AST101IN Fall, 2011 Follette Names: _____

Phases of the Moon & Planets Lab

"The moving Moon went up the sky,
And no where did abide:
Softly she was going up,
And a star or two beside."
[S.T. Coleridge in the "Rime of the Ancient Mariner"]

GOALS:

- understand why we see different "phases" of the Moon
- participate in a 3-D "model" to visualize the Moon as it orbits the Earth
- be able to predict if other planets display phases

To START:
Three people form a team and take turns role-playing the Earth and Moon. The Earth person stands within the simulated beam of sunlight from a light projector while the others coach him/her through Sections #A-H.

Earth person: Your head represents planet Earth and your nose is an imaginary person on the Earth's surface. For most of this exercise the Earth person holds a small ball at arm's length to represent the Moon. Mr. Nose will observe the appearance of the Moon as the Earth spins and as the Moon moves around the Earth. Remember: Just as a real person standing on the surface of the Earth, your nose can't see what's happening behind your head, on the other side of the "Earth."

Other people: These people stand a few feet away and coach the Earth person through the different sections. Because they are viewing the Earth and Moon from a larger distance, they should see the "big picture" of what's happening.

DO THE FOLLOWING SECTIONS IN ORDER. They build on each other conceptually. As you proceed, be sure to learn and understand the vocabulary words in bold italics.

Section A. Practice determining the time of day and night on the Earth.

The Earth person's head represents the globe of the Earth. Notice that half of the Earth (one "***hemisphere***") always experiences daytime while the other hemisphere sees night. (The nighttime side is basically within the Earth's shadow.)

Let the Earth rotate to the left (i.e., counterclockwise) so that Mr. Nose faces directly towards the Sun. In this position it's noontime for Mr. Nose and midnight for someone on the opposite side of the Earth. Locate Mr. Nose's horizons to the east and west.

QUESTION #1: What time of day (sunrise, noon, sunset, midnight) would it be for the left ear and also for the right ear?

Rotate the Earth (to the left) so Mr. Nose experiences these times: Sunrise, noon, sunset, midnight. Notice that the Earth's shadow always points straight away from the light source in the same direction at all four times.

QUESTION #2: For each of these times for Mr. Nose, what are the corresponding times for an imaginary person on the back of your head? Fill in the blanks in the following table.

Time for Mr. Nose	Time for back of head
Sunrise	
Noon	
Sunset	
Midnight	

Section B. Notice that the Moon shines because it reflects light from the Sun.

The Earth person should spin ("***rotate***") so that Mr. Nose is at sunset. The Earth person holds a small ball straight ahead at arm's length to represent the Moon. You should see the daytime and nighttime locations on the Moon at a phase known as First Quarter.

QUESTION #3: Why will half of the Moon (and Earth) always experience daytime while the other half has night? (It's simple but please answer with a complete sentence.)

Notice that the Moon produces its own shadow. Like the Earth, the Moon has a shadow that always points straight away from the Sun. However, the two shadows do not cross.

Section C. We see the Moon's "phase" change as it revolves around the Earth.

While holding the Moon at arm's length, the Earth person turns counterclockwise to let the Moon "***orbit***" the Earth. After one complete turn we say the Moon has "***revolved***" once around the Earth. As the Moon orbits the Earth, the Earth person notices different amounts of light and dark (day & night) on the Moon. In other words, you will see "***phases***" or different amounts of the day and night sides of the Moon.

The first diagram on the next page labels the different phases. The second diagram shows that the Moon's orbit is actually tilted so the Moon usually lies above or below the Earth's shadow. As a result eclipses are rare and the Moon's phases are **NOT** caused by the Earth's shadow.

Start again with the Moon pointed towards the Sun; i.e., at a "***New phase***." The Earth person should rotate one-quarter turn (i.e., about one week) counter-clockwise to place the Moon at "***First Quarter***" phase. Similarly, position the Moon at "***Full phase***" after another week has elapsed and, lastly, at "***Last (Third) Quarter phase***."

Notice that all parts of the Moon experience day and night as the Moon orbits the Earth. To prove this, imagine someone on the side of the Moon that faces away from the Earth at New and Full phases.

