

Secret of the Cardboard Rocket

Planetarium Show – Teacher’s Guide

PROGRAM OUTLINE

Description: In *The Secret of the Cardboard Rocket*, viewers join two young explorers as they magically travel through the Solar System aboard their handcrafted cardboard rocket. With “Book,” the talking astronomy book, as their guide, the travelers visit the Sun and the planets. They land on Venus, Mars, and Pluto, fly through the Great Red Spot on Jupiter, and view the other planets and the Sun from close vantage points. As they tour the Solar System, “Book” relays interesting facts about each planet, making sure that his students learn while on their wild ride.

Activities: Modeling the planets’ sizes; modeling distances in the Solar System; scaling the Solar System with toilet paper; seasons: the effect of the Earth’s tilt and the Sun’s rays; Planet Bingo; measuring the diameter of the Sun and the Moon; simulating Jupiter’s motion.

LEARNING OBJECTIVES

- Planets are different sizes. *Understand the relative sizes of planets and the fact that the gas giant planets are much larger than the terrestrial planets.*
- The planets in our Solar System are arranged at different distances from each other. *Learn how the Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, and Uranus are spread out within the Solar System.*
- The seasons on Earth are caused by the tilt of our planet’s axis. *Learn how the Sun’s light shines more directly or less directly on planets depending on if the planet is tilted toward or away from the Sun.*
- The Sun is much larger than all of the planets. *Measure the diameter of the Sun and compare this value to the diameter of the Earth.*

- Different constellations are visible at different times of the year, because of the Earth's motion around the Sun. *Demonstrate how our view of the stars changes throughout the year.*

Process Skills Focus: Inquiry, observation and communication.

Topics: The Solar System, planets, seasons, constellations.

OREGON STANDARDS

Scientific Inquiry Standards:

- K.3S.1 Explore questions about living and non-living things and events in the natural world.
- K.3S.2 Make observations about the natural world.
- 1.3S.2 Record observations with pictures, numbers, or written statements.
- 1.3S.3 Describe why recording accurate observations is important in science.
- 2.3S.2 Make predictions about living and non-living things and events in the environment based on observed patterns.

Engineering Design Standards:

- 1.4D.3 Show how tools are used to complete tasks every day.
- 2.4D.3 Describe an engineering design that is used to solve a problem or address a need.

Earth and Space Science Content Standards:

- K.2E.1 Identify changes in things seen in the sky.
- H.2E.3 Describe how the universe, galaxies, stars, and planets evolve over time.

Physical Science Content Standards:

- K.2P.1 Examine the different ways things move.

NEXT GENERATION SCIENCE STANDARDS

Practices

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
7. Engaging in argument from evidence

Crosscutting Concepts

1. Patterns
2. Cause and effect
4. Systems and system models

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a	✓		n/a		✓	✓	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

DCI Grade Band Endpoints

ESS1.A *Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (By end of grade 2).*

The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (By end of grade 5).

Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (By end of grade 8).

Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (By end of grade 8).

ESS1.B *Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (By end of grade 2).*

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. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (By end of grade 5).

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. (By end of grade 8).

This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (By end of grade 8).

Performance Expectations

1-ESS1-1. *Use observations of the sun, moon, and stars to describe patterns that can be predicted.*

1-ESS1-2. *Make observations at different times of year to relate the amount of daylight to the time of year.*

5-ESS1-1. *Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.*

5-ESS1-2. *Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*

MS-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-ESS1-2. *Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.*

MS-ESS1-3. *Analyze and interpret data to determine scale properties of objects in the solar system.*

GLOSSARY

Asteroid:	Small rocky or metallic bodies in the Solar System.
Asteroid Belt:	The region between Mars and Jupiter containing numerous rocky asteroids.
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 20 th and the autumnal equinox is around September 22 nd .
Moon:	A satellite orbiting a planet.
Orbit:	(noun) The path of a body through space. (verb) The action of moving through space.
Period of Revolution:	The time that it takes for a body to revolve around another object. The Earth's period of revolution around the Sun is approximately 365 days.
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.

- Rotation Period:** The time that it takes for a body to rotate on its axis. The Earth has a rotation period of roughly 24 hours.
- Solar System:** The arrangement of eight planets orbiting around the Sun. The asteroid belt between Mars and Jupiter is also part of the Solar System.
- 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:** Our nearest star, located approximately 93 million miles from Earth.
- 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.

