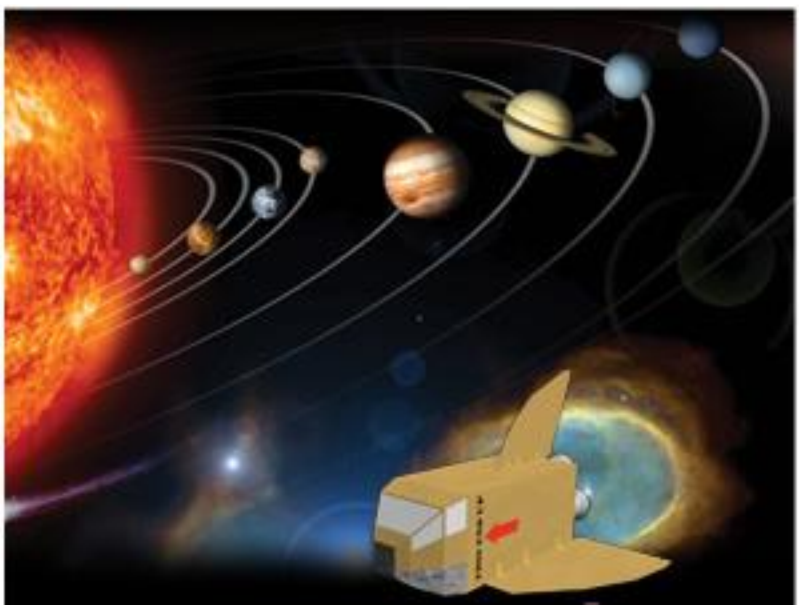
Emera Astronomy Center
and M. F. Jordan Planetarium

ASTRO.UMAINE.EDU FACEBOOK.COM/JORDANPLANTERARIUM 207-581-1341

Cosmic Classroom Guide



Secret of the Cardboard Rocket

COMPILED & EDITED BY
Leisa Preble

THE UNIVERSITY OF MAINE

A Member of the University of Maine System

Secret of the Cardboard Rocket

Compiled and Edited by Leisa Preble

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 – *Secret of the Cardboard Rocket*

Join two children on a magical journey through the Solar System, aided by a talking astronomy book, a cardboard rocket, and a vivid imagination. During this imaginative show, audiences will land on Venus, fly through the rings of Saturn, and discover the secrets of the Solar System.

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 *Secret of the Cardboard Rocket*, will 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://astro.umaine.edu .

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 lifelong 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 of the teamwork necessary to complete tasks
- B. applying that understanding and working effectively in 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 *Our Sky Family,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

<u>Grades Pre. K-2</u>

Science and Technology –

A2. Models
- b. Use a model as a tool to describe the motion of objects or the features of plants and animals.

B1. Skills and Traits of Scientific Inquiry
- e. Use writing, speaking, and drawing to communicate investigations and explanations.

D1. Universe
- a. Describe how the sun and moon seem to move across the sky.
- b. Describe the changes in the appearance of the moon from day to day.

D3. Matter and Energy
- a. Describe objects in terms of what they are made of and their physical properties

Social Studies

E1. Historical Knowledge, Concepts, Themes, and Patterns
- c. Identify past, present, and future in stories, pictures, poems, songs, or videos.

Visual and Performing Arts –

B. Creation, Performance, and Expression
- B1. Media Skills – Students use basic media, tools and techniques to create original art works.

Grades 3-5

Science and Technology –

B.1. Skills and Traits of Scientific Inquiry

a. Pose investigable questions and seek answers from reliable sources of scientific information and from their own investigations.
b. Plan and safely conduct investigations including simple experiments that involve a fair test.
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.
e. Communicate scientific procedures and explanations.

C2. Understandings about Science and Technology

a. Describe how scientists seek to answer questions and explain the natural world.
b. Describe how engineers seek solutions to problems through the design and production of products.

C3. Science, Technology and Society

a. Explain how scientific and technological information can help people make safe and healthy decisions.
c. Explain that natural resources are limited, and that reusing, recycling and reducing materials and using renewable resources is important.

D1. Universe

a. Show the locations of the sun, Earth, moon, and planets and their orbits.
b. Observe and report on observations that the sun appears to move across the sky in the same way every day, but its path changes slowly over the seasons.
c. Recognize that the sun is a star and is similar to other stars in the universe.