Please fill in the following table with the information you have discovered.

Moon Phase	**What fraction of the Moon's surface is lit by the Sun?**	**What fraction of the Moon's surface lit by the Sun can you see?**	**Which part of the Moon's surface facing you is lit by the Sun?**

Section D. Why does the Moon rise later from night to night.

Of course, the real Earth and Moon are not connected by your arm and do not move at the same speeds. The Earth rotates once per day (24 hours) while the Moon takes nearly 30 days (about one month or about four weeks) to revolve once around Earth.

Let a teammate hold the Moon at First Quarter phase while the Earth rotates. As the Earth person rotates one complete turn in one day, the Moon person should move very slowly around the Earth, about 12 degrees per day (i.e., about 1/30 of a circle).

QUESTION #4: If Mr. Nose sees a First Quarter Moon, approximately what phase of the Moon will a person on the opposite side of the Earth see when the Moon becomes visible to that person?

QUESTION #5: In several sentences and a diagram, explain why the Moon rises at a later time from night to night.

Section E. Does the Moon rotate on its axis?

From Earth, it appears that the same side of the Moon always faces the Earth. Draw a mark on the near side of the Moon. As the Moon orbits the Earth, the Earth person should always see this mark.

QUESTION #6: Although the Earth person sees the same side of the Moon, what do the other two teammates see? Does the Moon rotate from their perspective? Explain your observation.

This effect is called "***synchronous rotation***." The time for the Moon to revolve once in its orbit around Earth equals the time for the Moon to rotate once on its axis.

QUESTION #7: Can a person on the Moon ever see an "Earth-rise"? Why or why not?

Section F. Make some eclipses

Position the Moon to make a "***solar eclipse***" where the Moon's shadow hits the Earth.

Position the Moon to make a "***lunar eclipse***" where the Earth's shadow hits the Moon.

QUESTION #8: Based on Figure 2 below showing the Moon's orbit, explain why eclipses of the Sun and Moon do not occur at every New and Full Moon, respectively.

Section G. Consider the following discussion between two students about the cause of the phases of the Moon. (from *"Lecture-Tutorials for Introductory Astronomy"* by Prather et al. 2008)

QUESTION #9: Do you agree or disagree with either or both of the students? Explain your reasoning.

Student #1: "The phase of the Moon depends on how the Moon, Sun, and Earth are aligned with one another. During some alignments only a small portion of the Moon's surface will receive light from the Sun, in which case we would see a crescent Moon."

Student #2: "I disagree. The Moon would always get the same amount of sunlight; it's just that in some alignments Earth casts a larger shadow on the Moon. That's why the Moon isn't always a Full Moon."

Section H. Do other planets have phases? ACTING OUT phases of the planet Venus as seen from Earth.

For this exercise we assume that the Sun is located in the center of the Solar System (i.e., a ***"heliocentric"*** model) with the planets revolving in orbits around it at different speeds.

One person should be the Earth. Another represents the Sun. The third person is Venus which orbits around the Sun but closer to the Sun than Earth. Position yourselves so Venus lies between Earth and Sun. Keep Earth and Sun fixed and let Venus move in an orbit around the Sun as it would in the heliocentric model. Determine the phases of Venus that could be observed by someone on Earth.
QUESTION #10: In several sentences, explain why (a) Venus could never see a "New Earth" and (b) how the Earth could see a "nearly Full Venus." Use diagrams to illustrate your thinking.

