Phases and Eclipses

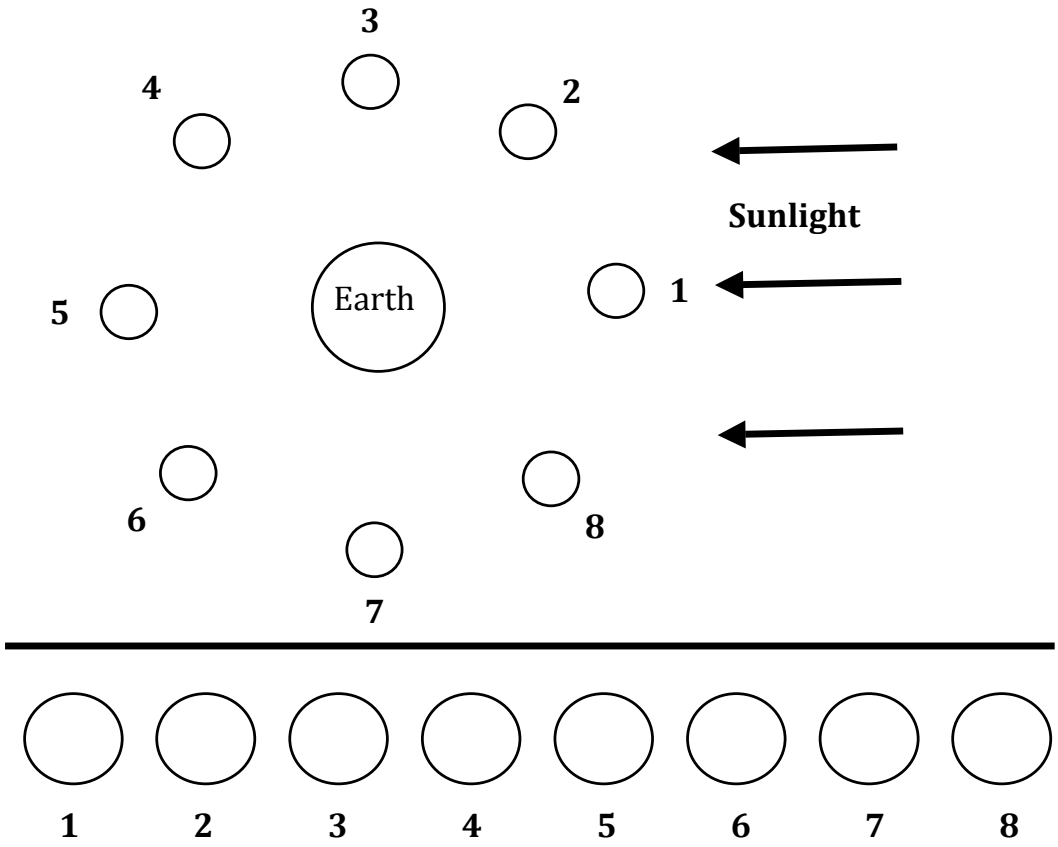
Laboratory 4

Astronomy 120. The Copernican Revolution

Purpose

To observe how the Moon's appearance and position in the sky on multiple occasions, and to relate this appearance and position to the Moon's location in its orbit, the observer's location on Earth, and the time at which the observation was made.

In the upper portion of the figure below, eight positions of the Moon are given in its orbit around the Earth, labeled 1 through 8. This part of the illustration represents the Moon's orbit looking down on the orbit from the above the North Pole of Earth. The lower part of the figure illustrates an Earth-bound observer's view of the Moon at each of these eight positions. For each of the Moon images in the lower part of the figure East is to the left and West is to the right, with North at the top and South at the bottom. This may seem backwards, but remember that when you are looking at the Moon you are looking *up*. Follow the instructions on the next page; refer to this drawing.



1. For each Moon position in the **top part** of the figure shade the dark and illuminated portions of the Moon *from the perspective of an observer above the Earth-Moon system.* USE A PENCIL! You may need to make corrections later.

