PHASES OF THE MOON

2

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OBJECTIVES

The objectives of this activity are intended to meet the following course goals:

G2. Students will develop critical and/or analytical thinking skills.
G5. Students will have an appreciation and knowledge of what can be seen in the night sky.
G8. Students will learn the big concepts in astronomy.

After completing this activity the student will be able to:

1. List the phases of the moon from new moon to full moon and back to new moon.
2. Construct a drawing of the moon's illuminated shape as viewed from the earth for each lunar phase.
3. Name the current phase of the moon and to be able to construct a drawing illustrating the earth, sun, moon relationship for this lunar phase.

STUDENT MATERIALS

The student will need the following items:

pencil
drawing compass
straight edge or ruler

LAB MATERIALS

These materials need to be in the lab room:

Medium size white balls (4-6 inches in diameter)
Bright light source(s) such as overhead projectors (flashlights do not work well for this activity.)

INTRODUCTION

The Moon is a dark rocky object that is illuminated by reflected sunlight. It is this reflected light which we see as moonlight. Because the Moon orbits our Earth we cannot always see its illuminated face. For example, when the Moon is between the Earth and

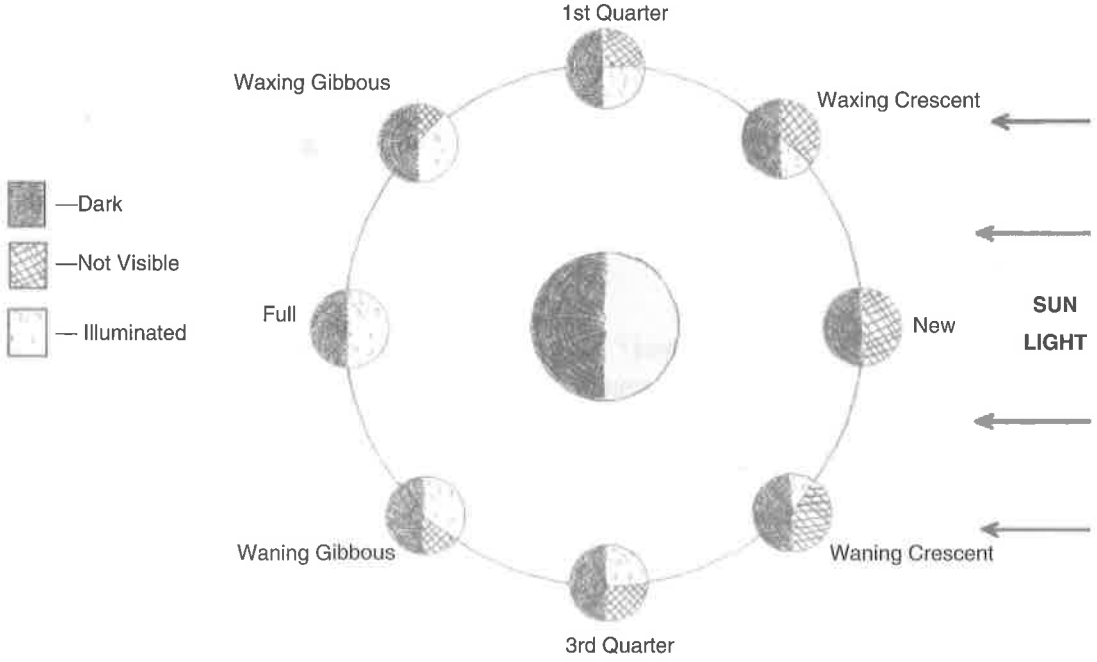


Figure 1: Phases of the Moon

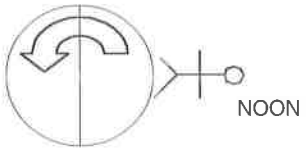
Sun we can't see the Moon at all because none of the illuminated part is facing the Earth (Fig. 1), we "see" only the dark side. This New Moon phase is important in many religions around the world, because it symbolizes rebirth. As the Moon orbits the Earth more and more of its illuminated surface can be seen (Fig. 1), which produces the phases of waxing crescent, 1st quarter, waxing gibbous and full moon. At full moon, the Moon is directly opposite to the Sun in the sky, and so its entire illuminated face can be viewed from Earth (Fig.1). After full moon less and less of the illuminated portion is visible as the Moon passes through the phases of waning gibbous, 3rd quarter, waning crescent, and back to new moon. At this point the cycle of phases repeats.

