The Accidental Astronauts Teacher Guide

An Earth Sun Moon Adventure

Clark Planetarium Education Department

Astronomy Lessons provided by Clark Planetarium thanks to generous funding from the Utah State Legislature and Utah State Office of Education.

Accidental Astronauts Teacher Guide

This Teacher Guide follows the topics that are covered in the short movie *The Accidental Astronauts* in greater detail. The activities in this book use hands-on activities to engage student interest and learning. All lessons integrate teacher background material and activities. This should give learners and teachers a framework for working through difficult concepts.

All worksheets and activity resources, such as slides, worksheets and cards, can be found in the last section of the book.

The lessons in this book will allow students to better understand these concepts and questions:

1. Explain that the Sun, Earth and Moon are spherical shaped along with planets, moons, and stars
2. The Earth rotates on its axis, which makes the Sun, Moon and stars appear to move across the sky
3. What causes day and night and how does Earth move through space?
4. How long it takes the Earth to orbit around the Sun
5. How long it takes the Moon to orbit around the Earth
6. The Sun creates its own light and the Moon and Earth reflect it
7. A basic understanding of Moon Phases
8. What are eclipses?
9. How far/big are the Sun, Earth and Moon?
10. Explain the differences between the Sun, Earth and Moon

Questions or comments can be directed to the Clark Planetarium Education Department at clarkeducation@slco.org.

2^{nd} – 3^{rd} Grade Activities

Newton's Laws and Rocketry

The Sun, Earth and Moon

Our Star, the Sun

Our Moon

Activity Worksheets and Resources

Newton's Laws and Rocketry

Teacher Background

Activity taken from *Flying with Sir Isaac: The Physics of Spaceflight* Teacher Guide – Hansen Planetarium 1994
Modified to fit a younger age group

The First Law of Motion

Newton's first law of motion says that something will keep moving the way it is already moving as long as it doesn't get bothered. A bowling ball that is sitting on the floor, will just keep sitting in the same place as long as nothing bothers it. You can even say that it is lazy. In fact, we could call the first law of motion the law of laziness. The first law also says that if the bowling ball is rolling across the floor it will just keep going in the same direction at the same speed as long as nothing bothers it. It's too lazy to stop itself.

The Second Law of Motion

The second law of motion says that something will change the way it is moving when it gets pushed or pulled. If the bowling ball is just sitting on the floor, push it to make it move. If you want it to go in a different direction, push - it in the direction you want it to go. To make it go faster, give it a bigger push. To stop it, push back in the opposite direction it is moving. You can move the ball any way you like by pushing on it.

You might notice that when things like bowling balls are moving across the floor they tend to slow down and eventually stop. This seems to disagree with the first law. However, the second law of motion helps to explain that. As the ball rolls across the floor, the floor (and the air) is pushing back on it and making it slow down and stop.

The Third Law of Motion

The third law of motion says that when something gets pushed, it pushes back just as hard. Whenever you push on a bowling ball, you notice a pressing feeling against your hand. That is the bowling ball pushing back on you as you push on it. If you push on it harder, you feel it pushing back harder. If you kick the bowling ball, it hurts. When you push on it with a force as big as a swift kick, it pushes back with just as much force which might be enough to do bad things to your toes.

Using the Laws of Motion to Understand How Rockets Work

Imagine that you are out in space just sitting somewhere. The first law of motion says you will stay right there. If you want to go somewhere else, use the second law, which says you need to get a push or pull from something.

If there is nothing around, you're stuck, unless you remember two things:

1. to bring along a bowling ball and
2. the third law of motion.

To get moving, simply throw the bowling ball. You throw the ball by pushing on it and, according to the third law, it pushes back on you and, according to the second law, you start moving the other way. It would be even better to have a lot of bowling balls. Whenever you want to go somewhere, all you have to do is throw some of the bowling balls.

That is, in fact, how rockets work. Except, in place of bowling balls, they use rocket fuel. Simply put, a rocket is a container full of fuel. At blastoff, the rocket throws the fuel down, pushing it very hard. The fuel pushes back on the rocket very hard causing the rocket to go up.

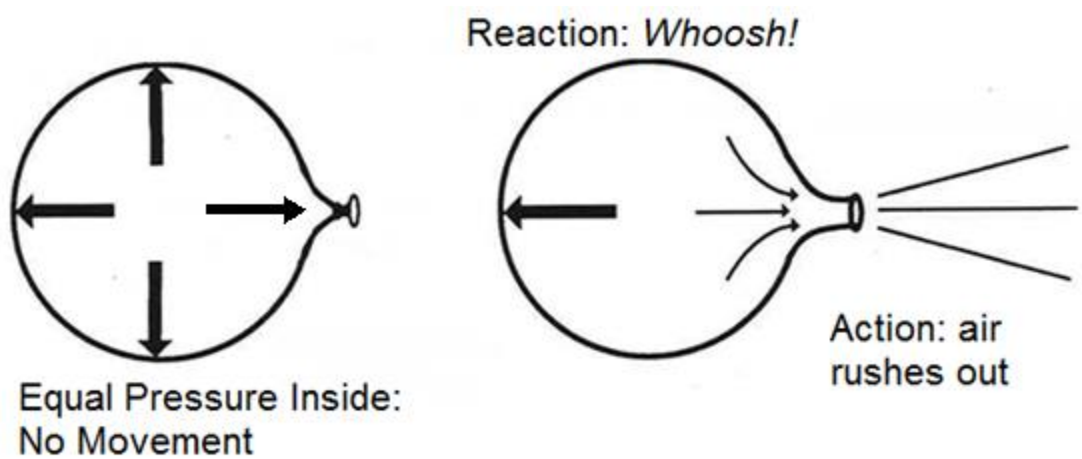
Making a Rocket That Really Works

Since rockets are so wonderfully simple and you understand just how they work, why not make your own? All you need is a balloon. A balloon makes a great rocket. It's easy to get, inexpensive, reliable, and you probably already know how to make it work. Just blow it up.

The air inside the balloon is fuel. Each molecule of air is like a bowling ball, it's just too small to see. Nonetheless, it obeys the laws of motion just like a bowling ball:

1. it is lazy
2. if you want to move it you have to push on it
3. if you push on it, it pushes back

If you wave your hand in the air, you are moving the air around by pushing on it. As you do, it pushes back, which is what you feel as a breeze on your hand.



When you let go of the balloon, it pushes the air out. So the air pushes back on the balloon and it goes flying off – *whoosh!* The balloon is indeed a rocket.

Resources

NASA's pages on Newton's Laws of Motion with extra activities

Kids Page: https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/dynamicsofflight.html#forces

Newton's Laws: https://www.grc.nasa.gov/www/k-12/airplane/newton.html

Balloon Rocket Activity

Activity #1

Grade Levels: 2nd – 3rd grade **Time Frame:** 45 - 60 min.

Overview

The students will better understand the Three Laws of Motion by using them to build and use a balloon rocket.

Materials

The class will need:

- fishing line or lightweight string
- tacks
- a number of straws, cut in 6 cm lengths
- tape
- Stop watch (optional)

Each student (or teams of students) will need:

- 2 different types of balloons (one round balloon and one long sausage balloon)
- 1 set of lungs
- 1 Styrofoam cup (for optional activity)

Preparation

Before class, string a piece of straw on the fishing line. Using tacks, secure the fishing line on one side of the classroom at about waist height, across the room and on the other side of the classroom near the ceiling. Additional lines may be strung for later races, or to accommodate more students.

This activity can be done outside. If you desire to do so, make sure you can find a space where you can tack the string into place as described above. Make sure before the date of your activity that the weather will permit such an activity.

Rocket Activity Part 1 – Experimenting with the "Rocket"

With the students, the teacher will:

1. Discuss the Three Laws of Motion with the students.
2. Brainstorm different kinds of rockets. What makes a good rocket?
3. Supply each student with one balloon. Let students pick between the different types of balloons, or start them all with one type first.
4. Why is this a good rocket? How can it fly? (The balloon pushes the air, so the air pushes back on the balloon.)

Each student will:

1. Load their rocket with fuel (blow it up).
2. Launch (Let it go). They will be launched without the aid of the string so the balloons may wander about the room. Have students release their balloons in small groups and retrieve them.

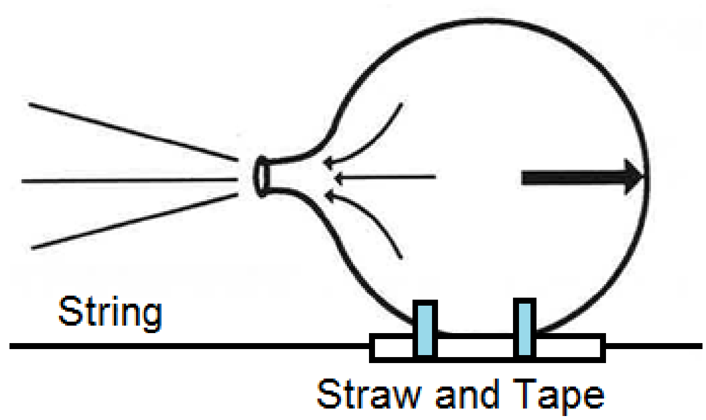
Students should be allowed to launch their rockets several times if necessary to answer the following questions:

- Which rocket travelled farthest?
- The longest?
- The fastest?
- What was the shape of the balloon as it deflated?
- Where was the air while the balloon was still in motion?
- How can you tell which direction the balloon will fly?