POST-VISIT QUIZ

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?

SUGGESTED CLASSROOM ACTIVITIES

Model the Planets' Relative Sizes

Description: In this activity, students become familiar with the relative sizes of the planets in the Solar System.

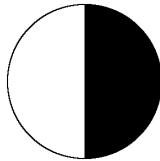
TIME REQUIRED

Advance Preparation



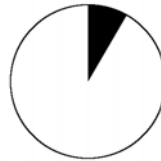
5 minutes

Activity



30 minutes

Clean Up



5 minutes

SUPPLIES

- Construction paper
- Rulers
- Scissors
- Compasses to draw circles (one for each student or group)
- Tape

ACTIVITY

- Students should work in groups. Measure, draw, and cut construction paper circles of appropriate diameters to demonstrate the general appearances and relative sizes of each planet. Display the model planets in the classroom. They may be able to be hung from the ceiling or taped to the walls. Be sure students understand that, while the relative sizes of the planets are to scale, the distances between the planets will not be.
- The paper should be cut to the following sizes, depending on the planet. Paper colors are also suggested.

Object	Paper Diameter	Paper Color
Sun	109"	Yellow
Mercury	1/2"	Gray
Venus	1"	Yellow
Earth	1"	Blue
Earth's moon	1/4"	White
Mars	1/2"	Red
Jupiter	11"	Tan
Saturn	9"	Tan
Uranus	4"	Green
Neptune	4"	Neptune
Pluto	1/4"	Gray

This activity can be expanded for older students to include the moons of the planets. Have the students determine the scaling factor for the model by finding the actual diameters of the planets and comparing that with the diameters in the model. After looking up the actual diameters for the moons of the other planets, they can calculate the model size for each moon using the equation below.

$$\frac{(\text{planet's model size})}{(\text{planet's actual size})} = \frac{(\text{moon's model size})}{(\text{moon's actual size})}$$

Modeling Distance in the Solar System

Description: These two activities present complementary ways of discussing the distances between planets in the Solar System. The first activity requires a large outdoor space (1030 yards) while the second activity can be accomplished in less space (37 yards).

The first activity, "**The Thousand and Thirty-Yard Solar System**," requires a large area but is preferable to the second activity as it allows students to compare the sizes of the planets to the space between them and better demonstrates the hugeness of space. The second activity, "**Scaling the Solar System with Toilet Paper**," has the advantage of requiring less room. On its scale, however, the planets would be tiny. This means that this activity doesn't allow students to easily visualize the sizes of the planets relative to each other or to the space between them. It has been included as a second-choice activity in

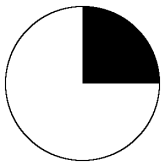
case the amount of space needed for “**The Thousand and Thirty-Yard Solar System**” is impossible to find.

In both activities, Pluto is included as a planet. Even though Pluto is technically classified as a dwarf planet, we have included it here to emphasize the enormous distances between bodies in the Solar System.

The Thousand and Thirty-Yard Solar System

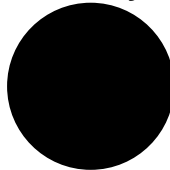
TIME REQUIRED

Advance Preparation



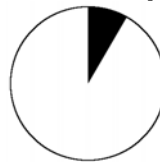
15 minutes

Activity



60 minutes

Clean Up



5 minutes

SUPPLIES

- 10 index cards
- Tape

Objects to represent the Sun and the planets:

- Sun – any ball, diameter 8 inches (a standard bowling ball is about 8 inches across. Inflatable balls of about the right size are also fairly easy to find).
- Mercury – a pinhead, diameter 0.03 inch
- Venus – a peppercorn, diameter 0.08 inch
- Earth – a second peppercorn
- Mars – a second pinhead
- Jupiter – a chestnut or a pecan, diameter 0.90 inch
- Saturn – a hazelnut or an acorn, diameter 0.70 inch
- Uranus – a peanut or coffee bean, diameter 0.30 inch
- Neptune – a second peanut or coffee bean
- Pluto – a third pinhead

Note:

Using distinct objects, such as peanuts and pins, is helpful because students associate sizes with the objects. This method helps them remember the relative sizes of the planets and their tiny size relative to the space around them.