D4. Force and Motion

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

Social Studies –

E1. Historical Knowledge, Concepts, Themes, and Patterns

b. Identify various major historical eras, major enduring themes, turning points, events, consequences, persons, and timeframes, in the history of the community, Maine, and the United States.

Next Gen Science Standards

Gr. K-2 Space Systems: Patterns and Cycles

1-ESS1-1. Use observations of the sun, moon, and stars remember that the Sun is a star we can see during the daytime.

Gr. 3-5 Space Systems: Stars and the Solar System

5-ESS1.A *The Universe and its Stars*: The Sun is a star that appears larger and brighter than other stars because it is closer.

5-ESS1.B. *Earth and the Solar System.* The orbits of Earth around the sun, and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns.

Gr. 6-8 Space Systems

M-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

MS-ESS1.B. *Earth and the Solar System.* The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

Gr. K-2 Engineering Design

K-2-ETS1-2. Develop a physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Gr. 3-5 Forces and Interactions

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

ELA/Literacy

W.1.7. Participate in shared research and writing projects.

Performance Indicators Snapshot

The Show

Grades Pre. K-2

Science and Technology - A2.b; D1.a, b; D3.a

Grades 3-5.

Science and Technology – B1.a, b, c, d, e; C3.a, c; D1.a, b, c

The Guide

Grades Pre. K-2.

Science and Technology - A2.b; B1.e; D1.a.
Social Studies – History - E1.b.
Visual and Performing Arts - E2.

Grades 3-5.

Science and Technology - B1.b,c, d; C2.a, b; C3.a; D1.a, c; D4.a.
Social Studies – History - E1.b

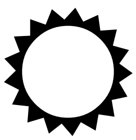
NGSS.

Space Systems – 1-ESS1-1; 5-ESS1.A, 1.B; MS-ESS1-1, 1.B
Engineering Design - K-2-ETS1-2
ELA/Literacy – W.1.7

The Sun Is a Star

Based on The Sun is a daytime star. by Susan Reynolds and Onondaga-Cortland-Madison Board of Cooperative Educational Services Math, Science and Technology.

Objectives and State of Maine Learning Results Performance Indicators:



1. Learners will be able to identify objects that are in the daytime and nighttime sky. (Pre.K-2. Science and Technology. D1.a.)
2. Learners will be able to identify the Sun as the only star visible during the day. (3-5. Science and Technology. D1.c.)
3. Learners will be able to use basic media to draw the daytime and nighttime sky. (Pre.K-2. Visual and Performing Arts. B.1.)

NGSS:

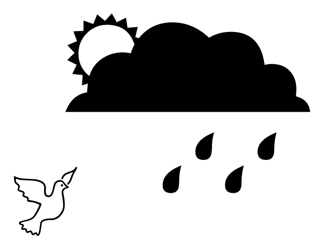
1. Learners will use observations of the sun, moon, and stars remember that the Sun is a star we can see during the daytime. (Space Systems: Patterns and Cycles. 1-ESS1-1)
2. Learners will understand that the Sun is a star that appears larger and brighter than other stars because it is closer. (Space Systems: Stars and the Solar System. 5-ESS1.A)

The General Idea:

When discussing astronomy we often mention the Sun, moons, stars and planets, but for many young students this may inadvertently cause them to believe that the Sun is not a star. The following activity is designed to help students remember that the Sun is a star we can see during the day.

Getting Ready:

- Ask the students to think about, and discuss, when the Sun can be seen.



What You Need:

Paper
Crayons, markers, chalk, etc.
Sunny day

What To Do:

1. Take the students outside on a Sunny day to observe the daytime sky (before going outside, emphasize to the students that they should ***never*** look directly at the Sun because it could hurt their eyes).
2. Have the students write down, or write down for your students, what they see out during the day.
3. Talk to the students about what they think the Sun is, what it's made of, etc.
4. Explain that stars are made of the same things that the Sun is made of; that the Sun is the same as many of the stars we see at night. In fact, the Sun is a star that is closer to us than all other stars and that's why it looks so much bigger.
5. Have students make a list of what they see at night and have a class discussion about the differences between this list and the list of things they see during the day.
6. Have each student fold a piece of paper in half.
7. Have students draw the daytime sky on one side of the piece of paper and the nighttime sky on the other side. Students can use these drawings to remember the differences in the daytime and nighttime sky as well as remembering that the Sun is a star.