Rocket Activity Part 2 – Racing the Rockets

Students can be in teams or individual for this part of the activity. Demonstrate the following to show students how to launch their rockets using the string as a guide. What do students think this will do to the rocket? Will it go farther? Faster?

1. Blow up the balloon and pinch its opening tight. Tape the balloon to the straw on the string. Make sure you start on the end of the fish line where it is waist high. The big arrow in the picture below points in the direction that the balloon will launch, which should be towards the upper end of the fish line.



2. Still holding the balloon in place, ask the students which direction the Balloon will go. Explain that the straw and string will help keep the Balloon in a straight Line.
3. Release the Balloon.

Racing the Rockets

Now that students have seen how to set up their rockets they can test them. Each student or group may tape their balloon to the straw and see how fast it goes against another student's rocket. Make sure students observe the following while racing against each other.

- Which rocket travelled farthest?
- The longest? Did any not go at all?
- The fastest? Slowest?
- Where was the air while the balloon was still in motion?

1. If the students started with the same balloons, have them try the second type of balloon after testing the first set.

2. If the students used different balloons in the first test, ask them if they want to try the other type of balloon and race again. Make to ask the following when using different types of balloons.

   - Which type of balloon rocket was faster? Slower?
   - Went farther? Did any not go at all?
   - Travelled the longest?
   - Which balloon rocket worked best overall?

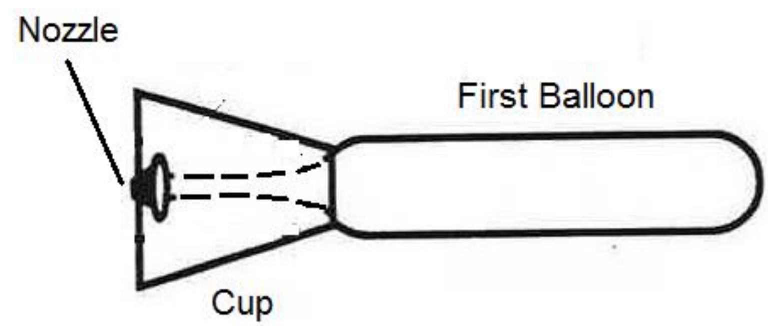
Remind students that scientists in the Space Program spend years testing rocket designs before they find one that performs how they want. Many rockets have gotten to the launch pad and were launched only to fall back to Earth with a big explosion. Scientists may have to work years, learning from each failed launch, before they find a design that works.

Optional Activity – Creating a Two Stage Rocket

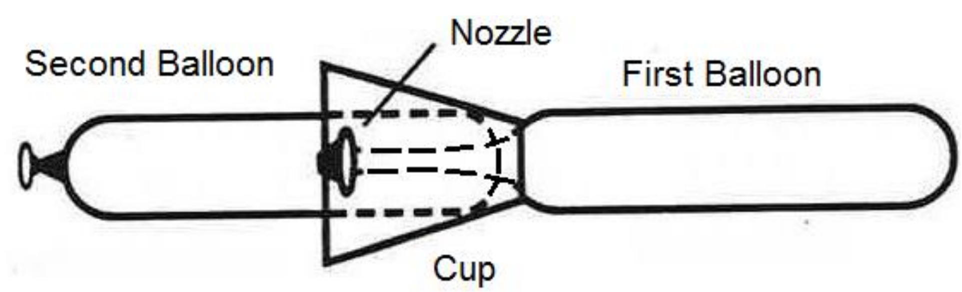
This activity is a little tricky, but it can fun for students who want to explore rocketry a little further.

Students can be in teams or individual for this part of the activity. Provide each student or team with two sausage balloons and a Styrofoam cup. Demonstrate the following to show students how to build their two stage rocket. A **two stage rocket** is like having two rockets, but the second rocket does not fire until the first one is almost out. What do students think this will do to the rocket? Will it go farther? Faster?

1. Remove the bottom of the Styrofoam cup.
2. Blow up the first balloon. This will be the second stage rocket.
3. Inset the nozzle through the cup, keeping the cup bottom against the balloon. Pull the nozzle through the cup and fold it up around the side of the cup.
4. Hold the nozzle tight against the cup side as seen below.

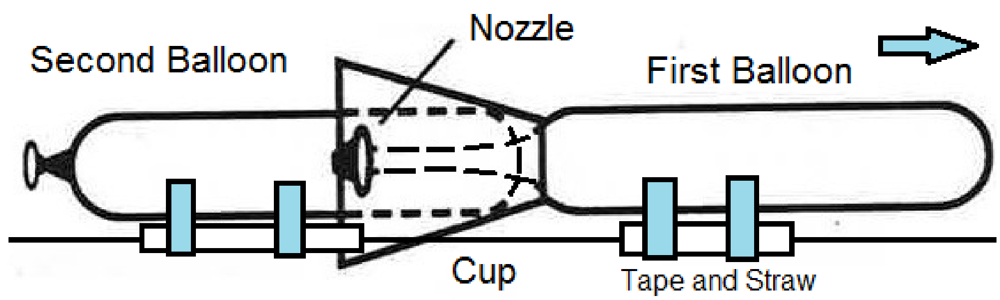


5. Inflate a second balloon and force the end of the second balloon into the top of the cup. This should prevent the first balloon from leaking air.



Racing the Two – Stage Rockets

1. You will need two straw pieces for this rocket on the fish line. Hold a prepared rocket next to the fish line on the side of the room where it is waist high. The first balloon should be taped to the first straw and the second balloon to the second straw. The second straw is the one closest to your starting point.



2. Test fire a rocket to show students how it is done. Ready two fish lines for racing the rockets.
3. When two or more teams (or individual students) are ready, have a count down and launch. (What happens if the rockets are loaded backwards?)
4. Compare the rockets of the two different teams. Consider the following questions:

    - How do these flights compare to the single-balloon rockets? Why?
    - Which are fastest? The slowest?
    - Which go the farthest? Do some not go at all?
    - What factors are important to separate the successful rockets from those which are not successful?

The Sun, Earth and Moon

Teacher Background

You have probably witnessed the Sun rising and setting over the horizon. The Moon also moves across our sky, changing its phases over the course of a month. In this book we will compare the similarities and differences of the Sun, Earth and Moon by their appearance, size and distance from the Earth.

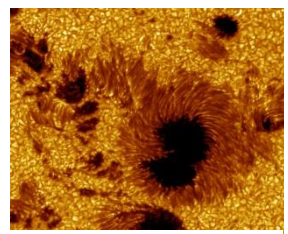
Scale Comparison Chart			
	Earth	**Sun**	**Moon**
Diameter	7,926 miles (12,756 km)	864,900 miles (1.392 million km)	2,159 miles (3,479 km)
Earth Diameters	1 Earth diameter	109 Earth diameters	About ¼ Earth's diameter
Relative mass	1 Earth	About 1.3 million Earths to fill the Sun	About 49 moons to fill the Earth (.0203 Earths)
Distance from Earth	---	92,960,000 miles (149,600,000 km)	238,900 miles (384,400 km)

The Sun

The Sun is a star, also known as Sol, hence Solar System. A star is a burning sphere that gives off light and energy. The Solar System is made up of our sun and the planets and other objects that orbit around it. It is not to be mistaken for the Milky Way Galaxy, which our Solar System resides in, or for the Universe, which all the galaxies reside in. The Sun is only the center of our Solar System.

Features of the Sun: Sunspots and Solar Flares

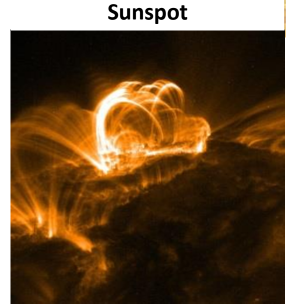
Sunspots are dark areas on the Sun where it is cooler than the surrounding area, but still hot enough to vaporize you. Sunspots can be so big you could fit an Earth or two inside of them.



Sunspot

Sunspots do not always appear on the Sun. When they form they can last anywhere from a few hours to a few months. The Sun will go through phases where its surface will show a lot of sunspots to none at all.

A solar flare occurs when magnetic energy that has built up is suddenly released. Radiation is emitted across virtually the entire electromagnetic spectrum.



Solar Flare

Planets

Planets orbit around stars. The word Planet, or *Planetes*, is actually Greek for "wanderer." Today planets are defined with these three rules:

1. It must orbit the Sun
2. It must have enough gravity, or be big enough, to pull itself into a s*pherical* shape.
3. It must have cleared other objects out of the way in its orbital neighborhood.

Earth is made out of rocky materials and its surface is mostly covered in water. Planets can be made of rock or gas, like Jupiter and Neptune. So long as they follow the three rules above, they are called a planet.

