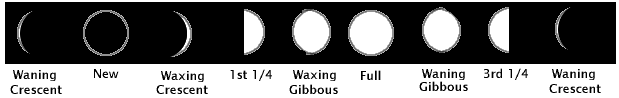
# Phases of the Moon

Summary

This lab is designed to be an introduction to the scientific process. You will, using simple tools and observations, deduce the motion of the Moon around the Earth. You will determine the direction of motion, and the reason for the phases.

Here are the phases of the Moon in time order as usually depicted in textbooks.



So let’s see if we can reproduce this.

### I. The Basics

From your group, choose one person will operate the Moon, one person will be the Earth looking at the Moon, and one person will record observations of the Moon phase, and positions of Earth, Moon and Sun at each of the phases. Your goal is to reproduce the phases in the picture above. The role of the Sun will be played by the window of our classroom. The role of the Moon will be played by a ball that is half black, half white. The white half is the part of the Moon that is lit up by the Sun so whatever you do in this activity, that side must always point toward the window. The black half is the half that is dark, so it always points away from the window.

Study the phases chart above, which shows the moon at different phases throughout the lunar cycle. Note carefully what changes about the moon from each image to the next.

The Earth stands in one spot for the entire lesson (but can turn around to see the Moon). The Moon is carried around the Earth to reproduce this sequence of phases in the proper order. The Earth decides when the appropriate phase is shown. If you have four people in your group, one of you can look down on the Moon from above and describe its position to the recorder.

A. Record your observations in the following diagrams.

|  |  |  |
| --- | --- | --- |
| http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif | http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif | http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif |
| Waning Crescent | New | Waxing Crescent |
| http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif | location of moon at different phases | http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif |
| First 1/4 | Waxing Gibbous | Full |
| http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif | http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif | http://www.astro.washington.edu/courses/labs/clearinghouse/labs/PhasesMoon/images/box.gif |
| Waning Gibbous | Third 1/4 | Waning Crescent |

***Discuss your observations with your instructor at this point***

B. In which direction does the Moon orbit the Earth, clockwise or counterclockwise? Would that be East to West, or West to East?

C. Assume you are observing from the northern hemisphere of the Earth. Which side of the Moon is illuminated when the Moon is just past new phase, the right side or the left side? Would an observer in the southern hemisphere agree with you? Explain.

D. If you were to observe a crescent moon from the northern hemisphere with the horns of the crescent pointing right, is the Moon waxing (the lit part is getting bigger) or waning (the lit part is getting smaller?) Hint: consider the chart above.

E. When an earth-bound person observes the Moon in its full phase, which phase of Earth is observed by a person on the Moon?

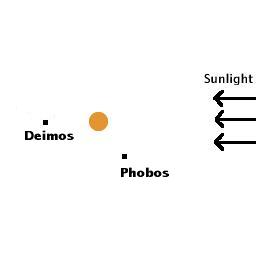
F. Mars has two moons, Phobos and Deimos. In the following picture,

a. What is the phase of Phobos as seen from Mars?

b. What is the phase of Deimos as seen from Mars?

c. What is the phase of Deimos as seen from Phobos?

Explain your answers.



***Discuss your observations with your instructor at this point***

### II. Beyond the Basics

As it happens, the phases of the Moon in the picture on the first page are wrong in one crucial respect. So lets fire up Stellarium and see if we can figure it out.

Stellarium is a planetarium simulator. It can show you what the sky looks like on any day ever at any time from anywhere on Earth. It does, however, have a few features that are cool, but that will get in the way of our observations. Sometimes the Moon will be below the horizon, so we need to turn off the ground. Sometimes it will be daytime and sometimes night. It is easier to see things if the sky is always dark, so we need to also turn off the atmosphere.



**Turn off Ground and atmosphere** If you move your cursor to the bottom of the screen, a toolbar will pop up. In the third group of buttons from the left, you’ll see one labeled Ground, one Atmosphere and one Cardinal points. Toggle all of these off. What you should end up with is a night sky all the time with nothing in the way of observing.

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**Switch to Equatorial Mode** In the fifth group of buttons from the left, you’ll see a telescope icon that toggles between equatorial and azimuthal mode. Azimuthal mode is the default but it is tied to your horizon, which depends on where you are on the Earth, and since the Earth is tilted and moves around, the horizon is changing its orientation relative to the stars all the time. So you’ll see stars bouncing around in all kinds of crazy ways that they aren’t really doing. Equatorial mode is tied to the north celestial pole, near the star Polaris, so it rotates with the Earth, keeping the same objects in view. Switch to equatorial mode by clicking the telescope button. It should change from grey to white.