ADVANCE PREPARATION

- Stick each pin through an index card; this technique makes the pins easier to see. Tape the other objects to index cards. Label each card appropriately. This helps keep the planets straight and makes the items harder to lose.

ACTIVITY

- Place all the objects on a table. Let the students examine them and have the students place the planets in the correct order (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto) next to the Sun.
- Once the objects are in the correct order, ask the students how much space they think you will need to make a model of the solar system using these objects. Young students may guess that the tabletop will be enough. Older students may guess the length of the room or the hallway will suffice.
- Introduce the idea of scale. You can take this discussion to various levels depending on the age of your students. For young students, a common example of scaling is probably sufficient. Here is one you can use: if an automobile is 5 meters (500 cm) long and your model car is 10 cm long, then the scaling factor is $500 \text{ cm} \div 10 \text{ cm} = 50$.
- Point out that in our model the tiny peppercorn represents the entire Earth that we live on! In the real Solar System, the Earth is 8,000 miles in diameter. In our model, the peppercorn is about $\frac{8}{100}$ of an inch in diameter. *So, in our model, 1 inch represents 100,000 miles.* The distance between the Earth and the Sun is 93,000,000 miles, or 930 inches in our model. That's about 26 yards, or 26 steps for an adult human. To emphasize how far this is try to take 26 paces across the room. You will probably hit the opposite wall! To complete your model, it will be necessary to go outside.
- Calculate the scaled distances between each planet, using the real distance to each planet and the conversion factor of 1 inch = 100,000 miles in our model. The values are listed below.

Planet	Real distance from the Sun (miles)	Model distance from the Sun (yards)
Mercury	36,000,000	10
Venus	67,000,000	19
Earth	93,000,000	26
Mars	142,000,000	39
Jupiter	483,000,000	134
Saturn	885,000,000	246
Uranus	1,787,000,000	496
Neptune	2,800,000,000	778
Pluto	3,700,000,000	1028

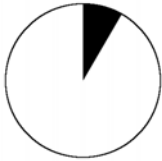
- Hand one planet to each group of students and go outside to the beginning of the 1,030 yard route you have chosen.
- Start by placing the Sun ball on the ground. Walk 10 yards (about 10 steps) and have the student holding the pinpoint labeled Mercury set the planet down. It's another 9 paces to Venus and another 7 to Earth. When you get to Earth, turn around and look back at the Sun and the other planets. The distance and tiny size of the planets might seem astonishing! The Sun warms the tiny peppercorn Earth from this far away. We can see Venus when it is "near" the setting Sun on our horizon. And yet there is so much space between the Sun and these inner planets.
- Continue on your journey, placing each planet on the ground when you come to the appropriate distance. You may need to place rocks on the cards to keep them from blowing away.
- If the distances between the Sun and the terrestrial planets don't surprise students, the distance to the gas giants should. From Mars to Jupiter you must walk 95 yards; that's more than two times further than you've walked so far!
- When you finish the activity, you will have walked over half a mile. (One mile is 1,760 yards.) Now, look back now towards the Sun. You can't see it. You won't even be able to see it with binoculars! Now look down at the pinhead that is Pluto. You may begin to feel the enormous size of our solar system.
- Turn your class around and retrace your steps. Re-counting the paces between the planets gives them a chance to learn them and looking for the little objects reemphasizes how lost they are in space.

- Have the student who retrieves each planet write on the card a brief description of where it was - “At 9th Street,” “In front of the public library”, etc. When you get back to the classroom, you can hang the objects on the wall or from the ceiling to remind the students of their journey.

Scaling the Solar System with Toilet Paper

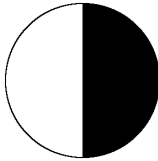
TIME REQUIRED

Advance Preparation



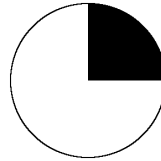
5 minutes

Activity



30 minutes

Clean Up



15 minutes

SUPPLIES

- 10 index cards
- Two rolls of 500-sheet toilet paper

ADVANCE PREPARATION

- Write the name of the Sun and the nine planets on the index cards, one object per card.

ACTIVITY

- Spread the index cards on a table and have the students arrange them in the correct order (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto).

- If you want to include learning about each planet in this lesson, see if the students can tell you something about each planet. If they can't, help them out. Here are examples of what you might tell them:

Mercury is a barren rock. It orbits the Sun in just 88 days. The side facing the Sun can reach temperatures around 700 degrees Fahrenheit, while the side away from the Sun has temperatures of about -330 degrees Fahrenheit.