What To Discuss:

1. What did you observe in the daytime sky?
2. What did you observe in the nighttime sky?
3. What can be seen in both the daytime and nighttime sky?

How to Build Your Own Rocket: Alka-Seltzer Rockets

Mars Education Program
Jet Propulsion Laboratory, Arizona State University

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to use a model as a tool to describe the motion of an object. (PreK-2. Science and Technology. A2.b.)
2. Learners will be able to safely conduct simple investigations to answer questions. (3-5. Science and Technology. B1.b)
3. Learners will be able to predict the effect of a given force on the motion of an object. (3-5. Science and Technology. D4.a)
4. Learners will be able to use appropriate tools, materials, safe techniques, and quantitative measurements to implement a proposed solution to a design problem. (3-5. Science and Technology. B1.c)

NGSS:
1. Learners will be able to develop a physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. (Engineering Design. K-2-ETS1-2)
2. Learners will be able to make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (Forces and Interactions.3-PS2-2)

The General Idea:

Building this rocket will help you to understand how real rockets propel themselves into space. You can use baking soda and vinegar to propel an object across the floor. The object, in this case your rocket, will slide across the floor by the chemical reaction created from the combination of baking soda and vinegar. A scientist from the early 1700's, named Isaac Newton, had an idea about how things move through space. He said a force pushing on an object will create a second force, with the same strength as the first, going in the opposite direction. This idea is now called Newton's Third Law of Motion.

Getting Ready:

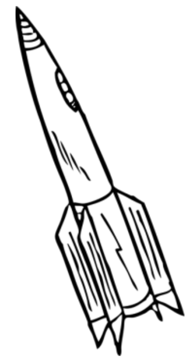
- Gather supplies listed below.
- Arrange all building materials on a large table and in boxes beside the table.

What You Need:

- Paper or index cards
- Tape
- Film canister (Fuji film canisters work the best, see picture)
- Scissors
- Water
- Paper Towels
- Effervescing antacid tablet (Alka-Seltzer)
- Watch or timer

What To Do:

1. Wrap and tape a tube of paper around the film canister. Invert the canister so that the lid lies flat on the table.
2. Cut fins from the index cards and tape them to the rocket.



3. Make a nose by cutting a circle out of paper. Cut out a pie shape from the circle and twist the paper into a cone. Tape the cone together then tape it on the open end of the paper tube.
4. Turn the rocket upside down and fill the canister 1/3 full with water.
5. Drop in a 1/2 tablet of Alka-Seltzer and snap the lid on tight.
6. Quickly stand the rocket upright (lid on the table) and stand back!
CAUTION: Be careful when launching your rocket. Stand back and don't point it at anyone.
7. Make sure you time how long it takes for your rocket to return to earth! This can help you a lot especially if you decide to try an experiment (See the 'What would happen if' ideas below).

What To Discuss:

What would happen if…

- You change the design of your rocket?
- You use more or less fuel (effervescing tablets and water)?
- You use hot or cold water?

Why does your rocket go up?

It goes up because gas is building and building in the closed film canister and since the lid is the weakest point of the canister, the lid pops off and all that gas comes rushing out of the end of the canister. This action can be explained using Newton's Laws of Motion, more specifically it is an example of Newton's Third Law of Motion – "Every action has an equal and opposite reaction". The gas rushing out of one end of the canister (the action) causes your rocket to move in the opposite direction (the reaction). This is exactly how all rockets work whether you use an effervescing tablet as your fuel or a chemical rocket propellant like they do at NASA.

Extensions:

1. If weight were added to the canister (such as clay to the outside of the canister), would that affect the distance and time the rocket was propelled? Why?
2. What role does gravity play in rocket launches? How does a real rocket get beyond the pull of Earth's gravity?

CAUTION: *There is danger of eye or facial injury if rockets are launched upward instead of horizontally. The canisters sometimes discharge prematurely. If canisters are launched upward (vertically), safety glasses should be worn and the activity should be under strict adult supervision.*

Alka-Seltzer Rockets
Student Sheet

Newton's Third Law

If one object exerts a force on a second object, the second object exerts an equal but opposite force on the first.