The Moon

Our Moon, also known as Luna, is a spherical rock that orbits the Earth. The definition of a moon is a celestial body that orbits around a planet. Not all moons are spherical like ours. For example, Mars has two rocky moons that are not very spherical.

Common Misconceptions:

1. The Sun is the center of the Universe or Galaxy.
2. The Sun and Moon are the same size.

References

A good story book reference to the "Man on the Moon" is *The Greedy Man in the Moon:* Written by Rick Rossiter and illustrated by Dick Smolinski (1994)

How Big is the Sun: Space.com
http://www.space.com/17001-how-big-is-the-sun-size-of-the-sun.html

Other fun space activities: NASA Kid's Club
http://www.nasa.gov/audience/forkids/kidsclub/flash/index.html#.VVZ3hflVhHw

Sun, Earth and Moon Matching Game

Activity #2

Grade Levels: 2^{nd} – 3^{rd} grade **Time Frame:** 20 min.

Overview

Students should be able to index pictures and terms relating to the Sun, Earth, and Moon. They will be given sets of cards that they can sort into the three categories. Some cards may fit into multiple categories.

What you need

- Sun, Earth, and Moon cards for each group of 2 – 4 students (Page #)
- Tape
- Whiteboard and markers

Preparation

The day before the activity make sure you have enough copies of the cards for each group in your class. Set aside a master copy of the cards for yourself. You may want to make the master set of cards larger so the whole class will be able to see them. You will need a white board to write on with enough space for the cards. The cards may also be placed on a wall in the room where the students can see them for the rest of the activities.

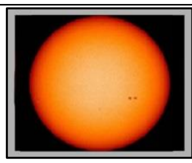
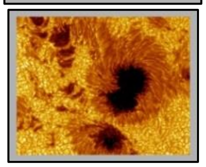
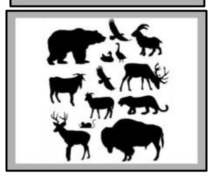
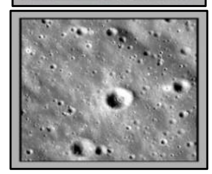
Activity Guide Matching Game

1. Organize the students into teams of 2 – 4.
2. On the board, write the words Sun, Earth, and Moon and draw them underneath. Encourage the students to come up with terms and descriptions of each category and write or draw them on the board. This will be a list of what the students already know about the Sun, Earth, and Moon.
3. Hand out a card set to each team. Explain that cards are part of a matching game and challenge the students to organize them into Sun, Earth, and Moon piles. They can use the notes from the board to help. Give the students 5 – 10 minutes to complete this task. Note that some cards may belong to multiple categories.
4. Once the cards are organized, take your master set and pull out each card. Ask the teams where each card should go on the board and tape it under the correct category. If anything is out of place, see if the students can spot it or help guide them to the right category. You can use the following guide when placing cards on the board.

Card Guide and Solutions

Some cards may make sense to place before other cards. The “Sphere” card is a good one to introduce early, but only after the pictures of the Sun, Earth, and Moon are on the board. Students can then look at the pictures and try to determine the objects’ shapes. The Sphere card also appears under every category. You can write it in on the board or print extra copies of the card for each group and your master set.

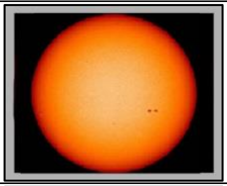
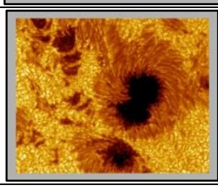
Quick Guide

Sun	Earth	Moon
		
I am shaped like a Sphere	I am shaped like a Sphere	I am shaped like a Sphere
		
		
I am a Star. My name is Sol.	I am a planet made mostly out of rock.	My name is Luna and I am mostly made of rock.
Solar		Lunar
I create my own light.	I reflect the Sun's light and we call it day time.	I reflect light from the Sun so you can see me from Earth.
		

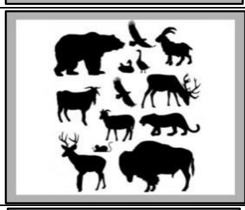
The next few pages have a more descriptive guide for each category.

Descriptive Guide

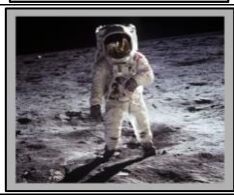
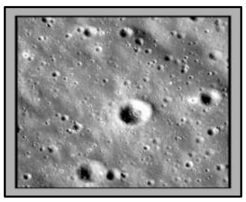
Sun

	Picture of the Sun.
I am shaped like a Sphere	After placing the picture of the Sun up you can ask “What shape is the Sun?” The Sun is a sphere, or round like a ball. A sphere is a three dimensional circle. Draw a circle on the board and show a ball to help students understand the differences.
	Sunspots are dark areas on the Sun where it is cooler. It would still vaporize you, but it is cooler than the surrounding area. Sunspots can be so big you could fit the Earth inside one.
	Sunsets are one of the beautiful views of the Sun that we can see from here on earth.
I am a Star. My name is Sol.	The Sun, Sol, is a star. What is a star? Stars are huge spheres in space that burn brightly.
Solar	The Term Solar is associated with our Sun because of its name. Where have you heard the term Solar before? (Solar System, Solar Flare, Solar Eclipse, etc.)
I create my own light.	The Sun creates its own light. Does the Sun have a shadow? The Sun does not have a shadow because it is illuminated from all sides. You can use a lit light bulb to demonstrate this if needed.
	Solar Flares are eruptions of electro-magnetic energy from the Sun. They are much larger than Earth. Good thing the Earth is very far away from the Sun!

Earth

	Earth, our home and the planet we know best!
I am shaped like a Sphere	After placing the picture of the Earth up you can ask "What shape is the Earth?" The Earth is a sphere, or round like a ball.
	Earth is where we live.
	Earth has many different life forms on it.
I am a planet made mostly out of rock.	Our Earth is a planet. Our planet Earth is made mostly out of rock. Planets are spheres. Some are made of rock and others are made of gas, like Jupiter and Saturn.
	Plants are one of the examples of life on Earth.
I reflect the Sun's light and we call it day time.	Does the Earth create its own light? No. It "reflects" the light from the Sun. Write reflect on the board. Reflect means that light bounces off an object. The Sun's light bounces off of the Earth.
	Earth is covered mostly in water, which is essential to life. We also have an atmosphere which is the air that we breathe.

Moon

	This is our Moon.
I am shaped like a Sphere	After placing the picture of the Moon up you can ask "What shape is the Moon?" The Moon is a sphere, or round like a ball.
	There have been 12 astronauts who have set foot on the Moon. The Moon is farthest a human being has travelled in space.
	Asteroids have hit the Moon periodically over thousands of years. Since the Moon has no atmosphere or wind to erode the craters, the craters on the Moon will look the same for many years. In fact, the astronauts' footprints from their visits are still in place on the Moon. If you were to visit the Moon now you would still see them.
My name is Luna and I am mostly made of rock.	Our Moon is also known as Luna. The Moon is made mostly of rock, much like the Earth. It does not have enough of an atmosphere or enough water to support life though.
Lunar	The term "Lunar" is associated with our Moon because of its name. Where have you heard the term Lunar before? (Lunar phases, Lunar Cycle, Lunar Eclipse, etc.)
I reflect light from the Sun so you can see me from Earth.	Does the Moon create its own light? No. It "reflects" the light from the Sun.
	You can see the Moon rise and set from the Earth, as well as see it go through its Lunar phases.

How Big are the Sun and Moon?

Activity #3

Grade Levels: 2nd – 3rd grade **Time Frame:** 20 min.

Activity adapted from the Utah Lessons Plans for 3rd grade: http://www.uen.org/Lessonplan/preview.cgi?LPid=10987

Overview

Students will use a scale model to compare the sizes of the Sun, Earth and Moon.

Key Terms: Model, Scale

What you need

- Chalk
- String
- Yard stick
- A piece of paper for each student
- Scissors for each student

Preparation

This activity is best done outside as it takes up a lot of space. Check the weather to make sure it is not raining or too cold. Cut a length of string to 5 ½ yards in advance.

Size Activity Guide

1. Explain to the students that you are going to help them to understand the sizes of Earth, Sun, and Moon by making a "scale model;" a model that will be smaller than the real thing, but that will maintain the size relationship between the three objects. We are using a scientific model because we cannot actually bring objects like the Sun into the classroom. They are simply way too big and too far away.

2. Show the students a circle of paper that is 4"(10 cm) in diameter. This will represent Earth. Now, ask them how big a paper circle you need to represent the moon. Have the students cut out a circle in the size they think the Moon should be and compare their estimates.

3. Give them the approximate diameters of the real Moon and Earth. Explain that the diameter is the straight line from one side of the circle or sphere to the other.

   Moon, about 2,000 miles (3,250 km)

   Earth, about 8,000 miles (13,000 km)

4. Ask again, "For a 4" paper Earth, how big should we make our paper Moon?" If they don't see the relationship, point out that 2,000 miles is one-fourth as big as 8,000 miles. Therefore, the paper Moon should be 1" (2.5 cm) in diameter or ¼ the diameter of the Earth.