Venus has thick clouds of sulfur that trap the Sun's heat and make it the hottest planet in the Solar System. It also rotates in the opposite direction as most of the other planets. Of all the planets, only Mercury and Venus do not have moons.

Earth is our home and is the only planet we know of (so far) in the whole universe that has life. About 70 percent of Earth is covered in oceans.

Mars is a red planet with very little atmosphere. It is a cold desert with a volcano the size of Oregon and a canyon that would stretch across the entire United States. It has ice caps at its poles.

Jupiter is the largest planet and the first of the Gas Giants. It is home to the Great Red Spot, a storm that is so large that the four terrestrial planets could fit inside. Jupiter also has the most moons of any planet (more than 60!).

Saturn is the second largest planet. It has bright rings of rock and dust around it. These rings can be seen through a telescope from Earth. Saturn is also the least dense of the planets. If you could make a cup of hot chocolate large enough to put Saturn in, Saturn would float like a marshmallow!

Uranus orbits the Sun tipped over on its side and rotates backwards. Like Saturn, it has rings made of particles ranging from 10 meters in diameter to tiny pieces of dust. However, unlike Saturn, Uranus's rings are dark and very difficult to see.

Neptune has the fastest winds of any planet in the Solar System. The winds of this gas giant can reach 1,200 miles per hour.

Pluto is a small and cold dwarf planet. Like Uranus, Pluto orbits on its side.

- The distance between the Sun and the Earth is 93 million (93,000,000) miles. In our model, we will represent this distance with 0.93 meters of toilet paper. *So, in this model, 1 meter = 100,000,000 miles.*
- Have your students calculate the scaled distances from the Sun to each planet, using the conversion that 100,000,000 miles of actual distance is equal to 1 meter in the model. You could also have them calculate the diameters of the Sun and planets on this scale. (They will be very small! Only the Sun would be wider than 1 cm in diameter. Jupiter, the largest planet, would only be 0.8 cm across). The values are listed below.

Planet	Real distance from the Sun (miles)	Model distance from the Sun (number of toilet paper sheets)
Mercury	36,000,000	3.6
Venus	67,000,000	6.7
Earth	93,000,000	9.3
Mars	142,000,000	14.2
Jupiter	483,000,000	48.3
Saturn	885,000,000	88.5
Uranus	1,787,000,000	178.7
Neptune	2,800,000,000	280.0
Pluto	3,700,000,000	369.9

- Take the toilet paper rolls and the index cards to the beginning of a route 37 meters long (37 meters is roughly the length of 370 sheets of toilet paper, the distance between the Sun and Pluto). Place the index card Sun on the ground. Unroll the toilet paper, laying the index cards with the appropriate planet names on it at the appropriate distances from the Sun.
- After building the model, remind students that the planets, even the gas giants, would be smaller than a centimeter on this scale. Have the students compare the distances between the planets and reflect on how far away each is from the Sun.

Seasons: The Effect of the Earth's Tilt

Description: This activity presents how the tilt of the Earth on its axis results in seasons and the changing length of the day throughout the year.