Directions:
Answer the following questions based on what you learned from you rocket experiments.

1. What do you think was taking place inside the canister with the baking soda and vinegar (or with the effervescent tablet)?

2. Why do you think the canister cap blew off?

3. How is this similar and/or different from a real rocket?

4. How did using different amounts of baking soda effect the time and distance traveled by the canister?

5. How does Newton's Third Law of Motion relate to the rocket launching?

Interplanetary Tourism

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to show the locations of the sun, Earth, moon, and planets and their orbits. (3-5. Science and Technology. D1.a.)
2. Learners will be able to use writing, speaking, and drawing to communicate investigations and explanations. (PreK-2. Science and Technology. B1.e.)
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.)
4. Learners will be able to work effectively in groups, including activities such as brainstorming (3-5. Science and Technology. B1.c.)

NGSS

1. Learners will use observations of the sun, moon, and stars to describe patterns that can be predicted. (Space Systems: Patterns and Cycles. 1-ESS1-1).
2. Learners will participate in shared research and writing projects. (ELA/Literacy. W.1.7.)

The General Idea:

This is an effective and enjoyable project for teaching the properties of a 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 from different locations and countries.

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.

Classroom Planetarium

http://www.discoveryeducation.com/teachers/free-lesson-plans/classroom-planetarium.cfm
created by Jesse Kraft, an elementary school teacher in Fairfax County, Virginia
Appropriate for Grades K-5

Objectives and State of Maine Learning Results Performance Indicators:

1. Students will be able to understand the relationship of the eight planets in our solar system to the sun by creating a three-dimensional representation. (3-5. Science and Technology. D1.a)
2. Students will be able to understand the planets' relative distance from the sun and their approximate size in relation to the Earth. (3-5. Science and Technology. D1.a)

NGSS:

1. Learners will understand that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (Earth and the Solar System: MS.ESS1.B)

The General Idea:

Begin by leading the class in creating a web of planet facts to tap students' prior knowledge of astronomy topics. When the web is as big as it's going to get, share some basic planet facts with your students: Mercury is closest to the sun, Venus is the hottest planet, Earth is mostly water, Mars is red because of rust, Jupiter is the largest planet and has a spot, Saturn's rings are made of ice and rock, Uranus spins like a bowling ball, Neptune's blue color is methane, and Pluto is the smallest planet. After sharing this information, provide your students with pictures of the planets, then have them paint balloons—you can inflate them and cover them with paper ahead of time—to reflect what they have learned.

What You Need:

- Round balloons of different sizes
- tempera paint and paint brushes
- fishing line (or strong string)
- construction paper
- newspaper torn into strips about one inch wide
- space paste (see instructions below)
- S-clips to suspend models from ceiling tile frames (large paper clips bent into L shapes or strong loops of tape will work as substitutes)

What To Do:

1. Before you begin the activity, you will need to create a batch of "space paste." You can do this by mixing papier-mâché mix (or flour) and water to make a thick paste. Use about one part mix (or flour) to three-quarter parts water.
2. When the paste is ready, divide your students into nine groups. Assign each group a planet. Provide each student with a copy of the Planet Information Sheet. Ask your students to fill in the chart using information they gather from library books, the Internet, or the TLC Elementary School documentary "Astronomy".
3. While they are working, turn a class bulletin board into a huge sun using construction paper. Invite any students who finish their research early to add solar flare designs to the sun.
4. Give each group a balloon. Explain to your students that all of the balloons should not be blown up to the same size. Stress that approximate size is all that is necessary, but that the big planets should be noticeably larger than the smaller ones.

