Do Not Remove!

Key

GS 104 Laboratory # 1
MODELS AND SYSTEMS

Introduction

We use models to represent the natural world in which we reside. Throughout human history, models have also been used to represent the solar system. From our reality here on Earth, we take part in an Earth-Moon-Sun system. The relationship between their positions at various times determines some common phenomena such as seasons, moon phases, and day length. In this lab, you will use physical models to explore these relationships.

Goals and Objectives

- To create scale models and make sketches that reasonably portray observations of components of the Earth-Moon-Sun system
- To use physical models to determine the reasons for the phases of the moon, the seasons, and the length of the day

Pre-Lab Assignment

Lab Jump Start Activity

INDIVIDUALLY

1. **What** do you already know about the Earth's place in the solar system?

2. **Why** do we have seasons on Earth?

3. **What** causes the phases of the moon?

IN YOUR GROUP

1. **As a** group, compile a list of reasons for why there are seasons.

2. **As a** group, compile a list of reasons for why the moon has phases?

Part A - A Model of the Sun-Earth-Moon System -- Phases of the Moon

You will construct a physical model of the Sun-Earth-Moon system. Materials for your model will be at the appropriate activity station. The purpose of this model is to investigate the phases of the moon, which include full, new, first quarter, third-quarter, and last-quarter. Refer to your textbook (Fig. 19.23, p. 539) to see how they appear in the sky.

Use a small sphere affixed to a stick to model the moon. Locate the 'observer' cut out and use the 'observer on a stick' to represent you standing on the earth's surface. This observer represents how "we" here in Monmouth, Oregon would view the moon phases. A lamp acts as the sun. Hold the observer about half a meter (50 cm) from the 'sun'.

Figure 2 represents the view of the model as if you were far from the earth, but above the North Pole. Position the moon, the Earth and the Sun (lamp) at the locations indicated below. **On Figure 2, blacken in the shadowed part of the moon.**

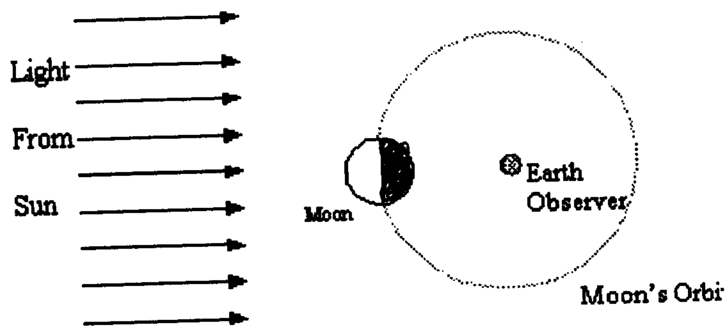


Figure 2: A top view of the Sun-Earth-Moon model.

Your job is to deduce what the 'observer on a stick' located on the Earth will see. On **Figure 3, blacken in the shadow of the moon's face** that the 'Earth observer' sees when looking into the sky.

The phase of the moon is

New.

Figure 3: The way a person on the Earth would observe the moon.

Figure 4 represents another top view of the model. Holding the moon at the new location **as indicated** below, **blacken in the shadowed part of the moon**.

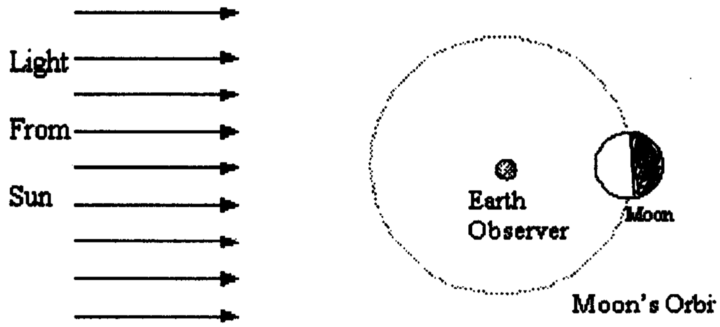


Figure 4: A top view of the Sun-Earth-Moon model.