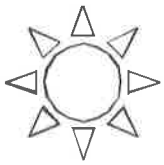
Phases of the Moon

First, we are going to work with time on Earth. Your instructor will provide a light source that will represent the Sun.

1. Below is a diagram of Earth and the Sun. You can draw little stick figures to represent certain times of the day.

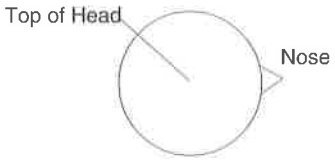
   Noon is already drawn for you, so please draw and label sunset (6 p.m.), midnight (12 a.m.) and sunrise (6 a.m.). Also shade the dark (shadowed) side of the Earth.

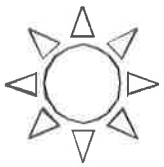




   Note this drawing is NOT to scale!!

2. Now, pretend your head is the Earth (we assume this throughout this activity). Using the overhead projector as the Sun, you must look right at it for it to be NOON. This picture shows you and the "Sun" in the correct orientation.



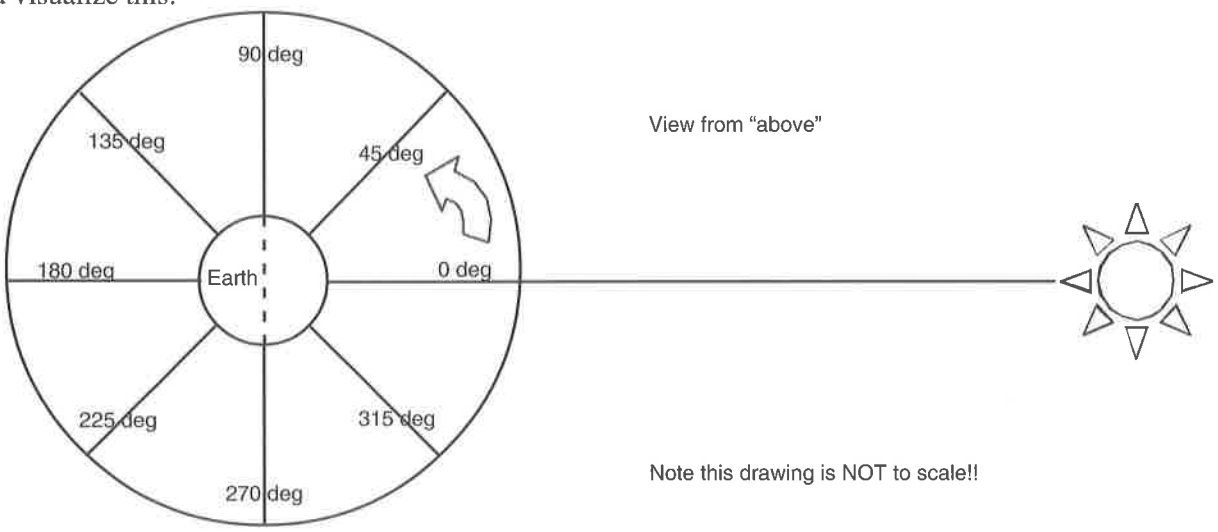


   What direction must YOU face for it to be sunset? Note that Earth rotates toward the left (counterclockwise as viewed from above the North Pole), so turn yourself to the left. Please draw a picture in the space below (the view should be from the top) of you and the Sun in the correct orientation.