5. Provide each group with a long piece of fishing line. Ask them to tie the line around the end of their balloon.
6. Provide each group with a supply of space paste and newspaper strips. Instruct them to dip each strip into the paste, gently pull it through their fingers to wipe off extra clumps, and then paste it onto balloon. They should use many layers, working until the balloon is covered completely. Encourage them to apply extra layers to make their balloons seem as round as possible. (The planets aren't perfect spheres, so they don't need to worry too much about roundness.)
7. Allow the balloons to dry. While they are drying, students should decide how they are going to paint the surface of their balloons. Which colors will really bring out the physical landscape? When the balloons are ready—which might not be for a while—have students paint them.
8. While the painted planets are drying, meet with each group to determine where its planet should hang in relation to the sun image. You can use these approximations for distance from the sun:

    Mercury—58.9 million km; **Venus**—108.2 million km; **Earth**—149.6 million km;

    Mars—227.8 million km; **Jupiter**—778 million km; **Saturn**—1,427 million km;

    Uranus—2,870 million km; **Neptune**—4,500 million km; **Pluto**—5,900 million km.
9. When the group has chosen a location, affix the dried planet model to the ceiling using the fishing line and the S-clips. Attach the appropriate Planet Information Sheet to each model.
10. When the project is complete, you might want to invite other classes to come visit.

Adaptations:

Begin leading the class in creating a web of planet facts to tap students' prior knowledge of astronomy topics. When the web is as big as it's going to get, share some basic facts with your students: Mercury is closest to the sun, Venus is the hottest planet, Earth is mostly water, Mars is red because of rust, Jupiter is the largest planet and has a spot, Saturn's rings are made of ice and rock, Uranus spins like a bowling ball, Neptune's blue color is methane, and Pluto is no longer a planet but a dwarf planet and is the smallest. After sharing this information, provide your students with pictures of the planets, and then have them paint balloons – you can inflate them and cover them with paper ahead of time – to reflect what they have learned.

What To Discuss:

1. Have you ever noticed how the moon is a different shape every night? Half of the moon is always lit up by the sun, but the half that's lit isn't always facing directly towards us. What if you were a moon creature looking at the Earth night after night? Would the Earth be a different shape every night too? Why?
2. Did you know that gravity is weaker on the moon than on the Earth? If you're standing on the moon, it's a lot easier to move around and lift heavy objects. Think of your favorite game or sport. How would it be different if you played it on the moon?
3. Uranus is different from the other planets. It spins like a bowling ball instead of like a top. Can you think of a reason why it does that?
4. Believe it or not, Pluto is actually smaller than the Earth's moon! Some astronomers say it's not really a planet (it got demoted in 2006). They think it used to be a moon that circled Neptune, but that it somehow got away. What do you think? Is Pluto a planet or a lost moon?

Assessment:

Have each group present an oral report to the class about its model and research. Students should explain their model. Why did they make their choices (color, size, and distance from the sun)? They should also share everything they learned and recorded on their Planet information sheet. This will allow you to assess student understanding of the information. It will also allow other students in the class to learn about the planets they did not research.

Extensions:

This is Some Field Trip!

Have your students make picture books about a trip they took with their classmates to one of the other bodies in the solar system – the moon, the sun, or one of the planets. Illustrations and text should teach their "readers" about astronomy. They can share their work with a younger class.

Outer Orbits

Students work individually or in groups to design a board game that takes planers through the solar system as they move around the board. The path from START to STOP could spiral out with stops on each planet. On each planet they could be asked a space science question. Each student or group can decide on specific rules of play.

Space Mail

Students design postcards from the planets and the moon, complete with a commemorative stamp. They should write a short message to a friend at home on Earth, explaining how their space vacation is going – the sights they have seen, what the terrain looks like, and how long it will take them to return.

The Maynard F. Jordan Planetarium - Cosmic Classroom Activity

Reasons for the Season

This lesson is part of the Sixth Grade Science Teacher Resource Book (TRB3) http://www.uen.org/Lessonplan/preview.cgi?LPid=2499
Author: Utah LessonPlans
Additional Resources: Alan Gould, Carolyn Willard and Stephen Pompea. The Real Reasons for Seasons Sun-Earth Connections. GEMS Lawrence Hall of Science, University of Berkeley, CA, 2002.

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to describe the relationship between the tilt of Earth's axis and its yearly orbit around the sun. (3-5. Science & Technology. D1.b)
2. Learners will be able to communicate effectively using scientific language and reasoning. (3-5. Science and Technology. B1.a)
3. Learners will demonstrate awareness of social and historical aspects of science. (3-5. Science and Technology. C3.a)
4. Learners will be able to examine the ways people form generalizations. (3-5. Science and Technology. B1.e)

NGSS:

1. Learners will understand that the orbits of Earth around the sun, and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. (Space Systems: Stars and the Solar System. 5-ESS1.B)
2. Learners will develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (Space Systems: M-ESS1-1.)

