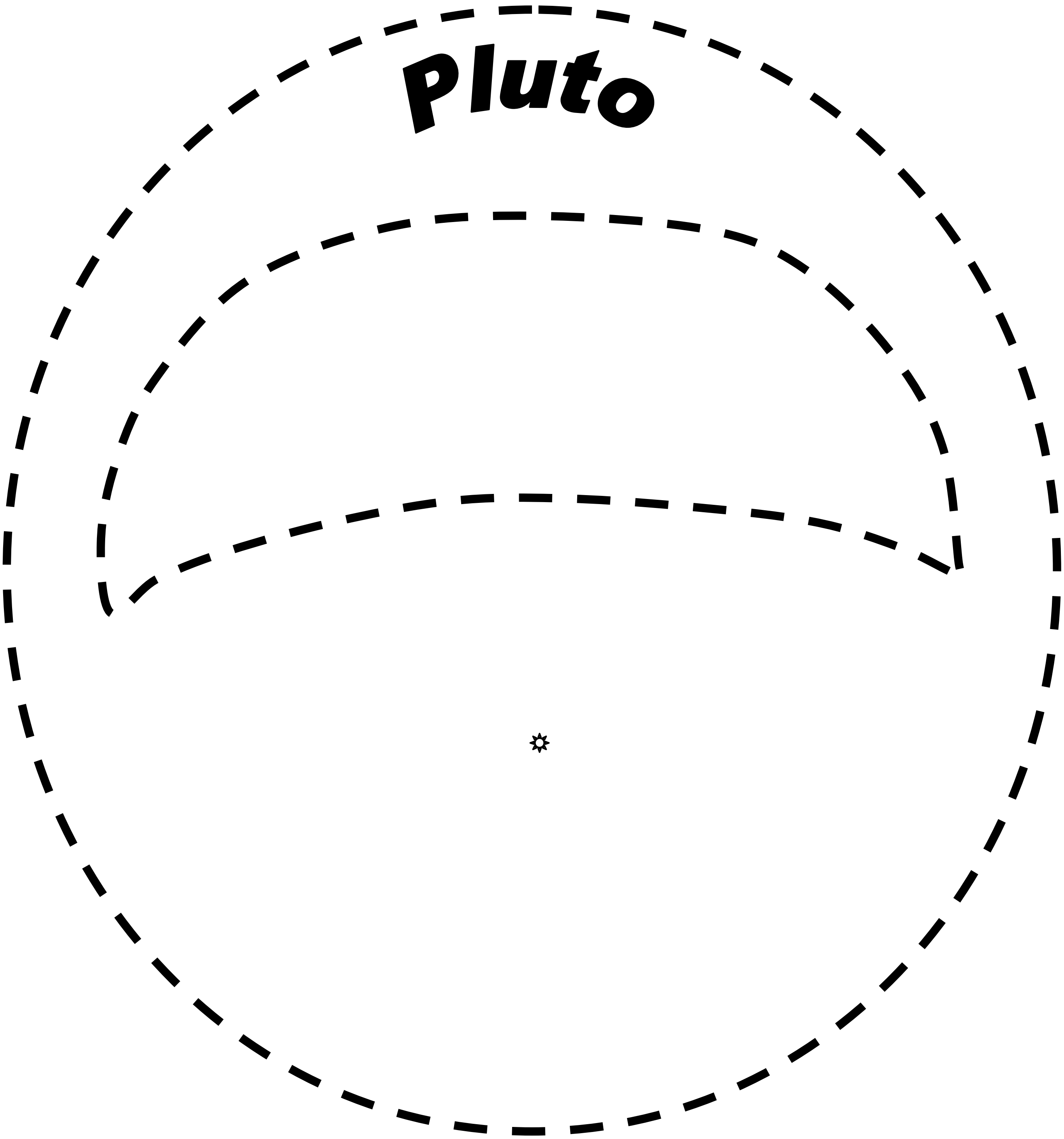
MODELING THE ORBITS OF THE PLANETS
STUDENT ACTIVITY SHEET

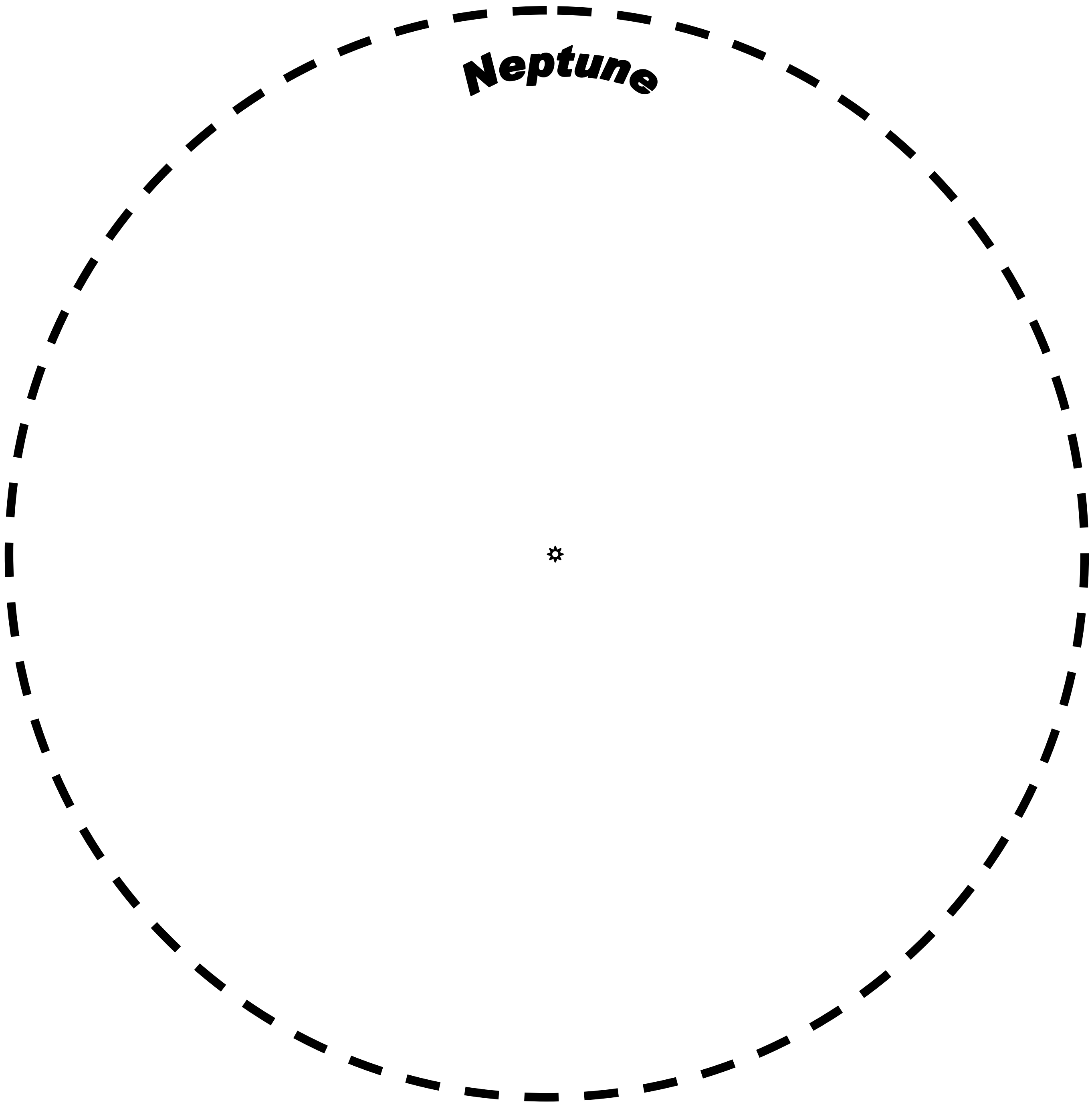
Cut out the orbits of the five Outer Planets along the dotted lines.



Color then cut out the five Outer Planets.

Jupiter Saturn Uranus Neptune Pluto


Pluto


Neptune

Interplanetary Tourism

Objectives and State of Maine Learning Results Performance Indicators:

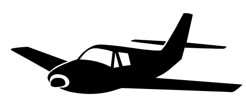
1. Learners will be able to describe the characteristics of the planets (6-8. Science and Technology. D1.a.)
2. Learners will be able to present information effectively and persuasively (3-5. Science and Technology. B1.f.)
3. Learners will be able to use various types of evidence to support the claims that they make about their planet (3-5. Science and Technology. B1.d.) (6-8. Science and Technology. B1.e.)
4. Learners will be able to work effectively in groups, including activities such as brainstorming (3-5. Science and Technology. B1.c.) (6-8. Science and Technology. B1.e.)

