Trust | Deliver | Learn

SUN, EARTH & MOON ORBITOR MODEL

CAT NO. BD0075

Experiment Guide

RECOMMENDED COMPONENTS (NOT INCLUDED)

Name of Part	Quantity
Tape Measure	1 per group
Caliper	1 per group
Meter sticks	1 per group

NOTE: AA size batteries (2 nos.) required.

SAFE HANDLING OF APPARATUS:

Breakable Warning: Be careful not to apply too much weight or put pressure on the arm holding Earth, as the arm may bend and not function properly.

GETTING FAMILIAR WITH THE SOLAR SYSTEM:

Learning Goals: (taken from BSSS Earth Science T Course)

- Enable students to critically research, analyse, evaluate and synthesis information from a variety of sources, including their own work and the work of their peers
- Students should be able to follow instructions and make accurate and precise observations while conducting practical investigations, while safely using appropriate equipment and techniques
- Students should be able to communicate scientific information to diverse audiences in an appropriate manner using a variety of media and technologies
- Enable students to work independently and collaboratively.
- Demonstrate a broad knowledge and deep understanding of the practical and theoretical concepts covered in Astronomy and applies this knowledge to solve problems.
- Demonstrate competence in their scientific approach to gain an understanding of the universe and in particular, the Solar System.
- Describe patterns and trends in data observations from Astronomical tools and make valid inferences.
- Apply a variety of communication skills, using appropriate scientific language to clearly express ideas, concepts and information pertaining to Astronomy.

From the Australian National Curriculum:

- Earth's rotation on its axis causes regular changes including night and day.
- Aboriginal and Torres Strait Islander have their own concepts of time and weather
- Predictable phenomena on Earth, including seasons and eclipses are caused by the relative position of the Sun, Earth and Moon

CONTENT

- Recognize that there are enormous distances between objects in space and apply our knowledge of light and space travel to understand this distance.
- Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides.
- Earth's changing position with regard to the Sun and the moon has noticeable effects. Earth revolves around the Sun with its rotational axis tilted at 23.5 degrees to a line perpendicular to the plane of its orbit, with the North Poles aligned with Polaris.
- During Earth's one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun's rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.
- Explain complex phenomena, such as tides, variations in day length, solar insolation, apparent motion of the planets, and annual traverse of the constellations.
- Compare various historical models of the Solar System, including geocentric and heliocentric.
- Explain why theories may be modified but are rarely discarded.

ACTIVITY 1: WHAT TIME IS IT?
TEACHER INSTRUCTIONS

Before beginning to explore all the topics that the Earth, Sun, and Moon Model can investigate, it might be helpful to have a discussion with your students about how we keep track of time. How long is a day? Why did we as a society pick 24 hours for a day? How long is a month? A year? Are these periods of time arbitrary or based on the motion of celestial bodies?   In small groups or pairs have students work together to think of all the different ways that we measure time and have them speculate about what types of movement define a year, a day, a second, a season, a month, etc. Have students be prepared to share at least one idea with the class and compile a list of students' thoughts and ideas to discuss.

What kinds of changes are brought about by a yearly cycle? Depending on your location on Earth, the changing seasons may mean a winter to save up food for, a growing season, a hurricane season, a monsoon season, etc. Have students brainstorm again about different types of seasonal changes all over the world.   Why would it be an advantageous to keep track of, and be able to predict these changes? Do these changes matter now? What are some things that our students do to plan for the changing seasons with their families? Things like packing away clothes that are too cold or too hot for the season, planting a garden, changing the types of outside toys that are available for use, etc.

For information about aboriginal views of the bodies in the night sky the following link is helpful:

http://www.questacon.edu.au/starlab/aboriginal_astronomy.html

*note that the above link is current at time of publishing this document, but may have changed since that time.

ACTIVITY 2: THE HELPFULNESS AND LIMITS OF MODELS
TEACHER INSTRUCTIONS

Have the students break off into groups of two or three and create a list describing how accurately this model of the Sun, Earth, and Moon portray the actual Sun, Earth, and Moon system. Have students make two lists: one of things are accurate according to our current model of the Sun, Earth, and Moon system and a second list of what things are inaccurate or misleading. Students can use rulers or calipers to see if the planet is the correct distance away from the sun and the correct diameter. Ask them to use the words geocentric or heliocentric to describe our model.