5. Cut out a paper Moon of that size.

6. Have students estimate how big to make the Sun before reviewing the size of the actual Sun. the Sun may be too big for paper so have the students demonstrate how big the Sun would be with their arms, objects in the classroom or by having two students stand apart from each other.

7. Have them change their estimates based on this information.

   Approximate diameter of the real Sun: about 800,000 miles (1,300,000 km)

8. How much larger will the paper Sun need to be than the paper Moon of 1"?

   800,000 divided by 2,000 is the same as 800 divided by 2 = 400

   So... if the paper Moon is 1", the paper Sun will be 400" (1,000 cm).

   400" divided by 36" gives you about 11 yards

You will not have paper big enough to make that circle! Instead, use 5 ½ yards of string to draw an 11 yard circle with chalk on the playground. Tie one end of the string to a piece of chalk and give it to a student. Have another student hold the other end. The student with the chalk will pull the string tight and draw a circle on the cement. Then, trace the paper Earth and the paper moon with chalk for comparison.

How Far are the Sun and Moon?

Activity #4

Grade Levels: 2nd – 3rd grade **Time Frame:** 20 min.

Overview

Students will use a scale model to compare the distances of the Sun, Earth and Moon. There are two parts to this activity. The first part will review the size scale of the Earth and Moon. Students will be able to take home their own Earth and Moon models that are the right size and distance from each other.

The second half of the activity students will identify the Sun, Earth and Moon as spheres. They will look at their size scale on a slightly bigger scale and see how far away the Sun is on this scale.

Key Terms: Sphere, model, distance

What you need

- Copies of the Earth and Moon sheets (page #)
- Pencils
- Scissors
- 20 foot long string for each student (Yarn is another good option)
- Ziploc bags (optional)
- Tape
- 12” diameter basketball
- Tennis ball
- Measuring tape (15’ or more)
- Map of school and surrounding area up to three miles.

Preparation

The second half of this activity can be done inside or outside. Measure from where you will be holding the basketball for the demonstration to about 30 feet away. Mark the start and end points of this distance with something discreet or make a mental note of how far away that would be. A small piece of tape on the ground or an object is a good reference.

Make sure you have a copy of one Earth and Moon sheets for each student in the (Page #) Cut the Moon page on the dotted line so the distance tag is separate. Cut a 20 foot length of string for each student. (You can also have the students cut the string during the activity. Make sure you have enough string or yarn for every student. When the activity is over, the Ziploc bags are useful for the students to keep their Earth and Moon pieces in one place.

Distance Activity Guide – Part 1: Take Home Model

1. In the previous activity we explored how big the Sun, Earth and Moon are compared to each other. Hand out the Earth and Moon papers, pencils, scissors and tape to each student. Have the students cut out the Moon and the Earth and label them with their pencils. Are they the right scale to each other? Remind the students that Moon is about ¼ the Earth's diameter so they should be able to fit four moons across the Earth paper.

2. Now that the students know their planet and moon are to the right size, how far apart should they sit from each other? Tell that students that on this scale 1" is equal to 1,000 miles. The Earth's diameter is about 8,000 miles so the model Earth is 8 inches in diameter. The Moon is about 2,000 miles in diameter so the model Moon is 2". See if the students can guess how far apart the Earth and Moon will be.

3. After their initial guesses, give the students the following information and see if they want to change their answers.

   The distance between the Earth and the Moon is about 240,000 miles

4. Help guide the students to understand that the Moon and the Earth would be 20' apart on this scale. Hand out the second half of the Moon sheet that has the distance information on it. Have the students cut the tag out of the paper.

   240,000 mi = 240 inches on this scale

   240 inches / 12 inches = 20 feet

5. Give each student a 20' piece of string. (If the yarn or string has not been pre-cut take the measuring tape and measure out 20 feet on the floor. Mark the beginning and end and have students come up and measure out their own piece of yard or strong.) Have the students tape each end of the string to the Moon and the Earth. Now they can tape their distance tag to the string. Have one set of students hold up a completed Earth/Moon distance and scale model for the class to see.

6. Have the students place their models in a Ziploc bag for taking home.

Distance Activity Guide – Part 2: Classroom Model with the Sun

This activity can be done outside or in a hallway with more room than a classroom.

1. Hold up the basketball and tennis ball for the class to see. What shape are these objects? They are sphere shapes. If the students answer circle shaped explain what a sphere is.

   Sphere: a round shape, like a ball, in a 3 dimensional space.

   A circle is a two dimensional or flat round shape while a sphere is round in every direction like a ball.

2. Like in the previous activity, we will be making a model to show how far away objects are from each other. Hold up the basketball and explain that this will represent the Earth. Ask the students what could represent the Moon. Any spherical object that is about ¼ the size of the basketball should work, but we will be using the tennis ball for this activity. Show that the tennis ball is about ¼ the diameter of the basketball by moving the tennis ball in front of the basketball in four tennis ball width jumps.

   Is this the same scale as the models made in part 1? No, these are a little bit bigger so the distance will be a little bigger too.

   You can also review with the students about how big the Sun would be on this scale. In this case, the Sun would likely not fit inside the classroom. The Sun would fit 109 Earth's across its diameter. That would be 109 basketballs!

3. If we shrunk the Earth and the Moon to this size, how far apart would they need to be to represent the correct distance? Have a student walk the distance they think the Moon would be from the basketball Earth. Remind them that this scale is bigger than the model activity scale, so they may have to adjust what they think the distance is. Encourage the student to keep walking until they are about 30 feet away from the basketball (Have the student stop at the place you marked or mentally noted as the stop point you prepared.)

   Explain that this is how far the Moon would be from the Earth on this scale. The Moon is about 240,000 miles away from the Earth or on this scale the Moon is 30 feet away.

4. Have the student return to their seat and ask the students how far away they think the Sun would be on this scale. You can give them a hint: in reality the Sun is about 93 million miles away. If the students are guessing in miles, then they are thinking big. The Sun would be… slightly less than 2 ¼ miles away from the basketball on this scale.

5. Use a map of the school and the surrounding area to show how far away 2 ¼ miles is to the class. See if they can identify where the school is on the map, or show them if they need help. Then point out a spot that is 2 ¼ miles away. If there any memorable landmarks at this distance, point it out to the students.

Our Star, the Sun

Teacher Background

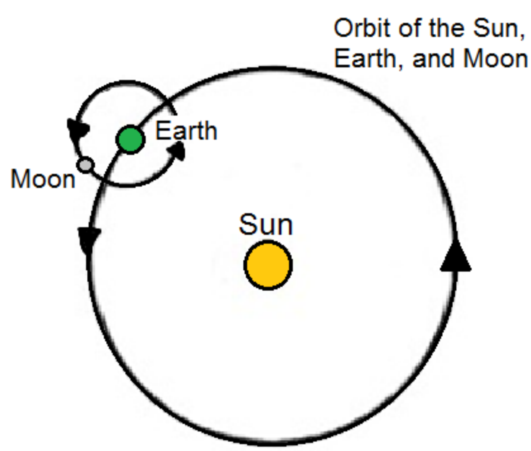
The Sun is our Solar System's star. It creates massive amounts of energy and heat. This energy and heat is crucial to life on Earth. At 93 million miles away, our little planet orbits at just the right distance where it is not too hot and not too cold.

The Sun's light shines on one half of Earth, creating daytime. The Earth's shadow side, facing away from the Sun, is nighttime. While the Sun (and Moon) may appear to rise, move across the sky and set, these apparent motions are actually the result of Earth rotating on its axis. This is a concept that will be addressed in the following Sun activities to help students understand the apparent motion of the Sun, Earth, and Moon.

As the Sun appears to move across the sky during the day, our shadows can get longer or shorter. We can use the length of our shadows to tell what time of day it is and determine where the Sun is in the sky.

Orbit, or Revolution, of objects around the Sun

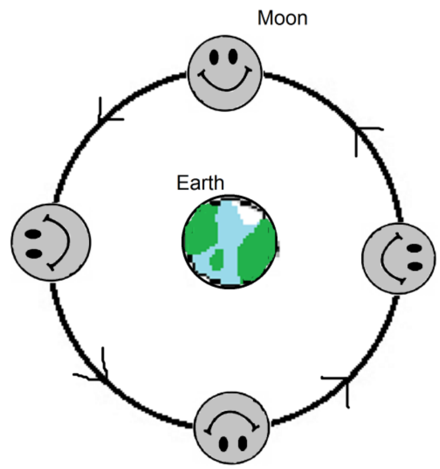
The Sun is a star, also known as Sol, hence Solar System. A star is a burning sphere that gives off light and energy. The Solar System is made up of our sun and the planets and other objects that orbit around it. It is not to be mistaken for the Milky Way Galaxy, which our Solar System resides in, or for the Universe, which all the galaxies reside in. The Sun is the center of our Solar System.