What does the 'observer on a stick' see now? To indicate this, **blacken in the shadow of the moon's face in Figure 5.**

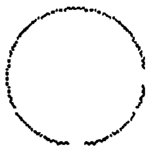


Figure 5: **The way a person on the Earth would observe the moon.**

The phase of the moon is

Full
________________________________.

You know what to do in Figure 6.

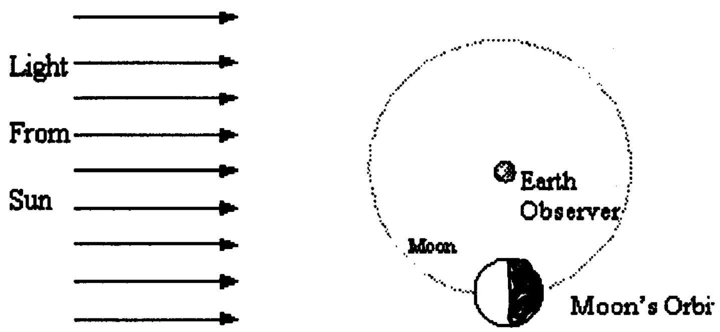
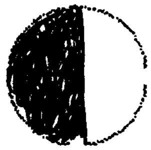


Figure 6: A top view of the Sun-Earth-Moon model.

Again, blacken in the shadow of the moon's face in Figure 7 when it is in the above **position**.



The phase of the moon is

1st Quarter.

Figure 7: The way a person on the Earth would observe the moon.

Once more blacken in the shadowed part of the moon when it is located as shown in **Figure 8**.

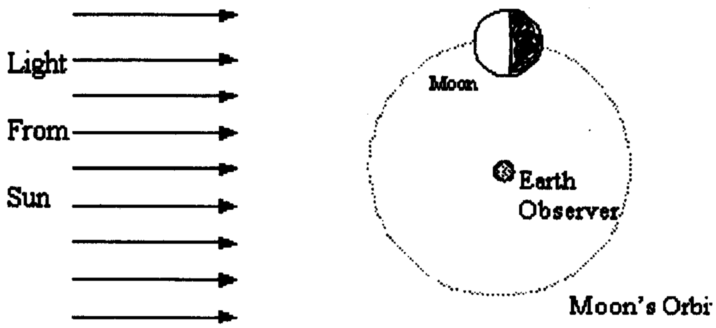
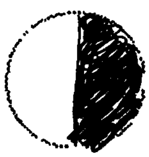


Figure 8: A top view of the Sun-Earth-Moon model.

When an observer looks into the sky, what will they see when the moon is located as it is **in Figure 8**? Indicate what they see in Figure 9, below.



The phase of the moon is

3rd Quarter.

Figure 9: The way a person on the Earth would observe the moon.

Mental Exercise:

The above drawings (Figures 3, 5, 7, 9) represent the moon phase view as seen from an Earth **observer**. Assume this observer was viewing the moon from the Northern Hemisphere, **located** here in Monmouth, Oregon. Now do the same tasks for an observer viewing in the Southern Hemisphere from a position "down under" in Australia. To model this **new position frame of reference**, take your observer on a stick and "walk" them down to **Australia** (Note the observer should now be "up-side-down."). In the spaces provided below, **draw the four corresponding Moon views for this new frame of reference position.**

Figure 3A: How a person on the Earth in **Australia** would observe the moon.

The phase of the moon is

New.

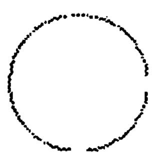


Figure 5A: How a person on the Earth in **Australia** would observe the moon.

The phase of the moon is

Full.

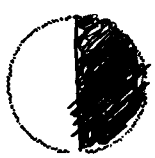


Figure 7A: How a person on the Earth in **Australia** would observe the moon.

The phase of the moon is

1st Quarter.

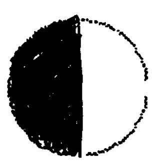


Figure 9A: How a person on the Earth in **Australia** would observe the moon.

The phase of the moon is

3rd Quarter.