The General Idea:

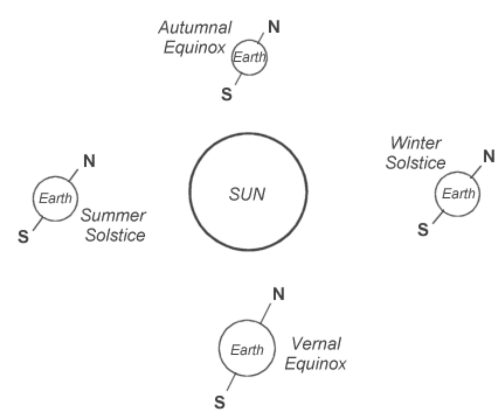
In this activity students will learn how Earth's axis of rotation affects the angle of sunlight and the length of day. Students will first learn the relationship between the height of a light source and the length of the shadow cast by an object in the path of the light source. They will record shadow lengths to infer changes in the sun's angle over at least a 3-month period. They will also record the high temperatures on the days where shadow lengths are recorded. Finally, students will compare day length with the high temperatures.

Getting Ready:

Have you ever run laps on a track? When you complete one lap you are back in the same place you started. Earth moves around the sun in a path that nearly repeats itself (like running a track) about every 365.25 days. Earth's path around the sun is called its orbit.

Earth's axis of rotation is an imaginary line that passes through Earth's North and South poles. Earth rotates around this axis, which causes day and night. Earth's axis of rotation is not straight up and down with respect to its orbit, but is tilted by about 23.5 degrees with respect to this up and down direction.

If you have ever watched the North Star, you may have noticed that it seems to stay in the same place in the sky all of the time. It is almost directly above Earth's North Pole. This shows that Earth's axis of rotation points in the same direction while Earth both rotates on its axis and moves in its orbit around the sun.



About June 21 every year, Earth is at a place in its orbit where the northern side of its axis is tilted toward the sun. Six months later, about December 21, Earth is on the other side of the sun where its northern axis is tilted away from the sun.

When the northern side of Earth is pointed away from the sun in December, the sun appears low in the sky and the angle of the sun's rays is small. In June when the northern side of Earth is pointed toward the sun, the sun appears high in the sky, and the angle of the sun's rays is large. In the spring and fall the angle of the sun's rays is half way between the angle in winter and the angle in summer.

The days with the least amount of daylight are not the coldest days, nor are the days with the most amount of daylight the warmest days. This is because some materials can be heated and cooled quickly (especially metals). Other materials can absorb heat without changing their temperature very much, so it takes a long time to heat and cool them. Water is a good example of this. About 3/4 of Earth's surface is covered by water which causes the heating and cooling of Earth to take place slowly. Although the maximum amount of heat received by the sun in the Northern hemisphere occurs on June 21, the highest average temperatures occur about one month later. Similarly, the lowest average temperatures occur after the date when the Northern Hemisphere receives the least amount from the sun.

<u>What You Need</u>:

- " Season Survey ", 2-3 copies per student (pdf file – see attached)
- meter sticks or measuring tapes
- lamp or flashlight
- dark room
- outdoor thermometer (a minimum/maximum thermometer would be ideal)
- graphing paper
- sunrise/sunset and temperature dates for the State of Maine (http://www.erh.noaa.gov/er/gyx/index.php)

<u>What to Do</u>:

1. Give each student 2 or more copies of the "Season Survey." Have each student complete a copy of the survey. Have them ask a family member or friend (not a member of the class) to complete the other(s). When all the surveys have been completed, together as a class, tally the number of responses for each answer choice for each survey question. Discuss with the class to determine which answers are correct. If a particular answer had the highest number of responses, does that mean that it is the correct answer? Explain that historically the majority of people have believed incorrect ideas. Ask if they can think of any examples? (Earth is flat; Earth is center of the universe) Explain that the best way to find out the correct answers is to research the problem. This will be done by making observations and by learning what other scientists have discovered.