Notice in the diagram above how the Moon and Earth orbit in the same direction? All planets orbit in this same direction around the Sun. Also, the Sun, Earth, and Moon all rotate on their axis in this same direction.

The Moon rotates on its axis?

Does the Moon rotate on its axis? When we look at the Moon we see the same side of it as it goes through its phases. There are folk tales and legends about what we see on that side of the Moon from the Man on the Moon to a Rabbit. It is a common misconception that this means that the Moon does not rotate on its axis, but it actually is proof that it does. In order for one side of the Moon to always face the Earth, the Moon would have to rotate.



Common Misconceptions:

1. It is okay to look at the Sun without eye protection for long periods of time.
2. The Sun has a shadow.
3. The Sun and Moon orbit around the Earth over the course of a day.
4. The Moon does not rotate.

References

Sun Pictures: STEREO Satellite
http://www.nasa.gov/mission_pages/stereo/main/index.html

Sun Pictures: SOHO Satellite
http://soho.nascom.nasa.gov/pickoftheweek/

NASA: The Sun Features
http://www.nasa.gov/mission_pages/sunearth/multimedia/Sunlayers.html

Movement of the Sun, Earth, and Moon

Activity #5

Grade Levels: 2nd – 3rd grade **Time Frame:** 30 min.

Overview

Students will learn that the Sun is at the center of the solar system and rotates or spins on its axis. The Earth rotates, or spins, on its axis as it revolves or orbits around the Sun. It takes one year for the Earth to complete its orbit around the Sun. The Moon rotates on its axis and orbits around the Earth. It takes the Moon 29.5 days, or approximately a month, to complete its orbit around the Earth. A scientific model will be used to demonstrate the motion of the Sun, Earth and Moon.

Key Terms: Orbit, Revolve, Rotate, Axis

What you need

- 6 – 9" foam ball
- Round foam disk
- 4" foam ball
- 1" foam ball
- 3 skewers
- Masking tape

Preparation

Make sure there is enough room for the activity (approximately 10' X 10' space is enough.) Mark a point in the center of this space. Measure a four to five foot diameter circle around this point and mark it with the masking tape. (Note: if this activity is done outside you can use chalk and string to draw this circle.)

Place the big foam ball on one end of a skewer and the foam disk on the other end. Put this in the center of the circle as it will represent the Sun. Take the 4" foam ball and place a skewer in it. Do the same for the smaller ball. Students can sit in a circle or a semi-circle around marked space. Make sure there is enough room around the marked circle for someone to walk.

Optional: The Sun foam ball could be painted yellow or orange, the 4" ball blue and green, and the small ball light grey to help represent the Sun, Earth, and Moon. You can also write Sun (or S), Earth (or E), and Moon (or M) on each object.

Movement of Sun, Earth and Moon Activity Guide

1. Have the students sit in a circle or semi-circle around the large foam ball on the edge of the 10' X 10' space. Explain to the students that this will be a scientific model of the Sun, Earth and Moon to help us understand their movement in space. Review with students the Size/Distance Scale activities. Explain this activity is not to scale because we are observing the movement of the items, not their size or distance.

2. Show the students the different objects for the activity. What do they think the large ball represents? The medium sized ball? The small one? They each represent the Sun, Earth, and Moon respectively. Express to students that this model is not to scale. Refer to the Size/Distance activities to see if students remember their scale. The model is focusing on the movement of the Sun, Earth and Moon.

3. Put the Earth and Moon ball aside. Ask the students what they already know about the Sun. Possible ideas to point out would be:

a. The Sun is the closest star to Earth

b. It is at the center of our Solar System

c. It spins slowly compared to the Earth – Show that the Sun spins slowly counterclockwise (as seen from above) in the center of our Solar System. It spins on its axis.

d. It is very hot!

e. It is the Earth's source of light

f. It is much bigger than the Earth

4. Review that the Sun is at the center of our Solar System. The planets orbit around the Sun. Ask the students if they know what *Orbit* means.

   Orbit or Revolve: the path an object takes around another object in space; to move or travel around an object in a curved path. To orbit means to *revolve* or move around another object.

   The Sun is like the hub of a bicycle wheel, with the planets orbiting around it counterclockwise (as seen from above).

5. Ask the students who would like to come up and hold the Earth ball. Pick a student to demonstrate the next part of the activity. The student can hold the Earth ball vertically or at a tilt if you wish to show the Earth's tilt. (The Earth's tilt is not crucial to this model so it can be ignored.)

   Ask the student to orbit around the Sun. As the student does this, ask the other students what needs to be changed. Express the following points.

   a. The student should be orbiting counterclockwise (as seen from above) around the Sun

   b. The Earth should be *rotating* on its axis counterclockwise (as seen from above)

   c. How long does it take the Earth to rotate once? A day or 24 hours.

   Rotate: To turn around on an *axis*.

6. Ask students how long it takes the Earth to orbit the Sun once. To help make this concept easier, choose a point on the Earth's line of orbit and mark it on the floor with masking tape. This will mark the Earth's starting point. The student with the Earth ball will now "make one year" around the Sun by making a complete orbit once.

   When the Earth orbits once around the Sun, how much time has passed? How old are the students now? How old will they be when the Earth makes one full revolution? How many times has the Earth orbited around the Sun since they were born?

7. Ask the students "What revolves or obits around the Earth?" Now bring out the Moon ball. What do we know about the Moon already?

   a. It is smaller than the Earth and Sun

   b. It orbits around the Earth

8. Ask for another volunteer to hold the Moon ball. Guide the Moon and Earth students through the following.

   a. Which way does the Moon orbit around the Earth? Counterclockwise (as seen from above). Have the Moon student guess which way to go first and then guide them to the counterclockwise motion.

b. Ask all the students, “How long does it take the Moon to make one complete orbit?” Accept their answers and explain that it is 29.5 days or about one month.

c. If it takes about one month for the Moon to orbit, then how many times does the Moon orbit around the Earth in one year? About 12 times. Start at the mark on the floor and make one Earth orbit around the Sun. The Moon student should follow the Earth and try to orbit around the Earth about 12 times before they return to the starting mark.

9. Invite the students to demonstrate what they have learned by taking the Earth ball and the Moon ball and trying the activity for themselves. Other students can help if the demo students are having trouble.

Going Further – Does the Moon Rotate?

The Earth revolves around the Sun and the Moon revolves around the Earth. The Earth rotates on its axis every 24 hours. Does the Moon rotate on its axis?

To answer this, ask two students to come up and represent the Moon and the Earth. Have the Earth student stand in the middle of the open space. The Moon student will first walk around the Moon without “turning on their axis” one time. Ask the Earth student to slowly turn and follow the Moon and describe what they see. They should see the Moon student’s face, sides of their head, and the back of their head as they do this.

Do we see all the sides of the Moon? Ask the students if they have heard of the “Man on the Moon.” This is a reference to the Moon looking like it has a grinning man on its face. Show pictures of the Moon and ask the students if they can see the face with their imagination. No matter where the Moon is in its orbit, we always see the same side of the Moon.

Now have the Moon student *rotate* on their axis so they are always looking at the Earth. The Earth student should follow slowly and notice that now they always see the Moon’s face. The Moon student would have turned on their axis only once during the orbit. The Moon rotates on its axis in the same amount of time that it orbits around the Earth!

Shadows and the Sun

Activity #6

Grade Levels: K – 3rd grade **Time Frame:** 20 min. over two different times of day.

Overview

Students will make a chalk drawing of a classmate's shadow at two different times in the day. They will compare the shadow lengths along with the position of the sun in the sky. Review what student's learned about the Earth's movement in the previous activity: The Earth orbits around the Sun and rotates on its axis to make the Sun, Moon, and stars appear to move across the sky.

This activity works best if you start shortly after school begins when the sun is not very high in the sky yet but is high enough that you can make out shadows on the ground. You will return to the shadow chalk drawings around noon to see if anything has changed.

What you need

- Different colored chalk (enough for whole class to use)
- Open space outdoors

Preparation

This activity takes place outside. You will want an open space outside where students will be able to draw on the ground with chalk.

Activity Guide

Before going outside ask the students what they know about the Sun so far. What do they know about shadows? Encourage the discussion so you can cover the following topics:

- It is very dangerous to look at the Sun. We NEVER look directly at the Sun!
- The Sun appears to move across the sky, but it is actually the Earth turning on its axis.
- The Sun creates shadows. When an object or a person stands in the Sunlight they cast a shadow. If the Sun is shining behind us, we will see our shadows in front of us.
- We all make shadows.

Take the students outside and arrange them into pairs. Ask for a volunteer to help you demonstrate the following steps so the students can trace their partner's shadows. This part of the activity is best started just after school starts when the sun is not very high in the sky yet but is high enough that you can make out shadows on the ground.

1. Trace the student's feet and have them write their name next to their feet. We are tracing our feet so we can stand in the exact same spot later on in the day. Make sure the student is facing the direction of their shadow so the Sun is behind them.
2. Trace the student's shadow outline now and write the time of day inside it. (Steps one and two can also be done using your shadow if you would like and have the student do the drawing as practice.)
3. After the drawing is complete, ask the students the questions below. **Remind students to NEVER look directly at the Sun!** The Sun, if you started this activity before noon, should be towards the East and low in the sky.