The General Idea:

This is an effective and enjoyable project for teaching the properties of the planet. By researching the characteristics of the planets and promoting tourism on each, teams of students will discover interesting and practical information about the planets. Encourage your students to be as creative as possible and to use their imaginations. In addition to learning about the planets, students will investigate ways that information can be slanted and after the activity they will look at real travel brochures and discuss where the information in them might be slanted as well.

What You Need:

Books about all the planets
Travel brochures



What To Do:

1. Divide the class into teams.
2. Assign each team a planet.
3. Each team is challenged to develop a TV commercial, sales pitch, or travel brochure (look at the travel brochures to develop an idea of what is expected) that would glamorize the properties of their planet (believe me, that's a challenge. For example, who would want to vacation on Venus with a night-time temperature of 900 degrees?)
4. Each team should research their planet in order to cover as much detail as possible.
5. You might want to create a brochure of your own along with you students.

What To Discuss:

1. Of all the planets covered, which one would the class ***really*** want to visit? Why? Why not the others?
2. What are some of the strategies that students used to slant the information about their planet in order to make it appealing?

Continuations/Extensions:

1. Considering what the class came up with as far as slanting information, look at the travel brochures and speculate about things that might not be as good as they sound and why.

Last Year on Pluto

NEW HORIZONS: To Pluto and Beyond
http://pluto.jhuapl.edu
http://pluto.jhuapl.edu/education/educators_GrowthCh.php
(to download Growth Chart poster, and for more activities)
Product of NASA's New Horizons Program Education & Public Outreach

<u>Objectives and State of Maine Learning Results Performance Indicators:</u>

1. Learners will be able to relate the passage of time on planets to historical events in the USA. (6-8. Social Studies - History. E1.b.)
2. Learners will be able to solve problems that arise in mathematics and other contexts. (6-8. Science and Technology. B1.d.)
3. Learners will be able to identify objects in the sky. (3-5. Science and Technology. D1.a.)

<u>The General Idea:</u>

The word "year" makes us think of many things that repeat like birthdays, special holidays, and starting a new grade in school. You may have wondered why a year is as long as it is, not shorter, nor longer. This activity will look at the relationship between the passing of time on planets and historical events in the USA.

<u>Getting Ready:</u>

Photocopy enough Student Activity Sheets for each student in class

<u>What You Need:</u>

- Student Activity Sheet
- Pencil

<u>What To Do:</u>

1. Given two basic facts about the orbital speed and distance traveled by the planets, students will deduce the length of one year on all the planets in the Solar System.

Answers:

1 Mercury Year =	0.2 Earth Years	1 Jupiter Year =	12 Earth Years
1 Venus Year =	0.6 Earth Years	1 Saturn Year =	29 Earth Years
1 Earth Year =	1 Earth Year	1 Uranus Year =	84 Earth Years
1 Mars Year =	2 Earth Years	1 Neptune Year =	165 Earth Years
		1 Pluto Year =	247 Earth Years

2. Students will use the information about how long one year is on several outer planets to determine what happened in the USA one year ago (on that planet's calendar).

Matching Answers:

One year ago on Pluto...Colonial America was starting to be annoyed with English rule. The American Revolution would soon follow.

One year ago on Neptune...Americans head west to settle the frontier.

One year ago on Uranus...Women first earned the right to vote in the USA.

One year ago on Saturn...Viking spacecraft lands on Mars.

One year ago on Jupiter...The internet was starting to be widely used.

What To Discuss:
Using computer research, can students find any other historical events that happened around the same timeframe for each planet.

Continuations/Extensions:
What historical events happened in the World if you go back one year on different planets? Two years? Five? Ten? Divide the class into 9 groups, and create a timeline of World events, with each group responsible for one planet. How many time-appropriate world events can they find?