Some great class follow up discussions include asking questions such as:

Is this model still useful even if it is not 100% accurate?

What reason do you think the manufacturer had to make the model the way they did? What would the model look like if it were to scale using the size of Earth as a base, how big and far away would the Moon and Sun need to be?

Would it be practical to build a solar system to scale?

What kinds of things can students learn from this model of the solar system?

STUDENT INSTRUCTIONS:

Use the following table, your knowledge of our solar system, and a ruler or calipers in order to decide how accurate this model of the solar system is. Make two lists, one of things are correctly represented by this model of the solar system, and some of things that are incorrect or misleading. Be prepared to share your lists with the class in order to compile one master list.

SOLAR SYSTEM DATA CHART

Object	*Mean Distance from the Sun (millions of km)*	*Period of Revolution*	*Equatorial Diameter (km)*
Sun	---	---	1,392,000
Earth	149.6	365.26 days	12,756
Earth's Moon	149.6 (0.386 from Earth)	27.3 days	3,476

Here are some examples of things your students may describe. If there are some discrepancies between students as to what belongs on each list, facilitate the discussion by encouraging the students to use facts and measurements to justify their thoughts.

Things that are accurate:

- We currently believe in a heliocentric view of the solar system, and this model has the sun as the center of the solar system
- The sun is much larger than the planet.
- The Moon revolves around Earth.
- The Sun is bigger than Earth, and Earth is bigger than the Moon.
- As Earth revolves around the Sun, the seasons change.
- The Earth spins on its axis and at all times exactly ½ of Earth is covered in light from the Sun.
- Earth is tilted at 23.5 degrees to a line perpendicular to the plane of its orbit.
- The Sun shines light upon Earth and the Moon.

Things that are inaccurate:

- The orbits of the planets are not circular, they are elliptical.
- The spacing and size of the bodies are not to scale.
- There are no metal posts holding the Sun, Moon, or Earth in orbit gravity does that.
- The actual Sun shines in all directions.
- The Moon in the model does not revolve or rotate on its own.
- The Earth in the model does not revolve or rotate on its own.

DATE & TIME OF SOLSTICES & EQUINOXES IN 2013 GMT = GREENWICH MEAN TIME

Equinoxes:	March 20 2013 11:02 GMT	September 22 2013 20:44 GMT
Solstices:	June 21 2013 05:04 GMT	December 21 2013 17:11 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2014

Equinoxes:	March 20 2014 16:57 GMT	September 23 2014 02:29 GMT
Solstices:	June 21 2014 10:51 GMT	December 21 2014 23:03 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2015

Equinoxes:	March 20 2015 22:45 GMT	September 23 2015 08:20 GMT
Solstices:	June 21 2015 16:38 GMT	December 22 2015 04:38 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2016

Equinoxes:	March 20 2016 04:30 GMT	September 22 2016 14:21 GMT
Solstices:	June 20 2016 22:34 GMT	December 21 2016 10:44 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2017

Equinoxes:	March 20 2017 10:28 GMT	September 22 2017 20:02 GMT
Solstices:	June 21 2017 04:24 GMT	December 21 2017 16:28 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2018

Equinoxes:	March 20 2018 16:15 GMT	September 23 2018 0154 GMT
Solstices:	June 21 2018 10:07 GMT	December 21 2018 22:22 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2019

Equinoxes:	March 20 2019 21:58 GMT	September 23 2019 07:50 GMT
Solstices:	June 21 2019 15:54 GMT	December 22 2019 04:19 GMT

DATE & TIME OF SOLSTICES & EQUINOXES IN 2020

Equinoxes:	March 20 2020 03:49 GMT	September 22 2020 13:30 GMT
Solstices:	June 20 2020 21:43 GMT	December 21 2020 10:02 GMT

Name:________________________________ **Helpfulness and Limit of Models**

Date:________________Partners:____________________________________

Use the following table, your knowledge of our solar system, and a ruler or calipers in order to decide how accurate this model of the solar system is. Make two lists, one of things are correctly represented by this model of the solar system, and some of things that are incorrect or misleading. Be prepared to share your lists with the class in order to compile one master list.