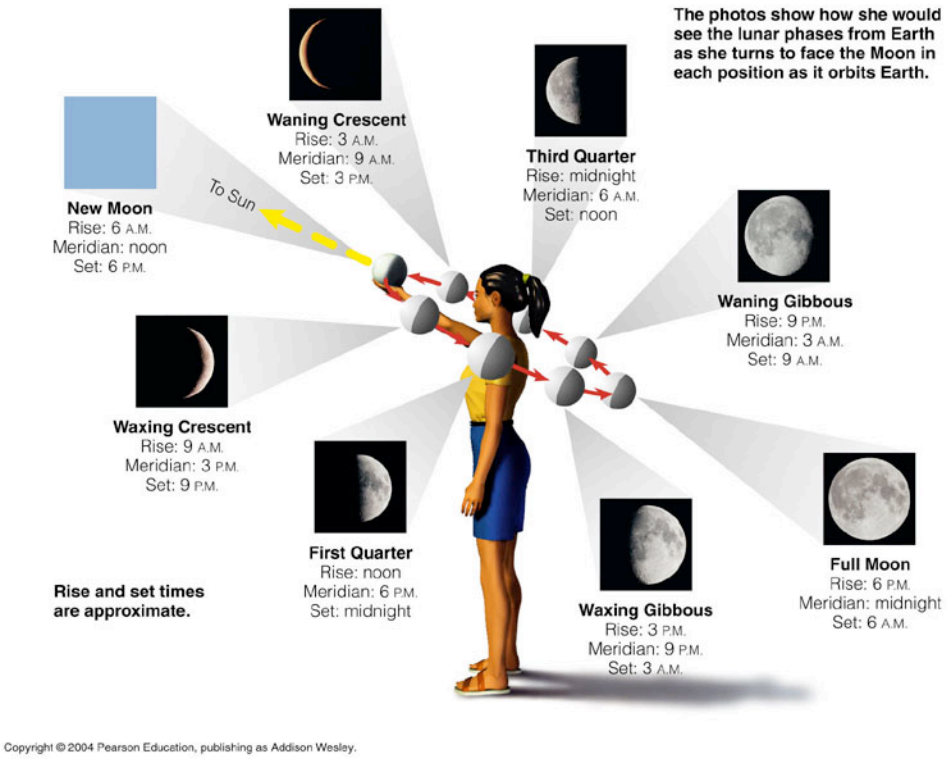

FIGURE 1

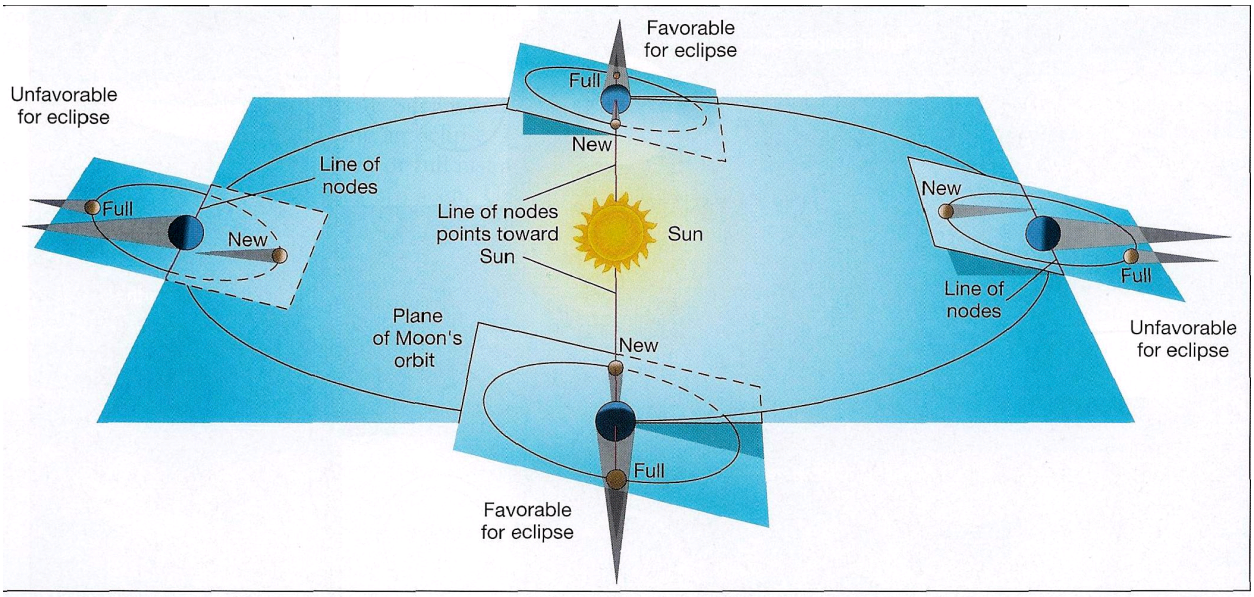

FIGURE 2