    - How high is the Sun?
    - Is the Sun East or West?

  - How long is the shadow? Long or short?

4. Now have the students spread out so they can trace each other's feet and shadows. Make sure the students stand so the Sun is behind their backs and that they write their names and the time of the day inside the shadows. It is best to write the time of day in the head of the shadow and not near the feet.

Once the students have finished making their shadow drawings in pairs you can return inside. Let the students know that they will be returning to trace their shadows again between noon and 1:00 PM. Ask the students if the following questions and record their answers on the board.

- Where will the Sun be around noon in the sky?
- What will happen to the shadows? Will they grow longer? Shorter? Be the same?

Returning outside around Noon

Have the students find their feet outlines and with their partners, trace their shadows again. They can write the new time of day in the head of their new shadow. Ask the following questions as they work.

- Was the second shadow the same as the first?
- How did it change?
- Did the shadow move?
- Where is the Sun now? (Remember; do not look directly at the Sun!)
- Did the Sun move? – **No** Did we move? – **Yes**! Our shadows changed direction because of the Earth rotating on its axis, not because the Sun moved. The Sun is still in the same place, but the Earth has turned giving us a different point of view.

Going Further – Outside one last time

You can take the students out for a third time near the end of school, asking what the students think they will see.

- Where will the third shadow be?
- Where will the Sun be?

Have students observe the final shadow and explain what has happened.

Our Moon

Teacher Background

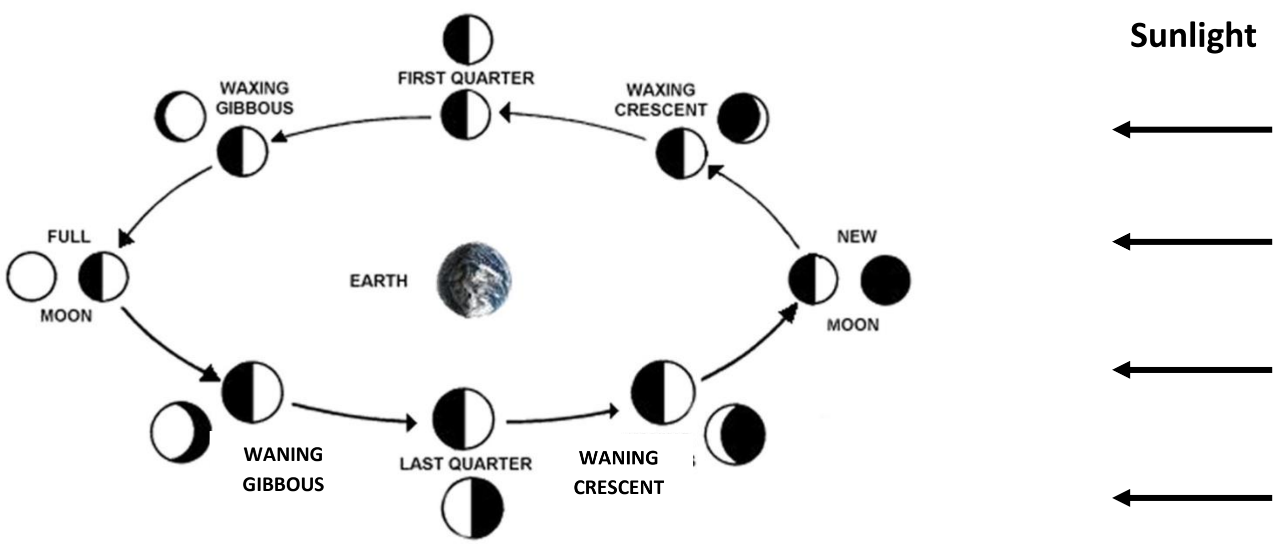
Moon Phases and Eclipse Activities taken from the *Seasons and Moon Phases Kits* by the Clark Planetarium – 2008
Modified to fit a younger age group

Moon Phases

The phases of the Moon are caused by the Sun's light reflecting off the Moon's surface in combination with the Moon's orbit around Earth. The Sun always illuminates half of the Moon. As the Moon travels around Earth our perspective changes and so does the amount of the lighted half of the Moon that is visible to us.

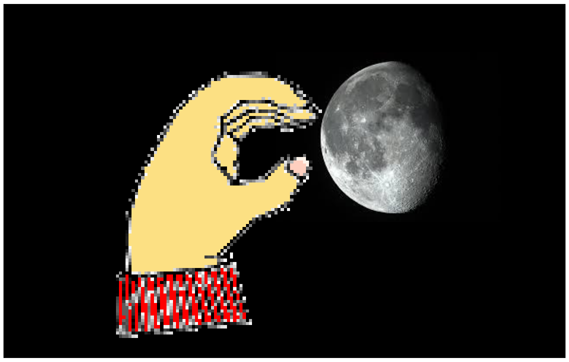
The Moon orbits around Earth from West to East. This may confuse some students because, as seen from Earth, the Moon appears to rise in the East, move westward across the sky, then set in the West. However, this apparent motion of the Moon results from Earth's rotation (spinning), not the revolution (orbit) of the Moon. The Moon orbits Earth from West to East slowly. It takes 29.5 days or about one month (or "moonth") to orbit Earth and return to the same phase. This slow trek eastward can be noticed by observing that the Moon rises on average about 45 minutes later each day.

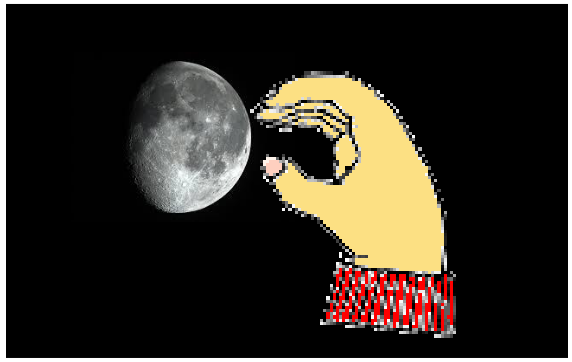
*Outer circle depicts lunar phases as viewed from Earth



When the Moon is at its new phase, the side opposite us is lit by the Sun and it is impossible for us to see the unlit side of the Moon. Two days after new moon, the Moon has moved enough for a small portion of the lit side to be seen, a crescent. As the Moon continues to orbit Earth more of its sunlit surface can be seen and the Moon is said to be waxing (growing). In about seven days the Moon goes from new to waxing crescent to its first quarter phase, where we see a quarter of the Moon's surface (1/2 the illuminated surface) illuminated by the Sun. As the Moon continues to travel around Earth, it proceeds from a waxing gibbous to a full moon. At the full moon phase, the Moon's surface that we see is fully illuminated and the bright moonlight can even cast shadows on earthly objects. After the full moon, less and less of the Moon's lighted surface is seen and the Moon is said to be waning. Over the next 14-15 days the Moon will slowly change to a waning gibbous followed by third quarter, waning crescent, then finally back to a new moon.

One way to help students identify waxing phases from waning phases is to use their hands. If they can line up the lit side of the Moon with a *backward* "C" made with their RIGHT hand (below right), it is a WAXING Moon. If they can line up the lit side of the Moon with a "C" made with their LEFT hand, it is a WANING Moon (below left).

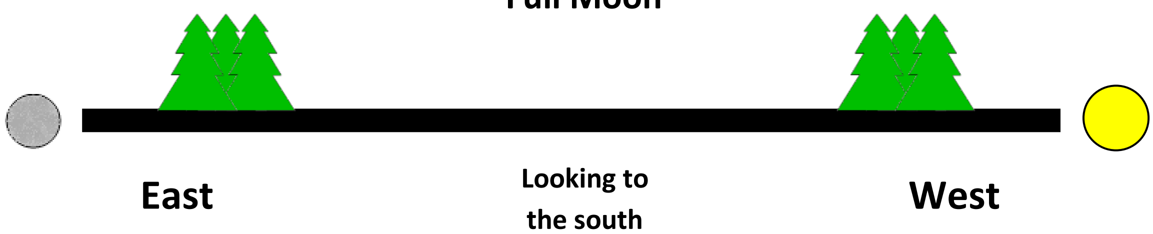




Left Hand - Waning **Right Hand - Waxing**

As the Moon revolves around Earth, the angle between the Sun and the Moon, as seen from Earth, changes. At the new moon phase, the Moon and the Sun lie in the same direction. At full moon, the Sun is seen opposite to the Moon in the sky. For this reason, the full moon rises at sunset (see below). This can be understood by visualizing the linear arrangement of the Sun, Earth, and the Moon.

Full Moon



Common Misconceptions:

Be aware that there are many misconceptions that students and adults have about the Moon and its phases. Some of these are:

1. The Moon shines because it is generating its own light.
2. The Moon has phases because clouds cover its surface.
3. The Moon has phases because Earth's shadow is being cast on it.
4. The Moon is visible every night and not visible during the day.