SOLAR SYSTEM DATA CHART

Object	*Mean Distance from the Sun (millions of km)*	*Period of Revolution*	*Equatorial Diameter (km)*
Sun	---	---	1,392,000
Earth	149.6	365.26 days	12,756
Earth's Moon	149.6 (0.386 from Earth)	27.3 days	3,476

Things that are accurate:

Things that are inaccurate:

ACTIVITY 3: AS THE WORLD REVOLVES
TEACHERS INSTRUCTIONS

OBJECTIVES:

- Earth's rotation on its axis causes regular changes including night and day.
- Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, and seasons.
- During Earth's one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun's rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.
- Explain variations in day length.

PROCEDURE:

Get familiar with your globe: Answer the following questions and then have your teacher check your answers before you begin working.

a. The half of Earth that is shining in the light represents _daytime_.

b. The half of Earth that is in darkness represents _night time_.

c. Take your right hand and orient it so your thumb is pointing the same direction as your North Pole. The direction your fingers are curling is the direction the Earth spins. Slowly spin your globe and focus on one city. As the city moves from darkness to light, this represents __sun rise_.

d. As the city moves from light to darkness, this represents _sunset_.

e. For your city in question the sun rises in the _East_ and sets in the _West_.

f. There are _24_ lines of longitude and _15__ lines of latitude on the globe.

g. The lines of longitude are evenly space apart at _15_ degrees of longitude each, therefore every line of longitude represents a time of _1_ hour(s).

h. The line 23.5 °S of the equator is called the _Tropic of Capricorn_ and this line is important because _this is the farthest South the direct rays of the sun will reach. The direct rays of the sun shine on this line around December 21st.

i. At 66.5°N of the equator is the Arctic Circle and 66.5 °S of the equator is the Antarctic Circle. These lines are important because inside the arctic and Antarctic circle it is possible to have 24 hours of daylight in a day or 24 hours of nighttime in a day.

1. Plug the model into an outlet and make the model Earth revolve around the sun until the black arm is extended over December 21st. (Move Earth to where the North Pole is pointed as far away as possible from the Sun.)
2. Move the moon to the opposite side of Earth (where night is).
3. Mark the following cities with an erasable marker, a small piece of sticky tack or a small piece of tape. Something that will be easy to remove and easy to see. Singapore, Indonesia; Canberra, Australia; Havana, Cuba; Rio de Janerio, Brazil; Cairo, Egypt; Victoria Island, Canada; The South Pole; Antarctica (where the post is holding Earth up).
4. Also find your position on the map and then mark it as well.
5. Determine approximately what day your globe is representing and write that on the line below ____December 21st____
6. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

*Note to the Teacher, these numbers can be tricky to count. Any number +/-2 hours will be enough for students to get the general idea of what is happening.

	Hours of Daylight	*Hours of Darkness*
Singapore, Indonesia (equator)	12	12
Cairo, Egypt (North of the Equator)	10	14
Canberra, Australia (South of the Equator)	16	8
Havana, Cuba (Tropic of Cancer)	11	13
Rio de Janerio, Brazil (Tropic of Capricorn)	13	11
Victoria Island, Canada (North of Arctic Circle)	0	24
The South Pole	24	0

7. Now make the model Earth revolve around the sun until the black arm is extended over June 21st. You can find this position by moving Earth to where the North Pole is pointed as close as possible to the Sun.
8. Determine approximately what day your globe is representing and write that on the line below
   _June 21st___

9. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

	Hours of Daylight	***Hours of Darkness***
Singapore, Indonesia (equator)	12	12
Cairo, Egypt (North of the Equator)	14	10
Canberra, Australia (South of the Equator)	8	16
Havana, Cuba (Tropic of Cancer)	13	11
Rio de Janerio, Brazil (Tropic of Capricorn)	11	13
Victoria Island, Canada (North of Arctic Circle)	24	0
The South Pole	0	24

10. Now make the model Earth revolve around the Sun until the black arm is exactly half way between the summer and winter solstice.
11. Determine approximately what day your globe is representing and write that on the line below

    __March or September 21st__

12. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

	Hours of Daylight	***Hours of Darkness***
Singapore, Indonesia (equator)	12	12
Cairo, Egypt (North of the Equator)	12	12
Canberra, Australia (South of the Equator)	12	12
Havana, Cuba (Tropic of Cancer)	12	12
Rio de Janerio, Brazil (Tropic of Capricorn)	12	12
Victoria Island, Canada (North of Arctic Circle)	12	12
The South Pole	12	12

QUESTIONS:

1. How does the duration of insolation change as the season change from December 21st to March 21st to June 21st to September 21st in the Northern Hemisphere?