Questions:

1. **Assuming the Earth-Moon-Sun position is the same, does the phase of the moon change when viewed from the Northern Hemisphere compared to the Southern Hemisphere? If we in Monmouth, Oregon view a first quarter moon phase, what phase will people in Australia view when they see the moon on the same evening?**

   They will see a 1st Quarter moon, but the shade side of the moon will be reversed

2. **What is the time in days between two successive full moons (i.e., from one full moon to the next full moon)?**

   29 1/2 days

3. **What is the orbital period of the moon around the earth (in days)?**

   27 1/3 days

4. **What is the time in days between a full moon and a new moon?**

   14 3/4 days

5. **What is the orbital period of the moon around the sun (in days)?**

   365 days

6. **If the full moon is in the west, what time of day must it be? Note, the moon's path approximately follows by 12 hours, the Sun's path (called the *ecliptic*) as viewed by an observer on Earth. The time of day will be** early morning, about 6 am.

7. **Draw** in and label the locations of the full moon and the new moon in Figure 10. Fill in the shadowed part of the moon in each case. Indicate which locations (beside one curved arrow) the moon is ***waning* -- where it is getting closer to a new moon**. Indicate which locations (beside the other curved arrow) the moon is ***waxing* -- where it is building up to a full moon.**

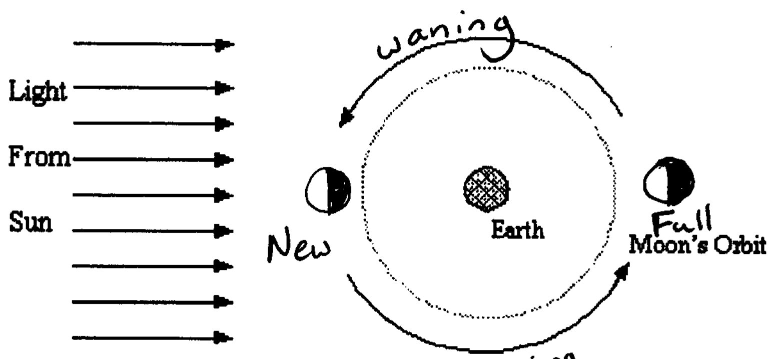


Figure 10 waxing

8. Write a brief explanation as to why we see the phases of the moon.

We see phases of the moon because during different times of the month, different portions of the lit and shadowed portions of the moon are visible as the moon orbits the Earth.

9. The color of material (rock and dust) that covers the moon is primarily light colored. What if the moon's material was colored all black... Would we see moon phases? Explain.

We see the lit portion of the moon because it is reflecting light from the sun. If the Moon were made of a dark (light absorbing) material, the "lit" portions of the moon would be difficult to see, if not impossible. Thus, there would be no phases.

10. **Mental Exercise:** Assume you are "camped" on the moon closest to Earth for a one-month **stay**. Will you be able to see the Earth? What will it look like during your stay? Will there be Earth Phases? (use a separate sheet of paper to answer this question)

see back

Part B – The Seasons

The Baroque composer Antonio Vivaldi wrote a pervasively familiar set of concertos called "The Seasons". Each of the set of four is devoted to one of the four seasons -- spring, summer, and autumn, winter. Concerto No. 1 mimics songs of birds, spring thunderstorms, and a spring zephyr. In the summer concerto, Vivaldi uses changes of meter (first 3/8 and later 4/4 time) to describe the exhaustion caused by the summer heat. Autumn, the season of harvest, Vivaldi uses the motifs of a tribute to Bacchus -- God of Wine -- via a feverish dance and The Hunt using the horns to herald the event. In Concerto No. 4, the frigid winds blow in an almost melody-less illustration.

The Venetians of Vivaldi's time all understood the effects and moods of the seasons, but how did they come about? In this activity, we look closely at an explanation.

First, we must dispel an old misconception. Figure 11 shows a sketch of the earth's orbit from a top view far above the sun. The orbit of the earth is slightly elliptical as shown below -- it is not a perfect circle, it's a 'squashed circle'. However, the 'squashed-ness' of the orbit -- its *eccentricity* -- is greatly exaggerated in Figure 11. **The common misconception is that when the earth is at point A, it is closer to the sun, and therefore it is summer on earth.** If you have ever gone in the wintertime to South America or Australia, you would discover it is summer there! The misconception would have it summer in both the northern and southern hemispheres.