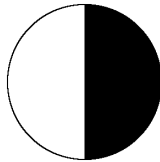
TIME REQUIRED

Advance Preparation



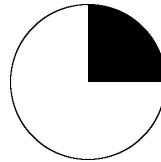
5 minutes

Activity



30 minutes

Clean Up



15 minutes

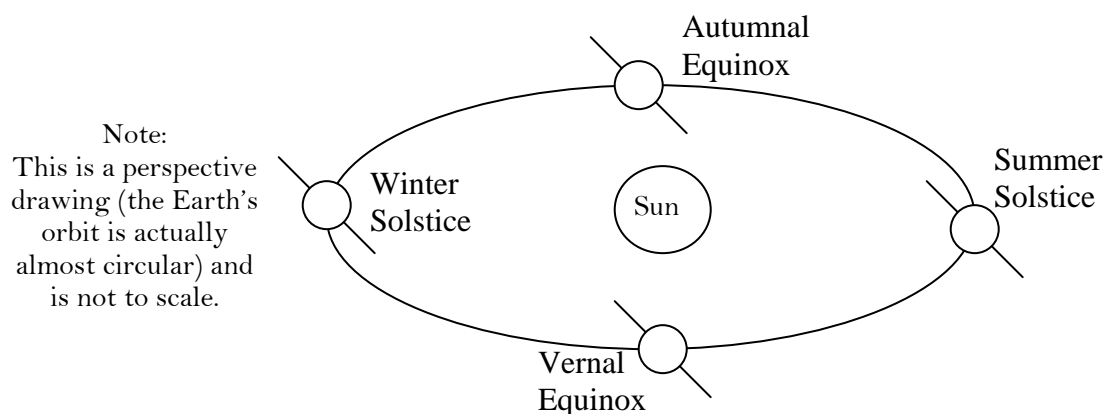
SUPPLIES

- Small lamp without a shade
- Small Styrofoam balls, one for each student
- Pencils, one for each student
- Markers
- Dark room

ACTIVITY

- Give each student a Styrofoam ball. This ball represents the Earth. Each student should draw a circle around the center of the ball. This line represents the equator. Mark an "X" for his/her approximate location on the globe (45 degrees above the equator for Portland, since we're at a latitude of 45 degrees). Poke a pencil into the bottom of the ball. This pencil indicates the axis of the Earth.
- Place the lamp in the middle of the room on a table. This is the Sun. First, have the students hold their globes with the north and south axes straight up and down at about the same height as the lamp. Each student should be a few feet from the Sun and should do their best not to block the light for other students.

- Turn off the room lights so that students can clearly see the lamp's light on their globes. They should notice that half of the Earth is dark and half is light. This represents day and night. Have them rotate their globes. See if they can reason out which way to rotate the globe. If they have trouble, ask them where the Sun rises. See if they can turn the globe in the correct direction to make the Sun rise in the East from the perspective of a person standing on its surface. (Looking down on the North Pole, the Earth rotates counterclockwise.)
- Now the students should move in a circle counterclockwise around the Sun, stopping at various points and rotating their globe. What do they observe about the lengths of the days? They should notice that they are all the same length. Hopefully, when they notice this they will realize that there is something wrong with the model, because our days on Earth are not equal lengths all year long. If they don't, you can lead them in that direction until they make that conclusion.
- To make the days different lengths, the Earth must be tilted on its axis. In fact, the Earth is tilted at an angle of 23.5 degrees from the upright position. Students should tilt their globes about 23.5 degrees (remember that tilting the Styrofoam ball by 90 degrees would point the north pole right at the Sun). Each student should keep the axis of his/her globe tilted and walk around the Sun as they did before. The North Pole should always point to the same spot in the room as they circle the Sun. You can hang a star cutout on the wall to symbolize Polaris, the North Star, so students can easily see where their axes should point, or you can simply choose an object in the room to represent the North Star.
- The students should stop at least at the following locations around the Sun and rotate their globes:



These four points represent the summer and winter solstices, and the vernal and autumnal equinoxes.

- Notice how the length of the days changes from season to season. Also, notice the angle of the Sun's rays on each hemisphere at each season. During half of the year, the Northern Hemisphere is pointed more directly toward the Sun. During this time, the days are more than 12 hours long. This is the spring and summer. For the other half of the year, the North Pole is tilted away from the Sun. The days in the Northern Hemisphere are shorter, the nights are longer, and the sunlight falls indirectly, or at an angle less than 90 degrees, on this hemisphere. This is fall and winter for the Northern Hemisphere. Halfway between summer and winter, during the spring and fall, the Sun's rays fall directly on the Equator. These are the spring and autumnal equinoxes, dates when the day and night are of equal length in both hemispheres. In the Southern Hemisphere the seasons are the opposite.
- At the end of the activity, students should be able to tell you that we have seasons because of the Earth's tilt on its axis. The axis always points in the same direction in the sky (toward Polaris, the North Star). As the Earth goes around the Sun, this tilt causes the changing seasons. The days are longer in the summer and shorter in the winter. The sunlight falls more directly on the Northern Hemisphere during its summer. Both the length of the days and the angle of the sunlight affect the seasons.
- If you wish, you can extend the discussion of seasons to the other planets. How would their seasons compare to ours? You will have to look at the angle of each planet's axis and at the length of its orbit to answer these questions.

Seasons: The Angle of the Sun's Rays

Description: This activity investigates how light hitting a surface at different angles results in different temperatures.