Eclipses

Moon Phases and Eclipses backgrounds taken from the *Seasons and Moon Phases Kits* by the Clark Planetarium - 2008

Solar Eclipse

Eclipses occur when an object in space casts a shadow upon another object. On Earth, two types of eclipses can occur, solar and lunar. A solar eclipse happens when the Moon passes in front of the Sun and casts a shadow on a small portion of the Earth. A solar eclipse always occurs during the new Moon phase. The disk of the Moon is just the right size to cover the Sun. However, the Moon is not the same size as the Sun; it looks like the same size because the Moon is closer to us. The Sun is 400 times larger than the Moon, but the Moon is 400 times closer to us. In the small area of the Earth shadowed by the Moon during a total solar eclipse, day seems to turn to early night as even stars begin to become visible.

Lunar Eclipse

A lunar eclipse occurs when the Moon passes through Earth's shadow in space. The Moon is in its full moon phase during the eclipse. When passing through the Earth's shadow, the Moon is usually at least slightly visible. This is because light from the Sun is refracted through Earth's atmosphere. Most of the light is scattered (the reason we have a blue sky) but long orange and red wavelengths of light make it through the atmosphere. During totality, the only light getting to the moon is light that has passed through Earth's atmosphere. This causes the Moon to become a reddish color during a lunar eclipse.

Eclipses do not occur every month because the Moon's orbit is tilted by about 5º compared to Earth's. This causes the Moon to pass a little above or a little below the Earth's shadow every month. Only on rare occasions do the Sun, Moon, and Earth line up just right for an eclipse to occur.

Common Misconceptions:

1. It is dangerous to be outside during a lunar eclipse. There is no danger at all. Solar eclipses should only be viewed with appropriate safety gear or safe methods such as image projection.

References and Links

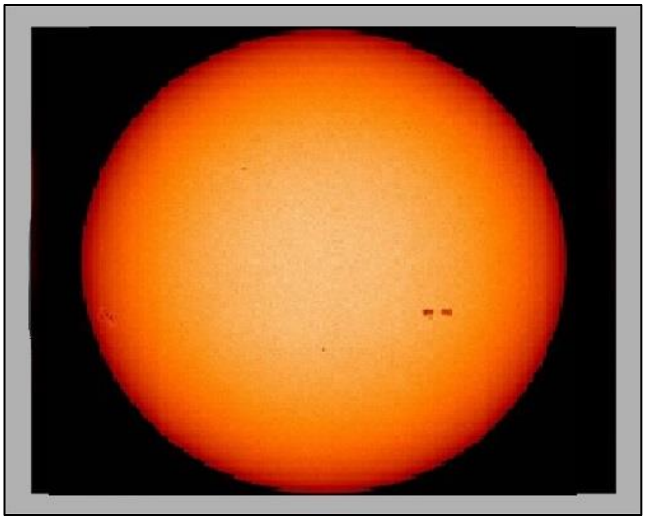
Moon Facts: NASA
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

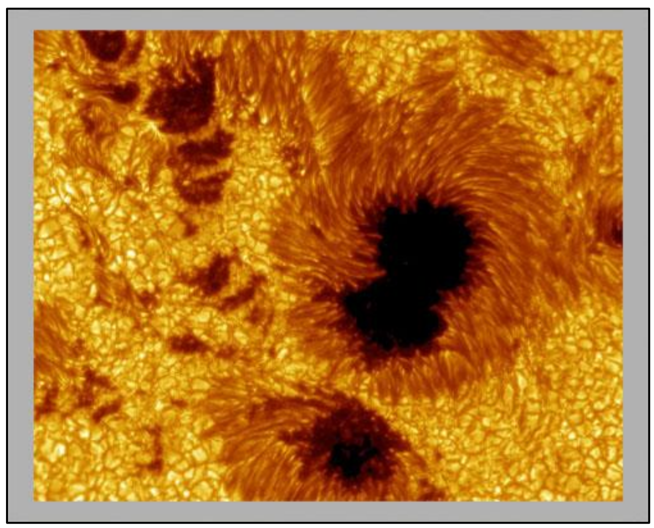
Craters: Lunar and Planetary Institute
http://www.lpi.usra.edu/education/explore/shaping_the_planets/impact_cratering.shtml

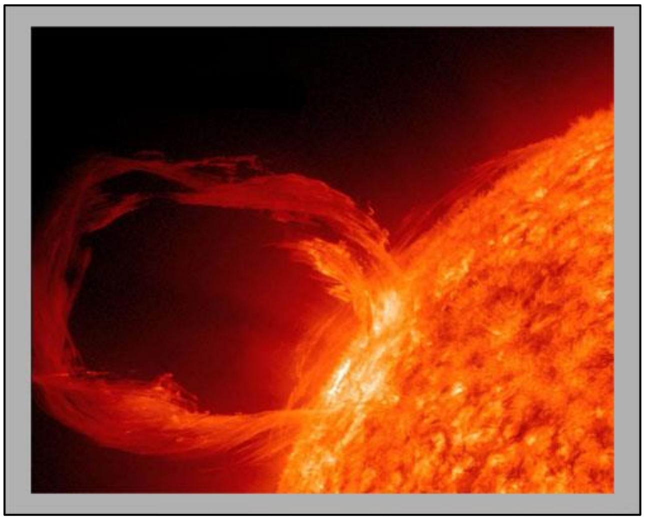
Activity Worksheets and Resources

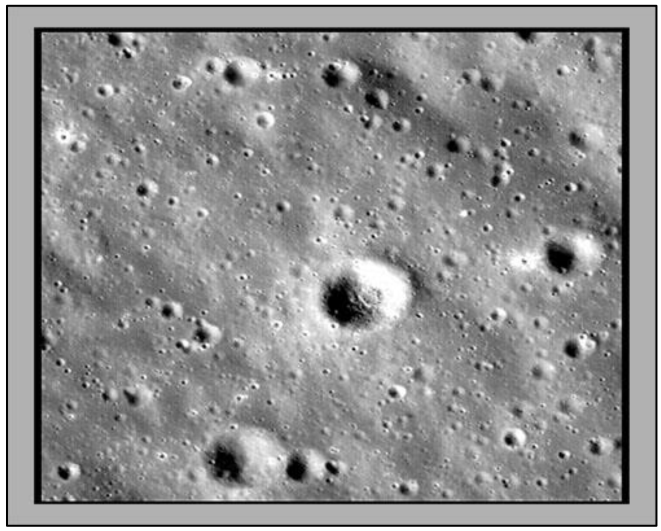
Activity #2 – Matching game Cards

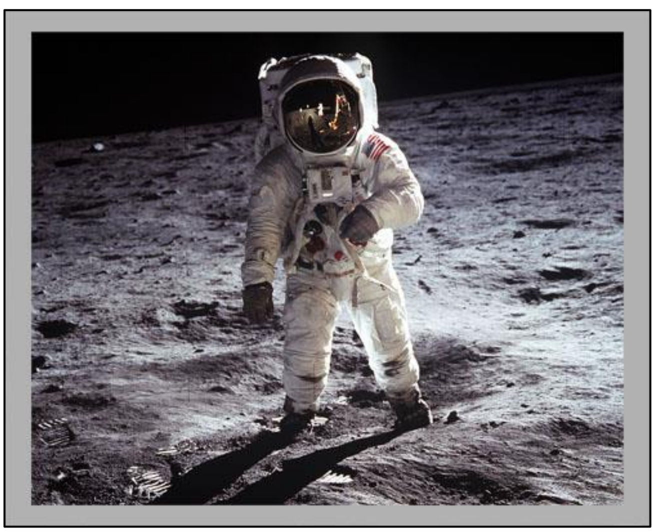
Cut out the cards along the border.

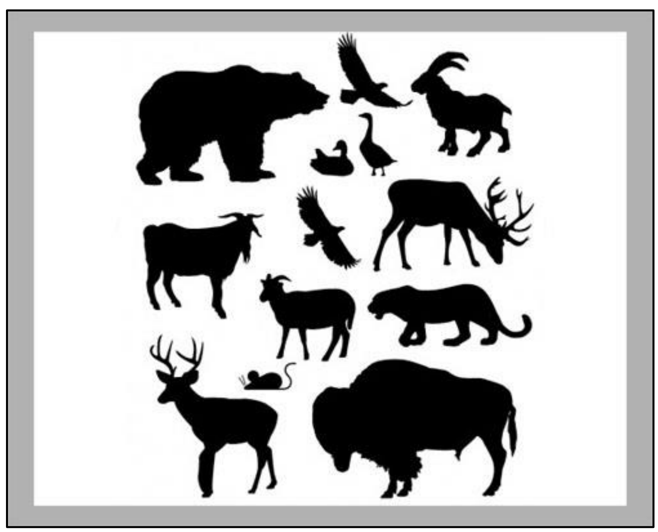












I am a planet made mostly out of rock.

I create my own light.

I am a Star.
My name is Sol.

I reflect light from the Sun so you can see me from Earth.

My name is Luna and
I am mostly made of rock.