   Around December 21st the duration of insolation is the smallest and it increases until the Spring Equinox when there are exactly 12 hours of daylight. As June 21st approaches the duration of insolation continues to increase until the summer solstice. At the summer solstice, around June 21st, the duration of insolation is the longest. After the summer solstice, the duration of insolation decreases until the winter solstice, around December 21st, and the cycle repeats.

2. How does the duration of insolation change as the seasons change from December 21st to March 21st to June 21st to September 21st in the Southern Hemisphere?

   Around December 21st the duration of insolation is the largest and it decreases until March 21st at the equinox when there are exactly 12 hours of daylight. As June 21st, winter approaches, the duration of insolation continues to decrease until the winter solstice. At the winter solstice, around June 21st, the duration of insolation is the shortest. After the winter solstice the duration of insolation increases until the summer solstice, around December 21st, and the cycle repeats.

Name:____ **As the World Revolves**

Date:__________________Partners:____

OBJECTIVES:

- Earth's rotation on its axis causes regular changes including night and day.
- Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, and seasons.
- During Earth's one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun's rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.
- Explain variations in day length.

PROCEDURE:

Get familiar with your globe: Answer the following questions and then have your teacher check your answers before you begin working.

a. The half of Earth that is shining in the light represents _______________.

b. The half of Earth that is in darkness represents __________________.

c. Take your right hand and orient it so your thumb is pointing the same direction as your North Pole. The direction your fingers are curling is the direction the Earth spins. Slowly spin your globe and focus on one city. As the city moves from darkness to light, this represents ___________________________.

d. As the city moves from light to darkness, this represents ___________________.

e. For your city in question the sun rises in the ________________ and sets in the _________________.

f. There are ____________ lines of longitude and _____________ lines of latitude on the globe.

g. The lines of longitude are evenly space apart at ___________degrees of longitude each, therefore every line of longitude represents a time of _________hour(s).

h. The line 23.5 °S of the equator is called the ___________________________ and this line is important because ____
____
____

i. At 66.5°N of the equator is the _______________ and 66.5 °S of the equator is ________________________. These lines are important because ____________
____
____

DIRECTIONS:

1. Plug the model into an outlet and make the model Earth revolve around the sun until the black arm is extended over the December 21st. (Move Earth to where the North Pole is pointed as far away as possible from the Sun.)
2. Move the moon to the opposite side of Earth (where night is).
3. Mark the following cities with an erasable marker, a small piece of sticky tack or a small piece of tape. Something that will be easy to remove and easy to see.

   Singapore, Indonesia; Canberra, Australia; Havana, Cuba; Rio de Janerio, Brazil; Cairo, Egypt; Victoria Island, Canada; The South Pole; Antarctica (where the post is holding Earth up).
4. Also find your position on the map and then mark it as well.
5. Determine approximately what day your globe is representing and write that on the line below________________________
6. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

	Hours of Daylight	*Hours of Darkness*
Singapore, Indonesia (equator)		
Cairo, Egypt (North of the Equator)		
Canberra, Australia (South of the Equator)		
Havana, Cuba (Tropic of Cancer)		
Rio de Janerio, Brazil (Tropic of Capricorn)		
Victoria Island, Canada (North of Arctic Circle)		
The South Pole		

7. Now make the model Earth revolve around the sun until the black arm is extended over June 21st solstice. You can find this position by moving Earth to where the North Pole is pointed as close as possible to the Sun.

8. Determine approximately what day your globe is representing and write that on the line below

____

9. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

	Hours of Daylight	***Hours of Darkness***
Singapore, Indonesia (equator)		
Cairo, Egypt (North of the Equator)		
Canberra, Australia (South of the Equator)		
Havana, Cuba (Tropic of Cancer)		
Rio de Janerio, Brazil (Tropic of Capricorn)		
Victoria Island, Canada (North of Arctic Circle)		
The South Pole		

10. Now make the model Earth revolve around the Sun until the black arm is exactly half way between the summer and winter solstice.