3. Why does the Moon have phases (that is, why does the Moon seem to change shape often)? Please write down what everyone in your group thinks (so you could have several answers to this question).

4. Now you will work with a Moon model (a Styrofoam ball).

   First we will set up a reference frame. Since the Moon makes a circle around Earth, we can refer to angles. Remember that 360 degrees make up a circle. If we say that a line connecting the Earth and the Sun is at 0 degrees, we can go around and refer to angles. We call these "elongation angles." The figure below will help you visualize this:

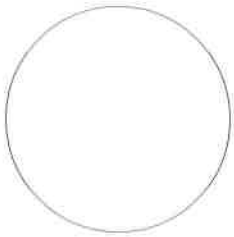


   Take your Styrofoam Moon and hold it, cupped in your hand, at arm's length (out to the side, not up or down or anything).

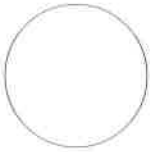
   Now hold it at an elongation of 90 degrees (talk to other groups around you or the instructor to see that you are at the proper orientation).

   Draw a picture of the Sun, you (the Earth) and the Moon in the correct orientation (it should be a view from above).

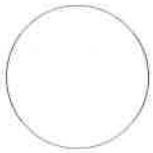
Still holding the Moon at 90°, draw what the Moon looks like from your point of view (not from above) – the dark part should be shaded:



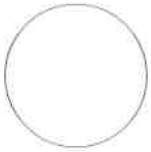
5. Now draw what the Moon looks like at elongation angles of 180 degrees, 270 degrees and 360 degrees (it's the same as 0 degrees). Always turn to the left as that is the direction the Moon orbits and hold the Moon straight out in front of you. Make sure that your head (or another person) doesn't block the "sunlight".



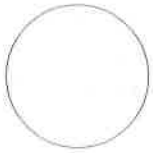
180 deg



270 deg



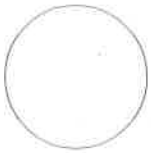
360 / 0 deg



90 deg (again)

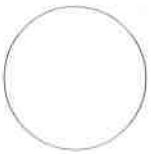
Check your answers with another group

6. You can also do other elongation angles – draw what four more Moons look like, this time picking an angle between the four elongation angles you had previously. Remember that the dark parts of the Moon should be shaded and write down the angle that you picked.



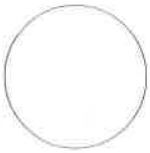
_____ deg

(between 0 and 90)



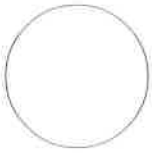
_____ deg

(between 90 and 180)



_____ deg

(between 180 and 270)



_____ deg

(between 270 and 360/0)

Compare your drawings and your chosen angles with another group around you. Did you pick different angles?

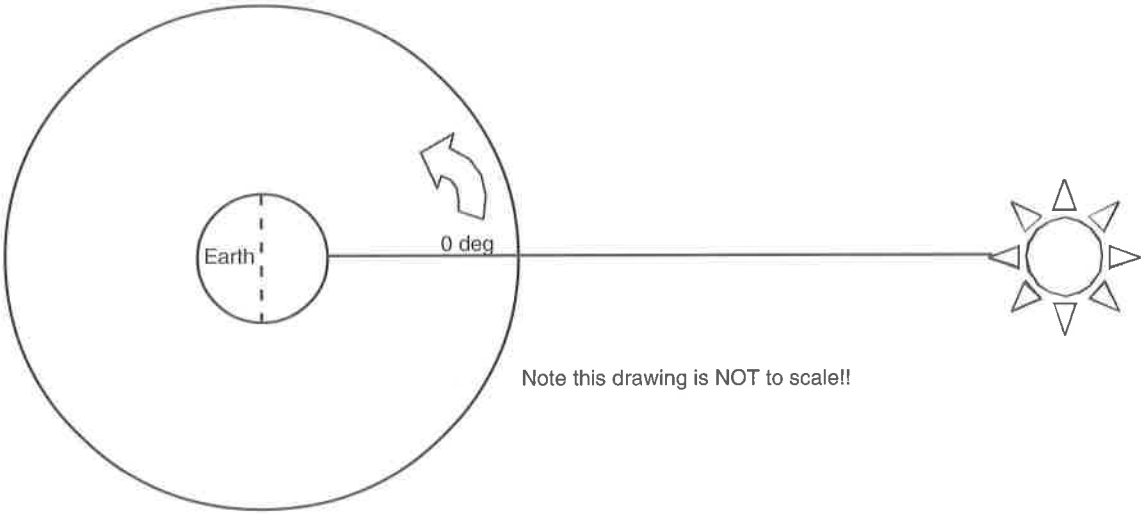
If you picked different angles, how do your drawings compare with the other group's drawings?