Name ___________________________

Date ____________________________

LAST YEAR ON PLUTO

STUDENT ACTIVITY SHEET

The word "year" makes us think of many things that repeat like birthdays, special holidays, and starting a new grade in school. You may have wondered why a year is as long as it is, not shorter, nor longer. Or, why is winter in the US always in January and never in July? The answers to these questions can be found by knowing the astronomical meaning of a year. One year is the time it takes for a planet to travel once around the Sun. The time it takes Earth to revolve once around the Sun is 365 ¼ days, or one Earth year.

A couple of facts to know:

1. It takes a different amount of time for each planet to travel once around the Sun, so the length of one year on each planet is different.
2. The closer a planet is to the Sun, the faster it travels.
3. The distance traveled by planets close to the Sun is much shorter than the distance traveled by planets far away from the Sun.

Now, use this information to figure out the length of a year on all of the planets.

12	1	165
0.6	0.2	2
247	84	29

1 Mercury Year =	Earth Years	1 Jupiter Year =	Earth Years
1 Venus Year =	Earth Years	1 Saturn Year =	Earth Years
1 Earth Year =	1 Earth Year	1 Uranus Year =	Earth Years
1 Mars Year =	Earth Years	1 Neptune Year =	Earth Years
		1 Pluto Year =	Earth Years

As you see, it takes some planets over a hundred Earth years to travel around the Sun once. Let's see what was happening on Earth one year ago on Pluto and some other distant planets!

Match the time on the left with the correct historical event on the right.

One year ago on Pluto...	...Women first earned the right to vote in the USA.
One year ago on Neptune...	...Viking spacecraft lands on Mars
One year ago on Uranus...	...Colonial America was starting to be annoyed with English rule. The American Revolution would soon follow.
One year ago on Saturn...	...The internet was starting to be widely used.
One year ago on Jupiter...	...Americans head west to settle the frontier.

Vocabulary List

Axis	An imaginary straight line around which an object rotates.
Astronomical Unit - AU	The average distance from the Earth to the Sun, 93million miles.
Circumpolar	Constellations that are close to the north or south celestial poles. These constellations do not set.
Constellation	A grouping of stars, considered by humans to form a picture in the sky. Often related to mythology.
Day	The time it take for a planet to make one full rotation (on Earth, 24 hours).
Diameter	The distance from one side of an object to another as measure through the center.
Gravity	The force of attraction between two objects which is influenced by the mass of two objects and the distance between the two objects.
Moon	A natural satellite orbiting a planet.
Orbit	A specific path followed by a planet, satellite, etc.
Planet	A massive object orbiting a star.
Radiate	Sends out rays or shines brightly.
Reflect	Light bouncing off an object.
Relative Distance	The distance between two objects as compared to something else.
Relative Size	The size of an object as compared to another object.
Revolution	The circling of a smaller object around a larger object.
Rotation	The spinning of an object on its axis.
Scale	Reducing or enlarging measurements by a ratio.
Scale Model	A model of an object that is a different size then the real objects.
Solar System	The system of planets, moons, and other objects revolving around a star (in our case, the Sun).
Star	a massive, self-luminous celestial body of gas that shines by radiation derived from its internal energy sources.
Sun	Sol, the star that is closest to Earth and from which we get heat and light energy.
Universe	The vast expanse of space which contains all of the matter and energy in existence.
Year	The time it take for a planet to make one full revolution around a star, in our case, the Sun (on Earth, 365.25 days).

Some good books to use with *Destination Pluto*

Atlas of the Solar System
Moore, P. & Hunt, G. 1983, Rand McNally.
Large illustrated atlas, a nice reference book.

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

Cosmic Catastrophes
Chapman C. & Morrison, D. 1989, Plenum.
Violent events in the solar system.

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

Our Solar System
Asimov, 1. 1988, Gareth Stevens.
Briefly describes the characteristics of the sun and planets

Planets Beyond: Discovering the Outer Solar System
Littmann, M. 1988, Wiley.
An introduction to the outer planets

Planets of Rock and Ice
Chapman, C. 1982, Scribners.
A readable introduction to the inner planets.

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

The Sun
Simon, Seymour. 1986, William Morrow And Company, Inc.

Mercury
Vogt, Gregory. 1994, The Millbrook Press

The Planet Venus
Hunt, G. & Moore, P. 1982, Faber & Faber.
An illustrated introduction.

The Home Planet
Kelley, K. . 1988, Addison-Wesley.
A picture album.