11. Determine approximately what day your globe is representing and write that on the line below

____

12. Fill out the graph below by counting the number of meridians that are exposed to the sunlight and darkness.

	Hours of Daylight	***Hours of Darkness***
Singapore, Indonesia (equator)		
Cairo, Egypt (North of the Equator)		
Canberra, Australia (South of the Equator)		
Havana, Cuba (Tropic of Cancer)		
Rio de Janerio, Brazil (Tropic of Capricorn)		
Victoria Island, Canada (North of Arctic Circle)		
The South Pole		

QUESTIONS:

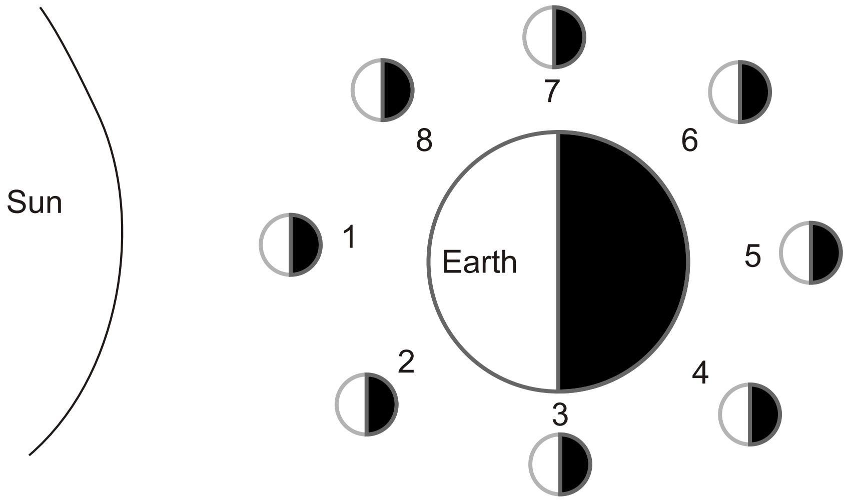
1. How does the duration of insolation change as the season change from December 21st to March 21st to June 21st to September 21st in the Northern Hemisphere?

2. How does the duration of insolation change as the seasons change from December 21st to March 21st to June 21st to September 21st in the Southern Hemisphere?

ACTIVITY 4: PHASES OF THE MOON
TEACHERS INSTRUCTIONS

Turn off all the lights in the classroom and plug in your model. Place the moon directly between the sun and earth. This is position 1. Pretend that the moon's orbit around earth is a big pie and cut that pie into eight slices.

1. In the space provided below for each 1/8th of an orbit around the earth, draw a top down view of which half of the sun and moon are light and which are dark.



2. Now pretend you are a nighttime observer from earth. Align your head so that you are always viewing the moon with earth directly between your head and the moon. You will only be able to see half of the moon. Draw a diagram for each position 1-8 and shade in the shadow side of the moon. Under each diagram state the phase of the moon it represents.