7. You can assign certain names to each of your moon phases. This table will help distinguish them:

Phase Name	Elongation	Phase Name	Elongation
New	0° or 360°	Full	180°
Waxing Crescent	1°to 89°	Waning Gibbous	181° to 269°
First Quarter	90°	Third Quarter	270°
Waxing Gibbous	91° to 179°	Waning Crescent	271°to 359°

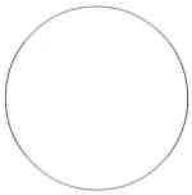
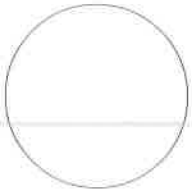
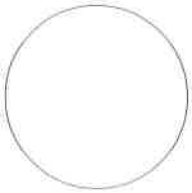
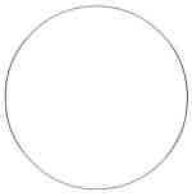
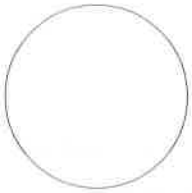
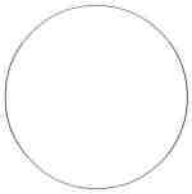
The term "waxing," means to grow or get larger. Therefore, if the Moon is waxing, it looks as if it is getting bigger night after night. Similarly the term "waning" means to shrink or get smaller. Therefore, if the Moon is waning it is getting smaller night after night.

The diagram below shows the Sun-Earth Moon system from above the North Pole. Using the data in the table above draw each phase of the moon listed in its proper place around Earth, then draw in the phases as you would see them on the Earth, in the table below and on the next page.



Note this drawing is NOT to scale!!

Phase Name	Drawing of Moon	Elongation Angle

Phase Name	Drawing of Moon	Elongation Angle
		
		
		
		
		
		

8. Now that you have seen all the phases, have one group member take your moon through all of the phases and the other group members see how much of the Moon is lit up by the Sun if you look from above or below, not from Earth.

   How much of the Moon is illuminated by the Sun as seen from the top or bottom? (that is, how much of the ENTIRE Moon's surface is lit up?)

9. Consider the following debate between three students:

   Student 1: *The phases of the Moon depend on how the Sun, the Earth and the Moon are aligned with one another. Sometimes, only a tiny part of the Moon will get lit up by the Sun and that's why we see a crescent. Other times, the whole Moon gets lit up by the Sun and that's why we see a full moon.*

   Student 2: *No, the Moon always gets the same amount of sunlight, it's just that sometimes, the Earth casts a larger shadow on the Moon and so that's why we get phases.*

   Student 3: *You are each half right - the phases of the Moon depend on how the Sun, the Earth and the Moon are aligned with one another. The Moon always gets the same amount of sunlight, but from Earth we can only see certain parts that are illuminated.*

Which student do you agree with? What makes the other two students wrong?

Discuss your answers with groups around you. Talk to your instructor if you need clarification.