As shown in the previous activity, the Northern Hemisphere is tilted toward the Sun during the spring and summer. As a result, the Sun's rays fall more directly on that hemisphere during those times. During the fall and winter, the Northern Hemisphere receives indirect light, which is light that comes in at an angle less than 90 degrees.

This activity can be done as a class or in small groups.

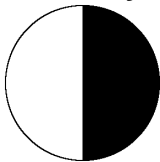
TIME REQUIRED

Advance Preparation



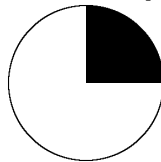
5 minutes

Activity



30 minutes

Clean Up



15 minutes

SUPPLIES

- Two small, flat boxes
- Two thermometers
- Sand or dry dirt
- Four small blocks or bricks
- Sunlight

ACTIVITY

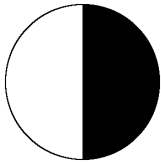
- Fill each box with an equal amount of sand (or dry dirt). Place a thermometer in each box, with the bulb covered by the sand or dirt. Set the boxes in the sunlight. Place one box flat on two blocks so that it is off of the ground. This technique will keep the ground temperature from affecting the box's temperature. The sunlight should fall at an angle onto this first box. Prop the second box up so that the sunlight falls directly (at right angles) onto the dirt inside it. The other two blocks may come in handy here.
- Leave the boxes in the sun for about 15 minutes. Then come back and check the temperatures. Notice that when the Sun's rays fall on the dirt at an angle, such as in the winter, the temperature is lower than when the light strikes at a right angle, as in the summer. This is because the Sun's rays are spread out over a larger area when they come in at an angle and, as a result, they don't provide as much concentrated heat.
- Discuss with your students that it's hotter in the summer than the winter because the sunlight falls more directly on the earth's surface in the summer. (The change in temperature between summer and winter has nothing to do with the distance of the Earth from the Sun. In fact, the Earth is slightly closer to the Sun in January than it is in July!)

Planet Bingo

Description: This activity summarizes the properties of different planets in a fun, interactive manner.

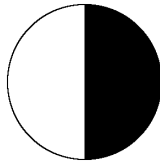
TIME REQUIRED

Advance Preparation



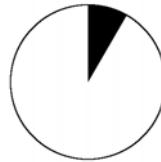
30 minutes

Activity



30 minutes

Clean Up



5 minutes

SUPPLIES

- Bingo card for each student
- 15 or more bingo markers (squares of construction paper, for example) for each student
- Bingo calling cards

ADVANCE PREPARATION

- Prepare a bingo card for each student. Each bingo card should list four or five planets and four or five general characteristics, such as distance from the Sun, size, surface, temperature, atmosphere, composition, and special features. The characteristics of the planets are listed below. Don't forget that each bingo card should be different.

ACTIVITY

- Each student should have a bingo card and at least 15 bingo markers.
- Begin by drawing a calling card from your pile. Call out the planet name first and then the feature. Allow students time to place the marker on the planet-feature combination if they have it on their card. Then, set the

calling card aside. Placing the calling cards in piles by planet simplifies the process of checking a player's "Bingo" at the end of the game.

- Continue drawing until a student has a "Bingo." A player has a "Bingo" when he/she has filled in a row, column, or diagonal completely.

Categories	Mercury	Venus	Earth	Mars
Mean Distance from Sun (millions of kilometers)	57.9	108.2	149.6	227.9
Period of Revolution	88 days	224.7 days	365.3 days	687 days
Equatorial Diameter (kilometers)	4,880	12,100	12,756	6,794
Atmosphere (Main Components)	Virtually None	Carbon Dioxide	Nitrogen Oxygen	Carbon Dioxide
Moons	0	0	1	2
Rings	0	0	0	0
Orbit Inclination	7°	3.4°	0°	1.9°
Eccentricity of Orbit	.206	.007	.017	.093
Rotation Period	59 days	243 days Retrograde	23 hours 56 min.	24 hours 37 min
Inclination of Axis	Near 0°	177.2°	23°27'	25°12'