2. In a darkened room have a student hold a meter stick upright where everyone will be able to see the shadow. Move the lamp or flashlight up and down to show that when the light source is high, the shadow cast by the meter stick is short. When the light source is low, the shadow is long. Have another student sit near the meter stick and have them point to the light source with their extended arm. The angle of the student 's arm is large when the light source is high and smaller when the light source is low.
   [Sun Shadow Observations - WARNING! - Never look directly at the sun!]

3. Begin shadow measurements on a sunny day. Select a straight up and down object on the school grounds such as a flagpole, tetherball pole, or basketball standard. Choose a time of day when students will be able to consistently make measurements (perhaps a recess break). It is very important that the shadow be measured at the same time of day each time it is measured. With the whole class watching, demonstrate how to measure the shadow cast by the object. It is also important that it is measured consistently each time. Before going outside to measure, decide on a format for keeping track of the records in student science journals. Have students record the date, time and length of the shadow in their science journals.

4. Arrange for an outdoor thermometer to be placed outside your classroom (not in direct sunlight). Have students record the high temperature for the days they observe the sun's shadow. You will need to work out a system for finding the high reading. Thermometers are available with a remote sensor so they could be read inside. Or, if you use a minimum/maximum thermometer it will automatically register the high (and low) temperature each day. An alternative to tracking and recording the actual temperatures is to find and record the official weather temperatures in the newspaper or on the Internet.

5. Continue to make observations with the whole class for about a week. Little change will be noticed, but it will set the pattern for further observations.

6. Organize the class in teams of two or three to continue making observations. Arrange a schedule for the class observations and a method for sharing information with other class members. Continue to make records for a period of at least 3 months. Ideally it would be best to keep records through the school year so students could see the seasonal changes.

7. Periodically discuss with your class what is happening to the length of the shadow. Have them note what is happening to the amount of daylight. This is a good time to discuss sunrise and sunset times. Discuss why this is happening. Be sure students know that Earth's axis of rotation is the reason for the sun's changing position in the sky.
8. Have students calculate the length of daylight for two days each month. Or you may have students gather information from newspaper or Internet sources or from class observations.
9. After sufficient data is collected, organize students in small groups to make the following series of graphs: a graph showing the shadow changes, a graph showing temperature highs, and a graph showing length of daylight. Compare the similarities and differences of the three graphs. Students may notice that the coldest days are not the days with the shortest shadow or the least amount of daylight. Help them understand that one reason for this discrepancy is because the materials Earth is made of take time to cool and warm.

Extensions:

- Students locate and use Internet sources to keep track of sunrises and sunsets and daily temperatures.
- Have students make two or three graphs on the same graph paper to show comparisons.
- Use this demonstration to show students how water heats and cools relatively slowly. Fill a pan with water and place it on a hot plate, turned on high. Help students notice that the pan heats up quickly, but the water does not. Monitor the temperature of the water throughout the experiment. Turn the hot plate down slightly to medium-high. Observe whether the water becomes immediately cooler. It does not. Actually the water temperature may go up. The water temperature does not respond quickly to temperature changes. Relate this to how the earth's surface (3/4 water) does not heat up or cool down immediately.

Assessment Plan:

1. Refer to the original survey students took at the beginning of the unit. Have them take the survey again. Discuss the correct answers.
2. Have students choose one misconception about the way people erroneously think about the seasons and write why the misconception is false and what the correct answer is.

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

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to identify objects in the sky. (3-5. Science and Technology. D1.a.)
2. Learners will be able to identify events associated with historically-based traditions. (PreK-2. Social Studies. E1.b.) (3-5. Social Studies. E1.b)
3. Learners will be able to use data to construct and support a reasonable explanation. (3-5. Science and Technology. B1.d.)

The General Idea:

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.

Getting Ready:

Photocopy enough Student Activity Sheets for each student in class

What You Need:

- Student Activity Sheet
- Pencil

What To Do:

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.
Asteroid	Small rocky or metallic bodies in the Solar System.
Asteroid Belt	The region between Mars and Jupiter containing numerous rocky asteroids.
Comet	Frozen masses of gas and dust which have a orbit through the solar system.
Compass	A tool for finding directions that uses a magnet to find magnetic North.
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).
Dwarf Planet	A classification of a minor body which is neither a planet nor a satellite of a planet (i.e., a moon). Dwarf planets in our Solar System include Pluto and Ceres, where Ceres is located in the asteroid belt.
Eccentricity	A measure of how much an object's orbit differs from a perfect circle. An eccentricity of 0 means that the orbit is circular while a larger eccentricity indicates that the orbit is non-circular. Bodies in our Solar System have eccentricities varying from 0.007 (Venus) to 0.248 (Pluto).
Equinox	Two specific times of the year when the path of the Sun intersects the celestial equator. At these times, the tilt of the Earth's axis is neither away from nor toward the Sun. The vernal (spring) equinox is around March 20th and the autumnal equinox is around September 22nd.
Galaxy	A cluster of stars, dust, and gas held together by gravity.
Gravity	The force of attraction between two objects which is influenced by the mass of two objects and the distance between the two objects.
Meteor	small particles of matter in the solar system that are observable only by their burning on entry into the atmosphere.
Milky Way galaxy	large spiral galaxy consisting of several billion stars, one of which is the Sun.
Moon	A natural satellite orbiting a planet.
Orbit	(noun) A specific path followed by a planet, satellite, etc. through space. (verb) The act of moving through space
Planet	A body orbiting a star. Planets must be massive enough to be roughly spherical in shape but not massive enough to undergo thermonuclear fusion in their cores like a star.
Retrograde	The apparent backwards motion of a body. Planets can show retrograde motion relative to one another: as seen from Earth, Jupiter briefly appears to move backwards relative to the background stars when Earth overtakes Jupiter in its orbit around the Sun.

Revolution	The circling of a smaller object around a larger object.
Rotation	The spinning of an object on its axis.
Solar System	The system of planets, moons, and other objects revolving around a star (in our case, the Sun).
Solstice	Two specific times of the year when the path of the Sun is at its highest or lowest point relative to the celestial equator. At these times, the tilt of the Earth's axis is oriented the most steeply toward or away from the Sun. The summer solstice is around June 21st and the winter solstice is around December 21st.
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).
Zodiac Constellation	One of 12 constellations that the Sun appears to pass through during the course of the year: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces.

Some good books to use with *Cardboard Rocket*

The Magic School Bus: Out Of This World
Posner, Jackie (adaptation). Illu. By Robbin Cuddy. 1996, Scholastic Inc.

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

The Planets in Our Solar System
Branley, F. 1986, Harper & Row.

Postcards from Pluto: A Tour of the Solar System
Leedy, Loreen. 1993, Holiday House.
Dr. Quasar gives a group of children a tour of the solar system

I Didn't Know The Sun is a Star
Petty, Kate. 1997, Copper Beech Books

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.

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.

Pluto
Vogt, Gregory. 1994, The Millbrook Press

Some good web sites to use with *Cardboard Rocket*

ssd.jpl.nasa.gov

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

spaceplace.jpl.nasa.gov/spacepl.htm

The Jet Propulsion Laboratory's web site for kids

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.

multiverse.ssl.berkeley.edu/Learning-Resources

Multiverse – Increasing diversity in Earth and Space Science through Multicultural Education at U. C. Berkeley. Includes Classroom Lessons, Hands-on Activities, and Online Activities.

btc.montana.edu/ceres

Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

www.discoveryeducation.com/teachers

Discovery Education offers a broad range of **free classroom resources** that allows teachers to search for lesson plans by grade and subjects.

Astronomy Web Sites Worth a Visit

Astro.umaine.edu

The Maynard F. Jordan Planetarium and Observatory home page.

hawastsoc.org

The Hawaiian Astronomical Society's home page

www.nss.org

The National Space Society page

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 and Information

Post Test – *Cardboard Rocket*

Season Survey

Post Test – Cardboard Rocket

Check your comprehension of the planetarium show!

1) How many Earth days does it take Mercury to revolve around the Sun?

2) What is the hottest planet in the Solar System? ___________. And why is it so hot?

3) What is the only planet in the Solar System that we know for sure has life and books? _____________.

4) Why is Mars red?

5) What is the Great Red Spot and how large is it?

6) Why is Saturn like a marshmallow?

7) The remarkable thing about Uranus is that it's _____________________.

8) Which gas giant is colored blue from all the methane in its atmosphere?

___________.

9) If you were standing on Pluto, what would the Sun look like?

10) What is the secret of the cardboard rocket?