10. If it takes the Moon 29.5 days to orbit the Earth, how many days will it take to go from New Moon to Full Moon?

    How long to go from Full Moon to Third Quarter?

    How long to go from Third Quarter to a Waning Crescent at 315 degrees?

    (Hint: look at the elongation angles of each of the phases mentioned above)

11. Recall the first 3 questions (the ones about time). Have another group member take your Moon and put in at an elongation angle of 180 degrees (make sure nothing – like someone's head – is blocking sunlight).

    First, which phase is this?

    Earth rotates once every 24 hours, so this happens much more quickly than the Moon can orbit around Earth. When the Earth group member rotates (toward the left!), that person will see the Full Moon rise (something rises just when you first see it out of the corner of your eye).

    What time does the Full Moon rise?

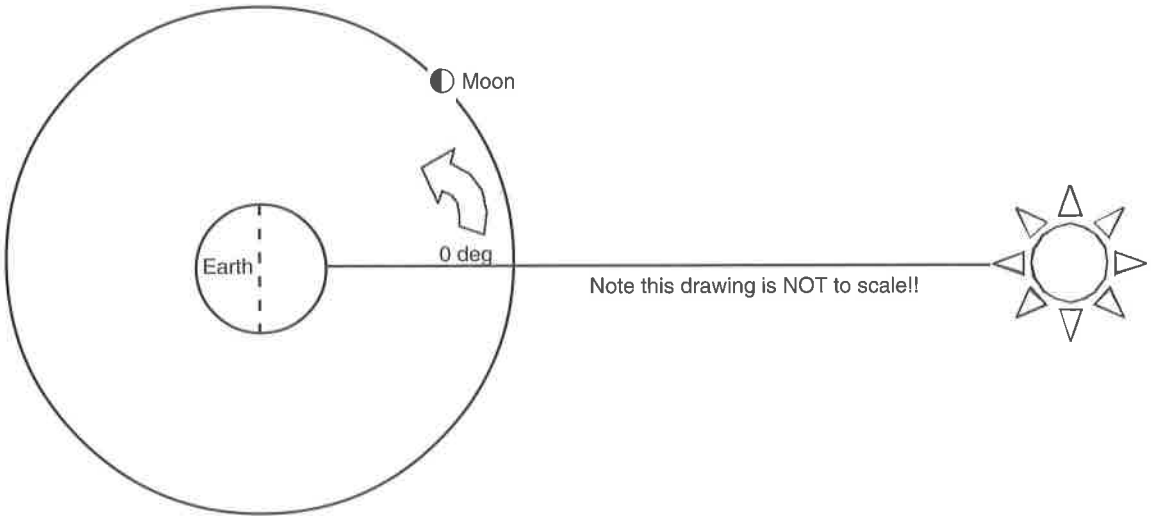
    When will the Full Moon set?

    You should have found that the Full Moon rises at sunset and sets at sunrise. Does this make sense? Why?

    (hint: think about alignment…)

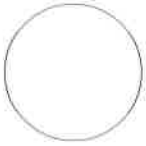
12. Now try this with Third Quarter. Someone should be the Earth and someone should be holding the Moon. When does the Moon rise and set?

13. Use the diagram below to answer the questions following:



What phase is this Moon in?

Please draw what this Moon would look like:



What is the elongation angle?

When will this Moon rise and set?

When might this Moon be highest in the sky? (Hint: think about when the Sun is highest in the sky)

14. Can the Moon be up during the daytime?

Check your answers with a nearby group or possibly with your instructor.

15. Look up the current phases of the moon.

Construct a drawing similar to the one shown in question 13 that shows the current sun, earth, and moon positions for tonight. Be sure to label the earth sun and moon. Indicate the direction to moon orbits the earth. Please use a compass and straight edge to make a nice neat drawing. Never turn in poor quality work.

Today's Date: _____

Phases of Moon: _____

Figure 2: Student drawing of the earth, sun and moon position to cause the current phase of the moon.