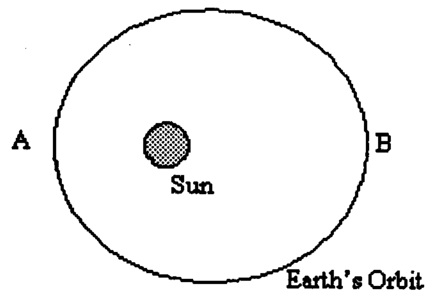


Figure 11

The common misconception fails on another point. The *eccentricity* of perfectly circular orbit is zero, whereas a 'flattened circle' has an *eccentricity* of one. The *eccentricity* of the earth's orbit is 0.0167, which is much closer to zero than to one. In conclusion, the orbit of our planet is so close to a perfect circle, that you probably cannot draw a circle on paper more circular than the earth's orbit -- not even with a compass!

You will construct a physical model of the Sun-Earth system. This model will not be to scale. The purpose of this model is to investigate the correct reasons for earth's daily and seasonal cycles.

Activity 1: The drawing below shows the Earth with incoming solar radiation.

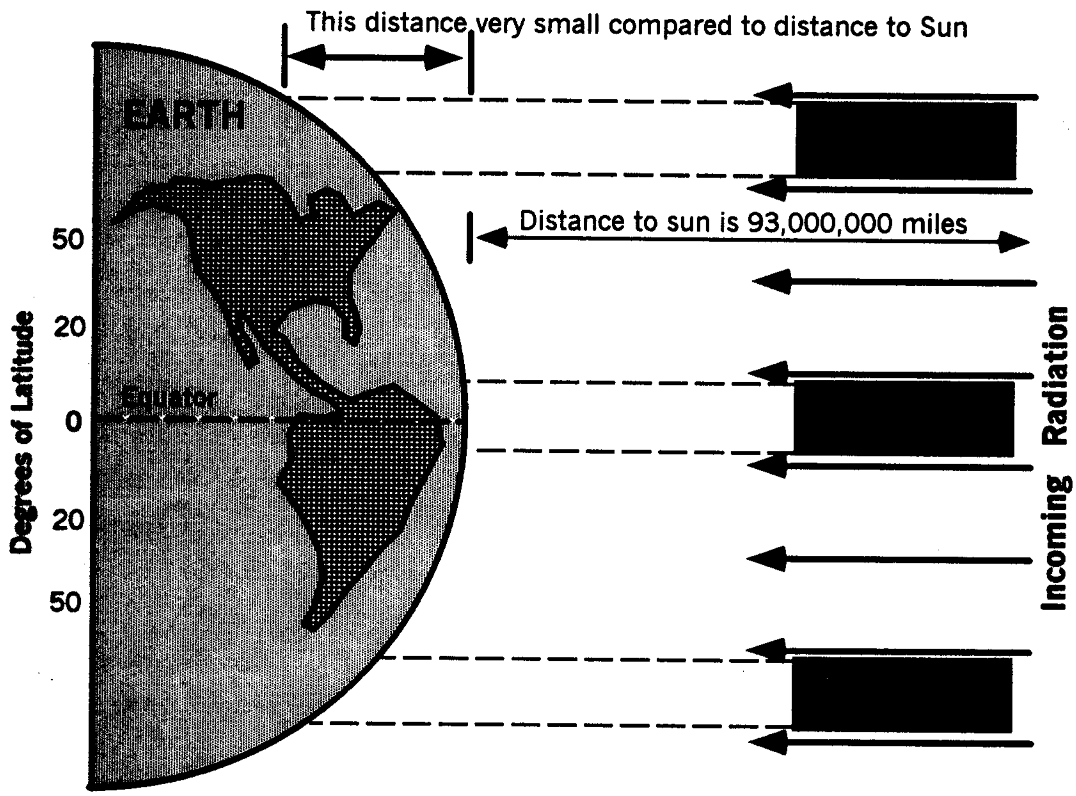


Figure 12: Schematic representation of Earth-Sun system emphasizing input of solar radiation.