Categories	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun (millions of kilometers)	778.3	1,427	2,871	4,497	5,914
Period of Revolution	11.86 years	29.46 years	84 years	165 years	248 years
Equatorial Diameter (kilometers)	143,000	120,000	51,800	49,528	~2,330
Atmosphere (Main Components)	Hydrogen Helium	Hydrogen Helium	Helium Hydrogen Methane	Hydrogen Helium Methane	Methane
Moons	67	31	27	13	3
Rings	3	1,000+	11	4	0
Orbit Inclination	1.3°	2.5°	0.8°	1.8°	17.1°
Eccentricity of Orbit	.048	.056	.046	.009	.248
Rotation Period	9 hours 55 min.	10 hours 40 min.	17.2 hours Retrograde	16 hours 7 min.	6 days 9 hours 18 min. Retrograde
Inclination of Axis	3°5'	26°44'	97°55'	28°48'	120°

Measuring the Sun's Diameter

Description: This activity uses the Sun's image projected on a card to estimate the diameter of the Sun.

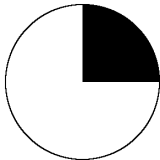
TIME REQUIRED

Advance Preparation



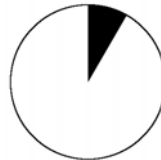
5 minutes

Activity



15 minutes

Clean Up



5 minutes

SUPPLIES

- Yardstick
- Two white index cards
- Tape
- Pin
- Pencil
- Window and a sunny day

ACTIVITY

- Make a small pinhole in the center of one card. Tape this card upright to the 1" mark on the yardstick. In the center of the other card, make two small marks $\frac{1}{4}$ -inch apart. Hold the yardstick so the pinhole card is close to the window. Hold the second card about 2 feet away. Adjust the yardstick so that the sunlight falls through the pinhole and makes an image on the second card. Move the second card up and down on the yardstick until the Sun image just fills the $\frac{1}{4}$ -inch space between the two marks. Record the distance between the cards. (It should be about 27 inches.)
- Use the following formula to calculate the Sun's diameter:

Diameter of image of Sun

----- x Distance from Earth to Sun = Diameter of Sun
Distance between cards

You should get something close to 864,000 miles as the diameter of the Sun.

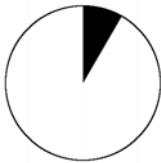
- Compare this value with the Earth's diameter (about 7,900 miles) and the diameters of the other planets or moons. How many Earths could fit across the Sun? Is the Sun wider than the widths of all the planets combined? The Sun is a sphere. Approximately what is the Sun's volume? How many Earths could fit inside? How many Jupiters?

Measuring the Moon's Diameter

Description: This activity uses measurements of the moon's size in the sky to estimate its actual size.

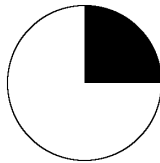
TIME REQUIRED

Advance Preparation



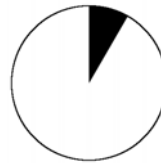
5 minutes

Activity



15 minutes

Clean Up



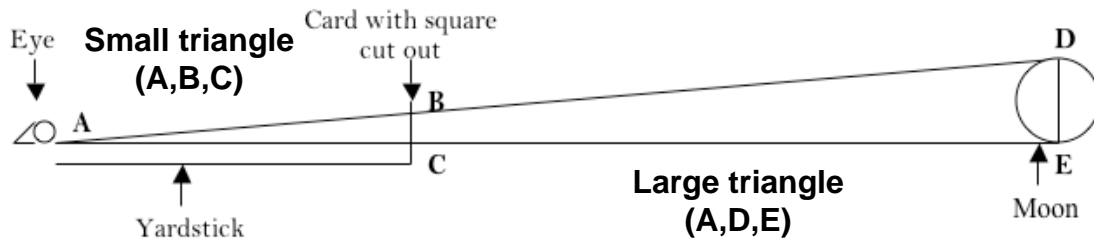
5 minutes

SUPPLIES

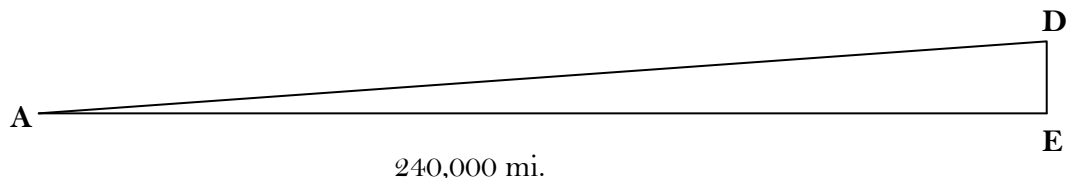
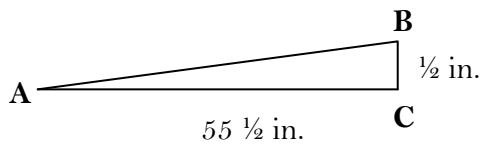
- Yardstick
- Index card
- Scissors
- Ruler
- Clear night with a full moon