2. For each Moon position in the **lower part** of the figure shade the dark and illuminated portions of the Moon *from the perspective of an observer on the surface of the Earth.* The best way to do this is to imagine that you are laying on your back at the equator, with your head to the North. You are looking straight up at the Moon, which is directly overhead. What would it look like? Once you have completed this part, show your work to Dr. T *before* proceeding to the next question. USE A PENCIL! You may need to make corrections later.

3. Go to a computer and run the MoonPhases program. This program shows how the appearance of the Moon changes (as seen from Earth) as the Moon moves around the Earth in its orbit. The band of color connecting the Earth and the Moon shows the portion of the Moon that is visible from Earth and the portion of the Earth from which the Moon is visible (think about that carefully). Study this simulation for a while and use it to double-check your answers to the previous questions. You should feel free to use this simulation to help you answer any of the remaining questions on this worksheet.

4. In the diagram above, label the Moon's phase (full, waxing gibbous, etc.) below each of the Earth views.

5. In which direction is the Earth rotating in the upper portion of the figure, clockwise or counterclockwise?

6. For each phase shown in the lower portion of the figure, determine the approximate time of day when the Moon in that phase would be directly overhead for an observer on the equator of Earth. Write this time below the picture of each phase. Note that the MoonPhases computer simulation shows the location of an observer on Earth's equator, as well as the corresponding time of day (on a 24 hour clock) for that observer. You may want to use the simulation to answer this question - but make sure you understand what the simulation is showing you and why it is the way it is.

7. Use your answers to the previous questions (and the computer simulation if needed) to determine the times during which each of the Moon's phases are visible. Fill in the table below.

Phase	**Rises**	**Sets**
New		
Waxing Crescent		
First Quarter		
Waxing Gibbous		
Full		
Waning Gibbous		
Third Quarter		
Waning Crescent		

8. Suppose the Moon is in its first quarter phase. If you go out to look at the Moon at 9 PM, will it be visible? If so, where would you expect to see it?

9. Suppose the Moon is in its waning crescent phase. If you go out to look at the Moon at sunset, will it be visible? If so, where would you expect to see it?

10. Explain *at least two* ways that you can tell the difference between a first quarter and a third quarter moon.

11. From the simple two-dimensional model we have studied so far, it might seem like lunar and solar eclipses should happen quite frequently. In fact, if the moon, earth, and sun were really always in a common plane then eclipses should occur once per month. Specifically, a lunar eclipse would occur every time the moon is in _____ phase, and a solar eclipse would occur every time the moon is in _____ phase.

12. As you are no doubt aware, lunar and solar eclipses do not occur every month. To see why they don't, run the SolarLunarEclipse program. This program shows the earth orbiting the sun[1] and the moon orbiting the earth. It also shows a view of the sky as seen from Earth (showing the moon, sun, and background stars). Does the plane of the moon's orbit line up with the plane of the Earth/Sun orbit, or it tilted?

[1] I know we haven't yet gotten to the idea that the Earth orbits the sun. In fact, we've been assuming that the sun orbits the Earth. Of course, you *know* the Earth orbits the sun, in the sense that you have been told that by trusted authorities. In any case, the basic principles are the same even if we have the sun orbit Earth instead of *vice versa* (the Moon orbits Earth in both the ancient and modern theories).

13. Explain why this means that the moon will *not* always be seen on the ecliptic.

14. Are there ever times when the moon *is* on the ecliptic? In the space below, sketch the moon's monthly path across the sky as seen from Earth (and as shown in the right window). Mark any points at which this path crosses the ecliptic.

15. Explain why we don't have solar or lunar eclipses *except* when the moon is on (or at least very near) the ecliptic.

16. What two things must happen for a lunar eclipse to occur? Why don't these two things happen every month?

17. What two things must happen for a solar eclipse to occur? Why don't these two things happen every month?