**Limit the information displayed** There’s one last thing we need to do to groom Stellarium. When you search for an object, it pops up a HUGE list of all the information about that thing that it has. This list is so large that it can get in the way of seeing things. If you move your cursor to the lower left had side of the screen, a different toolbar will pop up. In it, you will find a button that looks like a wrench turning a star (inside the red circle). That will bring up the configuration window. On the Information tab, change from All Available to Short. That will just show the name of the object and its position.

**Search for and lock on the Moon** Also on the left side toolbar, there is a button that looks like a magnifying glass looking at a star (inside the orange circle). This brings up the Search window, so search for the Moon. You should see a little thing labeled “Moon” with red crosshairs revolving around it. As long as you see those crosshairs, Stellarium will always be centered on the Moon. This basically means that as we follow the Moon around the sky, we will always be turned so that we are facing directly at the Moon. If that does not happen, search for the Moon, click on it, and press the space bar to lock on.

There are two ways to zoom in/out. You can do a two finger drag on a laptop touchpad, or you can use the page up/down keys. Zoom in so you can clearly see the Moon, enough to be able to tell what its phase is.

**Step forward or backward in time** There is a group of video controls on the bottom screen toolbar that you can use to fast forward through time (the orange circle in the first picture above). The more times you click >> the faster you go. That’s probably not the best way, though it is fun. It keeps moving so you don’t have time to take a good look at the phase.

Instead, on the left screen toolbar there is a clock button that brings up a small window allowing you to select date and time (the black circle in the second picture above). Click your way through a month, carefully observing the Moon phases that you see.

A. Can you determine the big difference between what Stellarium shows you for the phases (and therefore what you would see in the sky) versus the picture on the first page? It is probably a good idea to sketch a sequence of pictures showing the real phase.

B. Once you’ve settled on what the difference is, do whatever you have to do with your ball to make the phases you see on it match those you see in Stellarium. What does it tell you about the Moon?

C. If the pictures in Part I on the first page, and the way you reproduced them with your ball experiment were correct, how often should we see an eclipse? From what you’ve just learned, can you explain why we actually see eclipses a lot less frequently?

***Discuss your observations with your instructor at this point***

D. Here’s a fun thing you can do. The top button on the left screen toolbar looks like a compass rose. You can use it to change your location, *but not just on the Earth!* Down toward the bottom right, you can see a dropdown list labeled “Planet.” Not only can Stellarium show you the sky from any place at any time on any day, but also from any major object in the Solar System, and some minor ones.

So move yourself to the Moon, search for the Earth, and run it through its phases. You’ll probably have to turn off atmosphere and ground again. Use this to check your answer to question E in Part I. Also check some of the other phases (e.g. when the Moon is at first quarter as seen from Earth, which phase is the Earth at as seen from the Moon?) Does this agree with your conclusion in part I?

E. If you step forward a few days, you can tell whether the phase is waxing or waning. Go back to the Earth and see what the Moon is doing. Then go to the Moon and check on what the Earth is doing. Can you explain what you see? Your half lit/half dark ball model may help.

F. Change your location to Mars and search for Earth. You’ll definitely have to zoom WAY in to see the Earth as a globe. Run it through its phases as seen from Mars. Is it the same set as from the Moon? Does it take the same amount of time to go through the cycle as it did from the Moon? Can you explain why?

G. Pluto has, at last count, five satellites but the largest by far is Charon. Change your location to Pluto and watch Charon go through its cycle of phases. How do they differ from the Moon’s? Use your half lit/half dark ball model to figure out what this tells you about Charon’s orbit.

### III. Summary

A. Many people believe that the phases of the Moon are caused by the shadow of the Earth falling on the Moon. Using what you’ve learned in this activity, what do you think of that belief?

B. Another common belief is that since we always see the same side of the Moon, that means that the Moon does not rotate. Is this true? See if you can come up with an experiment using the same materials – you, the Moon Ball, and the windows – to figure this out.

C. Describe in a few sentences the most important things you learned about the Moon phases and the process of doing science from this activity.