Many people have the conception that the Polar Regions are cooler than the equator because they are further away and therefore the Sun's energy is "weaker" when it strikes the Polar Regions. Let's explore this reasoning.

1. The sun is 93,000,000 miles away from the equator. The radius of the Earth is a little less than 3500 miles. How much further (in percent) does the energy of the Sun have to travel before reaching the polar region? Show your calculations.

$$\frac{3500 \text{ miles}}{93{,}000{,}000 \text{ miles}} \times 100\% = 0.0038\ \%$$

2. **Do you think that this added distance (3500 miles) can account for the difference in temperature between the poles and equator? Explain your answer.**

No, the extra distance is such a small percentage of the total sun-Earth distance that it has virtually no effect on the light intensity reaching the poles.

3. **Briefly speculate on why the Earth heats up more rapidly at the equator (middle shaded band of radiation) than to the north or south (side shaded bands).**

The equator receives more direct, intense sunlight than higher latitudes.

Now let's test your idea. Use a piece of graph paper to measure the area of light striking the **Globe at the** equator and at the polar region when a flashlight is positioned 18 inches away from **the equator**. Are the two areas equal?

No. The area illuminated by light hitting the poles is larger than the area hitting the equator.

4. **Now suggest a reason why the poles may be cooler than the equator regions.**

Due to the curvature of the Earth's surface, light hitting the poles is spread out over a larger area than light hitting the equator. The light hitting the poles is much less intense as a result, causing the poles to be cooler than the equator.

Activity 2: Use a 'sphere on a stick' as the earth and the lamp as the sun to 'build' a sun-earth system model. It should look something like Figure 13 on the following page.

Successively place the 'earth' at locations A, B, C, and D (**remember to maintain the tilt of the Earth's axis in the same position**). Deduce what season it must be in the northern **hemisphere. Note that the tilt of the axis of the earth should not change. The axis will always lie along the same line as indicated.** (This is a result of conservation of angular **momentum** -- it is the same reason why the axis of a gyroscope will always tend to point **along** the same line.)

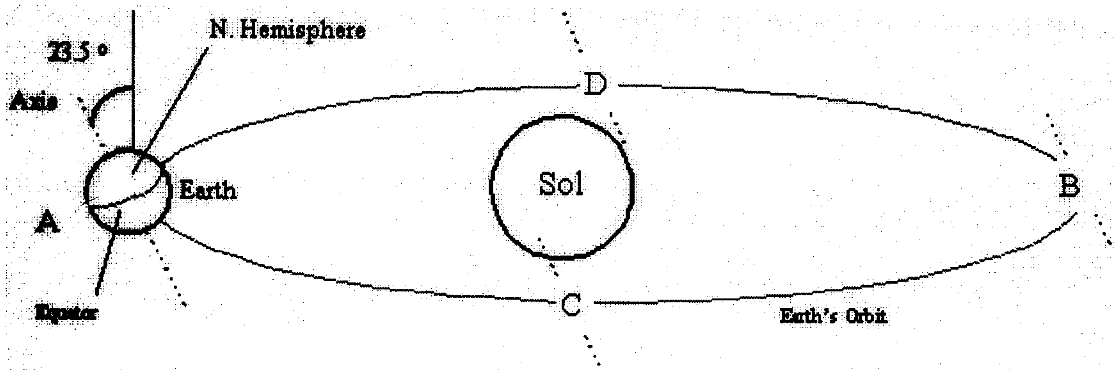


Figure 13: A perspective view of the sun-earth system. *Sol* is the official name of our star according to the ASA star registry.

Questions:

1. Complete the table using your observations:

Location of Earth in Figure 13	Season in the Southern Hemisphere	Season in the Northern Hemisphere
A	Summer	Winter
B	Winter	Summer
C	Fall	Spring
D	Spring	Fall

2. During which season does more direct or concentrated sunlight (and therefore more infrared radiation) hit the surface of the earth at the following locations?

Monmouth, Oregon

Summer

The Equator

Fall & Spring (at the Equinoxes)

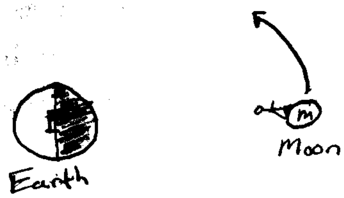
3. Why do the northern and southern hemispheres have opposite seasons?