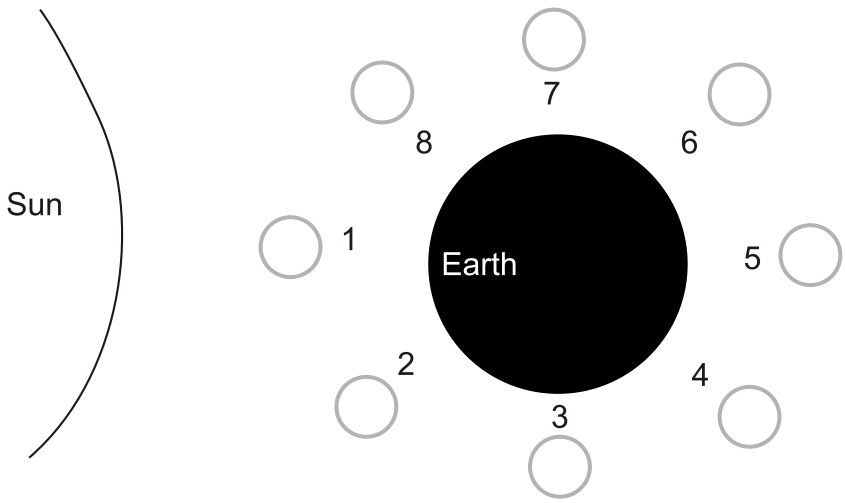
Name:____ **Phases of the Moon**

Date:______________________

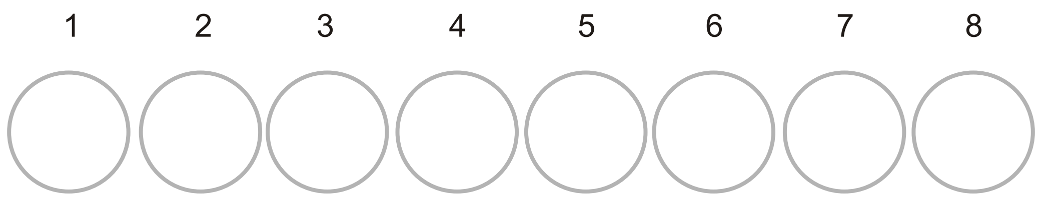
DIRECTIONS:

Turn off all the lights in the classroom and plug in your model. Place the moon directly between the sun and earth. This is position 1. Pretend that the moon's orbit around earth is a big pie and cut that pie into eight slices.

1. In the space provided below for each 1/8th of an orbit around the earth, draw a top down view of which half of the sun and moon are light and which are dark.

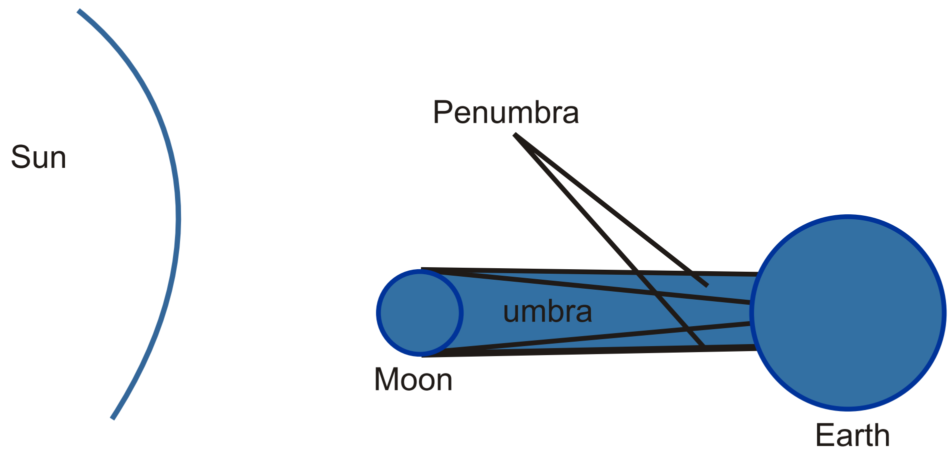


2. Now pretend you are a nighttime observer from earth. Align your head so that you are always viewing the moon with earth directly between your head and the moon. You will only be able to see half of the moon. Draw a diagram for each position 1-8 and shade in the shadow side of the moon. Under each diagram state the phase of the moon it represents.