ACTIVITY

- Measure and cut a $\frac{1}{2}$ -inch-by- $\frac{1}{2}$ -inch-square in the center of the index card. Tape this card to the 1" end of the yardstick. Look out the window on a clear night at the full or near-full moon with the card near the window. Move your eye toward and away from the card, along the yardstick, until the diameter of the Moon just fills the square. Make a mark on the yardstick even with your eye. You can now use geometry to estimate the actual diameter of the Moon.



- The distance between the card and the mark should be about $55 \frac{1}{2}$ inches and the opening in the card is $\frac{1}{2}$ inch. The distance to the Moon is about 240,000 miles.



Comparing the triangles,

$$\frac{AC}{BC} = \frac{AE}{DE}$$

So, the diameter of the Moon, which is given by the distance DE on the big triangle, is approximately 2162 miles. Check this value for yourself and use your own measurements from your yardstick!

Planets in Motion: Jupiter

Description: This activity demonstrates the motion of Jupiter to explain how planets both rotate on their axis and also revolve around the Sun.

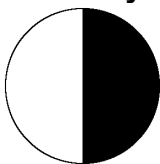
TIME REQUIRED

Advance Preparation



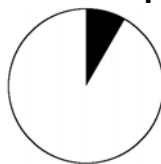
5 minutes

Activity



30 minutes

Clean Up



5 minutes

SUPPLIES

- Lamp without a shade
- Large open classroom
- A sign for each constellation in the Zodiac (see map at the end of the activity)
- Tape

ADVANCE PREPARATION

- Hang the Zodiac signs around the classroom in the order shown on the Zodiac map. This map shows the signs in the same order they appear in the actual sky.
- Move the chairs and desks to the edge of the room and place the lamp in the center of the room.

ACTIVITY

- Have the students stand in a circle, facing the Sun. Each of them represents the Earth. Each student should turn counterclockwise in place to simulate the sunrise and sunset. Have the students stand so that it is

noon (facing toward the lamp) and then midnight (away from the lamp). While standing so it is midnight, they should write down the Zodiac constellation that they see.

- Next, the students should revolve counterclockwise around the Sun as if six months have passed (i.e., halfway around Earth's orbit). What constellation do they now see at midnight? Record the name of this constellation.
- Now, you as the teacher will represent Jupiter orbiting the Sun at the same time as your students orbit the Sun as many planet Earths. Stand near the wall. Jupiter orbits the Sun slower than the Earth, so you will take one step for every three steps that the students take. The students should write down the constellation that you appear to be in front of.
- When you say "go", the students should take three steps and you should take one. Have them record again the constellation that you appear to be in front of. Repeat this methodology until one year on Earth has passed (i.e., your students have completed one full revolution around the lamp). The students should observe shifts in direction and speed in your motion as they move through one year on Earth.

♒ Aquarius



♓ Pisces



♈ Aries



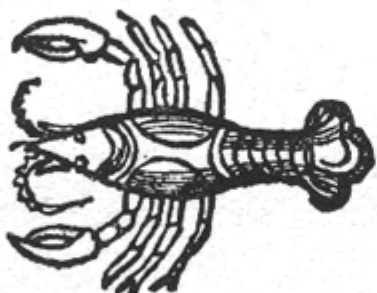
♉ Taurus



♊ Gemini



♋ Cancer



♌ Leo



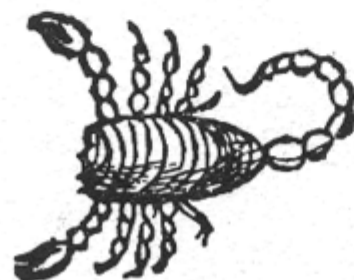
♍ Virgo



♎ Libra



♏ Scorpius



♐ Sagittarius



♑ Capricornus



RESOURCES

NASA Education

<http://www.nasa.gov/offices/education/about/index.html>

Monthly Skymaps

<http://www.skymaps.com/>