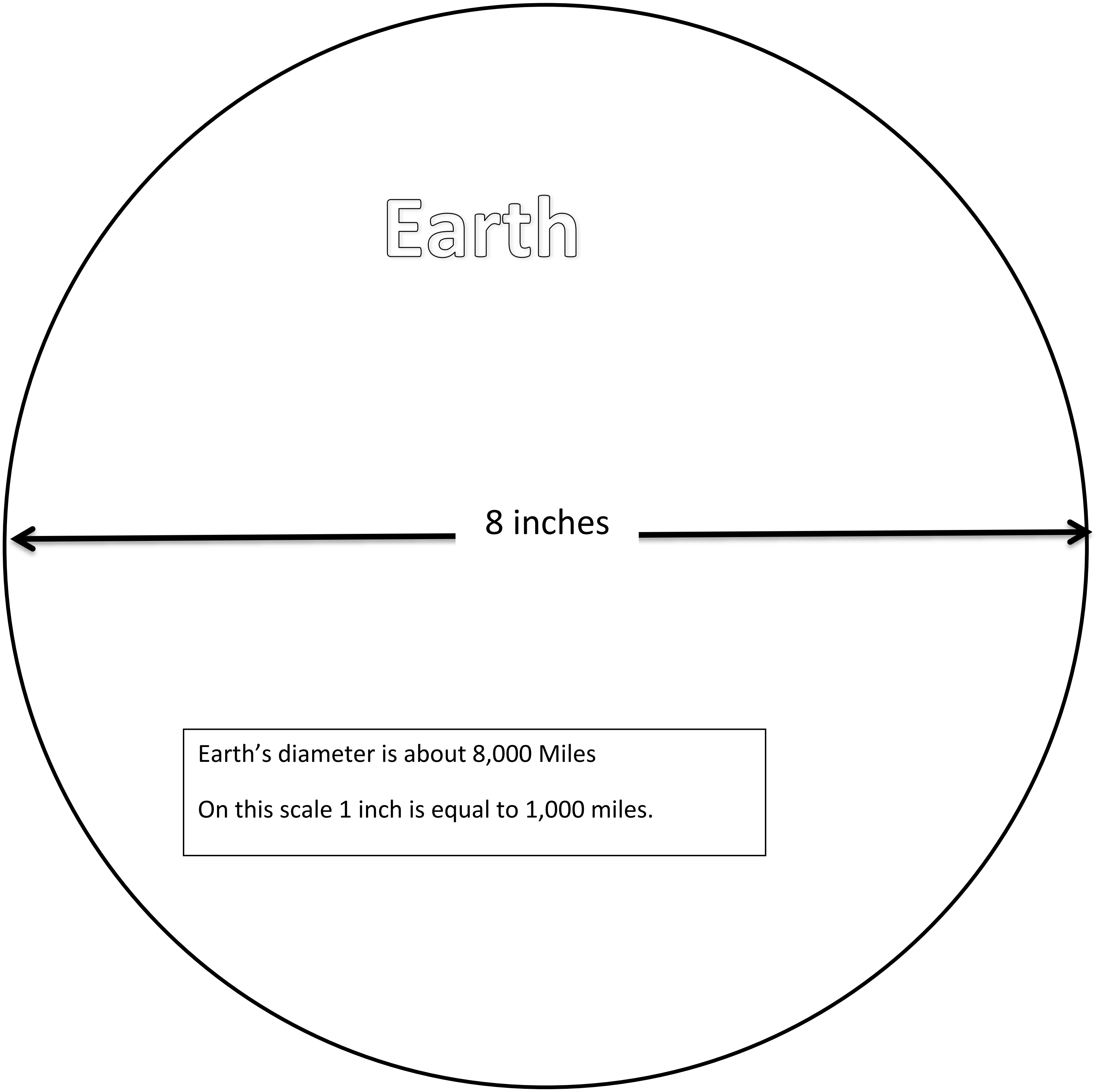
I reflect the Sun's light
and we call it day time.

I am shaped like
a Sphere

Lunar

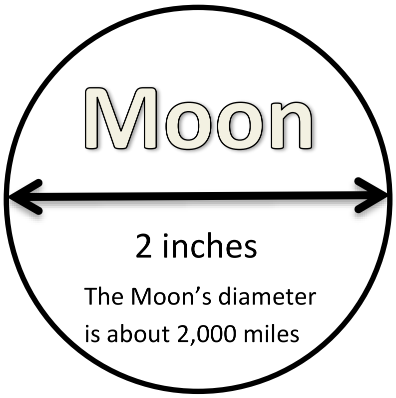
Solar

Activity #4 – How Far are the Sun and Moon?



Earth's diameter is about 8,000 Miles

On this scale 1 inch is equal to 1,000 miles.



The distance to the Moon is about 240,000 miles. On this scale, 1 inch = 1,000 miles. So the distance to the Moon is about 20 feet (240 inches) on this small scale.

Glossary

Axis: A real or imaginary line through a spinning object.
The Earth spins on its axis.

Crater: Roughly circular, excavated holes made by impacts of meteorites.

Crescent Moon: The appearance of the Moon when we see less than half of light on its surface. This phase is shaped like a crescent or C shape.

Day: The Earth rotates on its axis once to make a day. A day is about 24 hours long.

Distance: The amount of space between two objects.

Earth: Our planet and home. Earth is mostly covered in water, but is mostly made of rock. It is the largest of the rocky planets in our Solar system.

Galaxy: Galaxies are home to billions of stars. Our own galaxy is the Milky Way Galaxy and it houses over 100 billion stars.

Gibbous Moon: This Moon Phase is when the Moon is more than halfway lit up, but not quite full, from our point of view.

Lunar: of or relating to the Moon. A term used to describe things associated with our moon.

Lunar Eclipse: When the Moon passes through the Earth's shadow.

Month: This is approximately how long it takes the Moon to orbit around the Earth. The Moon takes about 29.5 days, or one "Moonth" to complete its orbit and cycle of phases.

Moon: a natural satellite that orbits around a planet.

Moon Phase: How much of the illuminated side of the Moon we see from Earth.

Newton's First Law of Motion: An object will keep moving the way it is already moving as long as it doesn't get bothered. An object in motion will stay in motion. A object not moving will stay not moving.

Newton's Second Law of Motion: An object will change the way it is moving when it gets pushed or pulled.

Newton's Third Law of Motion: If an object gets pushed, it pushes back just as hard; equal and opposite forces.

Orbit: The curved path of an object around a star, planet, or moon. See also Revolution.

Planet: Planets orbit around stars. The word Planet, or *Planetes*, is actually Greek for "wanderer." Today planets are defined with these three rules:

1. It must orbit the Sun
2. It must have enough gravity, or be big enough, to pull itself into a roughly sphere shape.
3. It must have cleared other objects out of the way in its orbital neighborhood

Reflect: The bouncing of light off a surface.

Revolution: movement around a central point or object. See also Orbit.

Rotate: The act or process of turning on an axis.

Scale: a succession or progression of steps or degrees. A standard of measurement or estimation; point of reference by which to gauge or rate

Shadow: A shadow is created when light is blocked by an object.

Scientific Model: A systematic description of an object or phenomenon that shares important characteristics with the object or phenomenon.

Solar: of or relating to the Sun. A term used to describe things associated with the Sun.

Solar Eclipse: When the Moon blocks the Sun's light. During a Solar Eclipse, the Moon will move in front of the Sun and block its light, creating a shadow on the Earth.

Solar Flare: occurs when magnetic energy that has built up is suddenly released on the Sun

Solar System: the Sun and all the objects in orbit around it (planets and their moons, dwarf planets, asteroids, and comets). Not to be mistaken for Universe or Galaxy.

Sphere: a 3D shape of a circle, round in all directions; like a ball

Star: a burning sphere that gives off light and energy.

Sunspot: dark areas on the Sun where the temperature is cooler

Universe: all existing matter and space considered as a whole; the cosmos

Waning: means to become less. Describes Moon Phases when the light is decreasing over time across its surface from Earth's point of view

Waxing: means to grow. Describes Moon Phases when the light is increasing over time across its surface from Earth's point of view

Year: The amount of time it takes the Earth to complete one full revolution around the Sun.

References and Links

Moon Facts: NASA
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

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http://www.lpi.usra.edu/education/explore/shaping_the_planets/impact_cratering.shtml

How Big is the Sun: Space.com
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Other fun space activities: NASA Kid's Club
http://www.nasa.gov/audience/forkids/kidsclub/flash/index.html#.VVZ3hflVhHw

Sun Pictures: STEREO Satellite
http://www.nasa.gov/mission_pages/stereo/main/index.html

Sun Pictures: SOHO Satellite
http://soho.nascom.nasa.gov/pickoftheweek/

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http://www.nasa.gov/mission_pages/sunearth/multimedia/Sunlayers.html

How Big is the Sun: Space.com
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NASA's pages on Newton's Laws of Motion with extra activities
Kids Page: https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/dynamicsofflight.html#forces
Newton's Laws: https://www.grc.nasa.gov/www/k-12/airplane/newton.html