The Moon Observer's Handbook
Price, F. 1989, Cambridge University Press.

Mars
Vogt, Gregory. 1994, The Millbrook Press

Destination: Jupiter
Simon, Seymour. 1998, Morrow Junior Books

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

A Distant Puzzle: The Planet Uranus
Asimov, Isaac, 1994, Milwaukee : Gareth Stevens Pub.,
Revised edition of "Uranus: The Sideways Planet"

Neptune : the farthest giant
Asimov, Isaac. 1990, G. Stevens Children's Books.
Describes the characteristics and movements of the planet Neptune.

Clyde Tombaugh and the Search for Planet X.
Wetterer, Margaret K. 1996, Carolrhoda Books.
The story of the young farm boy who became an astronomer and discovered the planet Pluto.

Some good web sites to use with *Destination Pluto*

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

ssd.jpl.nasa.gov
A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

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.

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

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

school.discoveryeducation.com

This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects.

www.eduref.org/Virtual/Lessons/index.shtml

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.

Astronomy Web Sites Worth a Visit

www.galaxymaine.com

The Maynard F. Jordan Planetarium and Observatory home page.

www.galaxymaine.com/SA/SA2.htm

The teacher resources and bibliography page on the Maynard F. Jordan Planetarium web site

hawastsoc.org

The Hawaiian Astronomical Society's 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

ufrsd.net/staffwww/stefanl/myths/stories.htm

Find out the names of each constellation in the northern hemisphere 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.

Additional Activities

Pluto Crossword Puzzle

Pluto … A World of Extremes

Planet: Pluto

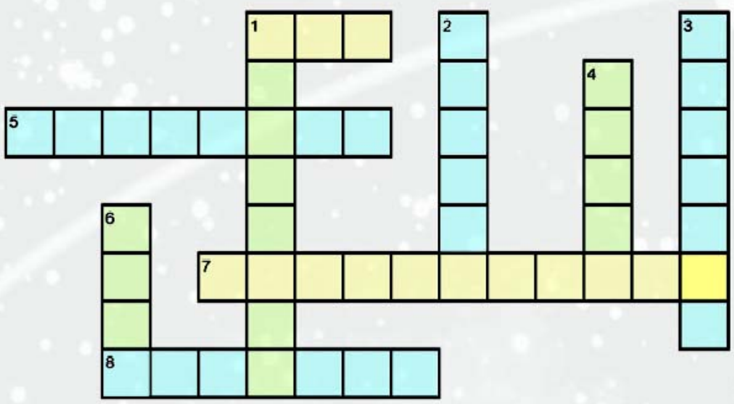
- Pluto is the smallest planet in the solar system.
- Pluto is the only planet classified as an "ice dwarf," a small body with a solid surface made of ice and rock.
- Compared to the size of its planet, Charon is the largest moon — about half the size of Pluto.

Orbit: Pluto

- Pluto is usually the farthest planet from the Sun — its distance ranges between 30 – 48 AU.
- All planets travel along an ellipse as they orbit the Sun; Pluto's orbit is elongated enough so that sometimes Pluto is closer to the Sun than Neptune.
- Even though the orbits of Pluto and Neptune cross, the two planets will never collide.
- Although the Sun is the closest and brightest star, it looks like a bright dot in a rather dark sky and provides little light and heat.
- It takes 248 years on Earth for Pluto to travel once around the Sun. (248 Earth years = 1 Pluto year)
- It takes 6½ Earth days for Pluto to rotate once on its axis. (6½ Earth days = 1 Pluto day)

Visit: Pluto

- Pluto is the only planet that has not been visited by a spacecraft from Earth. This is about to change as NASA's New Horizons mission is scheduled to fly by the planet as early as 2015!



New Horizons: NASA's Mission to Pluto and Beyond http://pluto.jhuapl.edu

Across

1 Brightest star in Pluto's sky
5 Pluto is this type of planet
7 Name of first spacecraft planning to fly by Pluto
8 From 1979 to 1999, this Planet was farther from the Sun than Pluto

Down

1 Is Pluto the smallest or largest planet in the solar system?
2 Compared to Earth, the temperature on Pluto is not hotter, it is ___
3 Shape of Pluto's orbit
4 Ninth planet
6 Charon is the name of Pluto's ___