When the Northern hemisphere is tilted away from the sun and is having winter, the Southern hemisphere

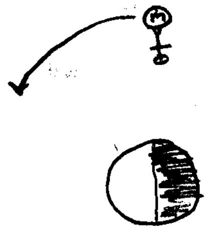
You will be able to see the Earth, and it will have phases.

New Earth

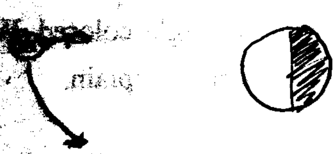
View from Moon

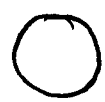


1st Quarter Earth

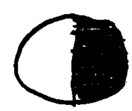


Full Earth





3rd Quarter Earth



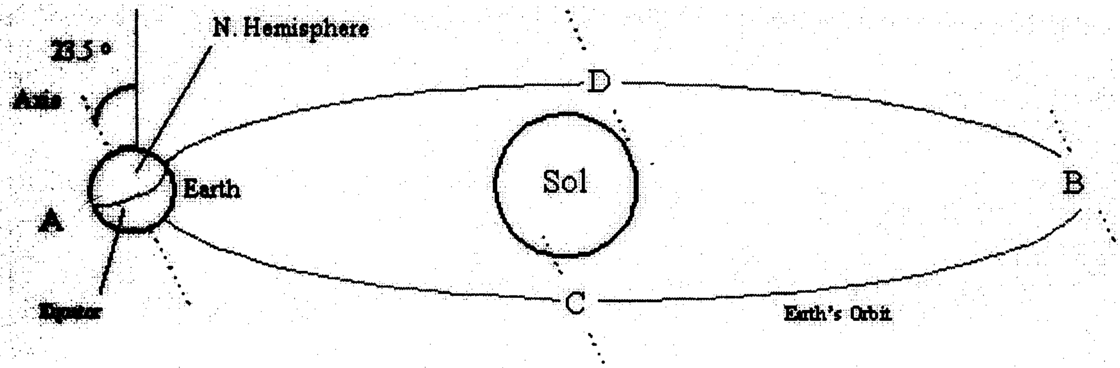


Figure 13: A perspective view of the sun-earth system. *Sol* is the official name of our star according to the ASA star registry.

Questions:

1. **Complete the table using your observations:**

Location of Earth in Figure 13	Season in the Southern Hemisphere	Season in the Northern Hemisphere
A	Summer	Winter
B	Winter	Summer
C	Fall	Spring
D	Spring	Fall

2. **During** which season does more direct or concentrated sunlight (and therefore more **infrared** radiation) hit the surface of the earth at the following locations?

Monmouth, Oregon

Summer

The Equator

Fall & Spring (at the Equinoxes)

3. **Why do the northern and southern hemispheres have opposite seasons?**

When the Northern hemisphere is tilted away from the sun and is having winter, the Southern hemisphere is tilted towards the sun and is having summer. 6 months later the situation is reversed.

Activity 3: Examine the two models provided, Model A and Model B. Complete the table by answer the questions for each model.

	MODEL A	**MODEL B**
What does the model demonstrate?	The relative positions of the Sun, Earth, Moon and an inner planet	The stars that are visible from different locations on the globe and the path of the moon.
What does each part of the model represent?	See above	Outershell: positions of stars Inner shell: Earth ball on wire: moon
What is distorted or "misrepresented" in this model?	The relative distances and sizes of the moon and planets are wrong. The moon's plane of orbit around the Earth should be inclined to the Earth's plane of orbit around the sun.	Relative distances & sizes of the Earth and Moon are incorrect.
What are the limitations for this model?	This model makes some in accurate predicts. For example, it predicts a solar and lunar eclipse every month. It does represent the phases of the moon & planets well.	See above

POST-LAB ASSESSMENTS

1. Make a list of all of the models you worked with today.

2. How do each of the models compare to the real thing?

3. How did these models help you investigate the earth-moon system and the earth-sun system?

4. What are the limitations of each of the models you studied?