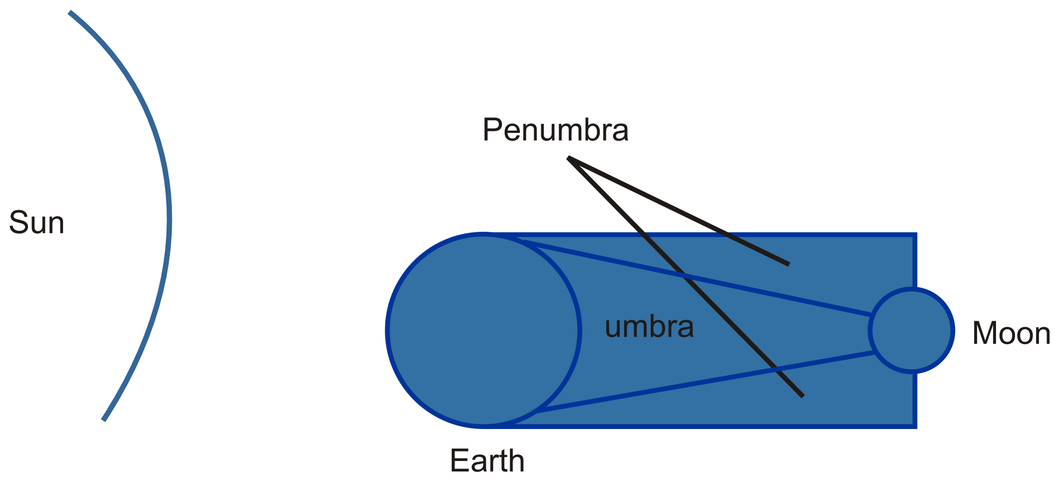


ECLIPSES AND TIDES EXPLAINED USING THIS MODEL: TEACHERS INSTRUCTIONS

A solar eclipse occurs when the moon comes between the Earth and the Sun. In the space below sketch the position of the Earth, Moon, and Sun during a solar eclipse:



A lunar eclipse occurs when the Earth comes between the moon and the Sun. In the space below sketch the position of the Earth, moon and Sun during a lunar eclipse:



On your model of the Earth, Moon, and Sun system notice that the shadow of the Moon or Earth is dark towards the center of the shadow. This dark part is called the umbra. The lighter part around the edges is called the penumbra. Label this portion of your diagram.

Tides occur because of the rotation of the Earth and the gravitational pull on Earth by the Sun and moon. High tide is when the moon is directly overhead. As earth rotates the moon is also revolving around earth. It takes about 24 hours and 50 minutes for the moon to be directly overhead again. High tide occurs again when the moon is on the exact opposite side of earth. Therefore the time between high tide until high tide is 12 hours and 25 minutes.

Neap Tide: When the sun and moon are at right angles to one another the change in water levels from high tide to low tide are the most modest. This is because the gravitational pull from the moon is pulling at a right angle to the gravitational pull of the sun.

The neap tide occurs during which two phases of the moon?
The first quarter and the last quarter.

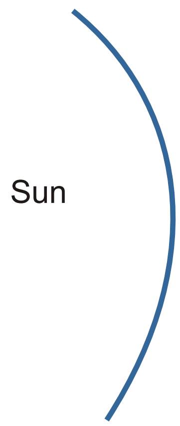
Spring Tide: When the sun and moon are in line with earth, the highest high tide and the lowest low tide occur.

The spring tide occurs during which two phases of the moon?
At full moon and new moon.

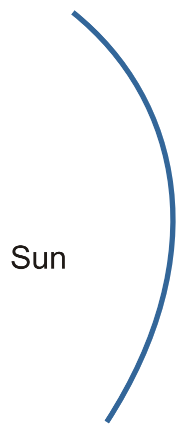
Name:____ Date:___________________

ECLIPSES AND TIDES EXPLAINED USING THIS MODEL:

A <u>solar eclipse</u> occurs when the moon comes between the Earth and the Sun. In the space below sketch the position of the Earth, Moon, and Sun during a solar eclipse:



A <u>lunar eclipse</u> occurs when the Earth comes between the Moon and the Sun. In the space below sketch the position of the Earth, Moon, and Sun during a lunar eclipse:



On your model of the Earth, Moon, and Sun system notice that the shadow of the Moon or Earth is dark towards the center of the shadow. This dark part is called the <u>umbra</u>. The lighter part around the edges is called the <u>penumbra</u>. Label this portion of your diagram.

Tides occur because of the rotation of the Earth and the gravitational pull on Earth by the Sun and moon. High tide is when the moon is directly overhead. As earth rotates the moon is also revolving around earth. It takes about 24 hours and 50 minutes for the moon to be directly overhead again. High tide occurs again when the moon is on the exact opposite side of earth. Therefore the time between high tide until high tide is ____

Neap Tide: When the sun and moon are at right angles to one another the change in water levels from high tide to low tide are the most modest. This is because the gravitational pull from the moon is pulling at a right angle to the gravitational pull of the sun.

The neap tide occurs during which two phases of the moon?

____ .

Spring Tide: When the sun and moon are in line with earth, the highest high tide and the lowest low tide occur.

The spring tide occurs during which two phases of the moon?

____ .

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