

Modeling the Moon's Motions — Student Guide

OVERVIEW

The lessons and activities in this kit are designed to help you understand the motions of the moon and how to interpret them. Primarily, you will learn about the phases of the moon, as well as the difference between a lunar (synodic) month and a sidereal month.

The diagrams that you receive and the notes that you take during the lesson(s) are the only resources that you will be allowed to use during the lab investigations. You will need to pay attention, take good notes, and work with each other to successfully complete each lab task.

GLOSSARY

The following terms are among those used in the lessons/activities discussed in this kit. By the end of all of the activities, you should have a good understanding of these terms.

apparent motion — the continuous change of position of a celestial body with respect to a second body.

celestial body — a natural or man-made object found on the celestial sphere. Examples of celestial bodies include planets, stars, asteroids, and man-made satellites.

celestial sphere — the imaginary sky dome encircling the Earth, on which all celestial bodies appear to be affixed. Only a portion of the celestial sphere can be seen from any position on Earth at a given time.

day — the length of time it takes for a planet to make one complete rotation on its axis. For the planet Earth, a day is 24 hours long. For the planet Jupiter, a day is nearly 10 Earth hours long. For the planet Venus, a day is approximately 5832.5 Earth hours long.

geocentric model — Earth-centered model of the universe.

heliocentric model — Sun-centered model of the solar system.

lunar or synodic month — the time required for the Moon to pass through its complete series of phases from new moon to new moon; this takes 29.5 days.

occultation — the hiding of a distant star or celestial body when the Moon passes between Earth and the distant star or celestial body.

revolution — the motion of an object around a closed orbit, following a circular or elliptical path.

rotation — the circular motion of an object turning on its own axis.

satellite — a small solid body moving in an orbit around a larger body. The moon is a natural satellite of the Earth.

sidereal month — the time required for the Moon to complete a 360° revolution around the Earth; this takes 27.3 days.

year — the time required for a planet to complete a 360° revolution around the Sun. For the planet Earth, this takes 365.25 days. For other planets, a revolution around the Sun can take from 88 Earth days (for Mercury) to more than 90,000 Earth days (for Pluto).

ACTIVITY #1 — MODELING THE MOON'S MOTIONS

Objectives:

- To investigate the rotation and revolution of the Moon
- To investigate the apparent and actual motions of the Moon

Materials Needed:

"Orbit of the Moon" sheet
Sun model (yellow ball)
Earth model (blue and black ball)
Moon model (white ball with black dot)
3 caps
Your notes on rotation and revolution

General Procedure:

1. Place each model (Sun, Earth, and Moon) in a cap. This will keep the models from rolling around while you work with them.
2. Find the "Orbit of the Moon" sheet and lay it down on a flat surface. Place the Sun model on the spot on the sheet labeled "Sun". Place the Earth model and cap on the dot labeled "Earth." Make sure you place the Earth model so that the blue side, representing daylight, faces the Sun. Place the Moon model and cap on top of position 1 on the sheet. Make sure you place the Moon model so that black dot faces the Earth.
3. Move the Moon from position 1 to position 2, making sure that the black dot continues to face the Earth. To do this, you will need to slightly turn or rotate the Moon model.
4. Move the Moon model from position 2 to position 3, making sure that the black dot continues to face the Earth. Again, you will need to slightly turn or rotate the Moon model.
5. Continue moving the Moon model from one position to the next along its orbital path around the Earth, until the Moon has completed its orbit around the Earth. **Throughout this exploration, make sure that the black dot on the Moon ALWAYS faces the Earth.**
6. Follow the directions on the Activity #1 Worksheet (pages S4-S5) and answer the worksheet questions.

ACTIVITY #1 WORKSHEET— MODELING THE MOON'S MOTIONS

Move the moon counterclockwise completely around the Earth (positions 1-8).

Name: _____

Date: _____
Class/Period: _____

1. This motion of the Moon around the Earth is called (rotation/revolution) _____

2. The time that it takes for the Moon to make one complete revolution around the Earth is known as a (sidereal/lunar) _____ month.
3. How many Earth days does it take for the Moon to make one complete revolution around the Earth?

4. How many degrees does the Moon move during one complete revolution around the Earth? _____
5. Using your answers from questions 3 and 4, determine how many degrees the Moon moves *each Earth day*. _____ (Show your work for this answer. Round your answer to the nearest degree.)
6. Using your answer from question #5 above, determine how many degrees the Moon moves in 1 hour: _____ (Show your work for this answer.)

Repeat the entire activity, moving the Moon around the Earth. Make sure that the dot on the Moon always faces the Earth as it revolves around the Earth.

7. Does an Earth-bound observer ever see the back side of the Moon (that is, the side with no dot) at any point during the Moon's rotation? _____
8. To an Earth-bound observer, does the Moon *appear* to rotate? _____. Does the Moon *actually* rotate?

9. To an Earth-bound observer, in which direction does the Moon *appear* to move through the celestial sphere (east to west /west to east)? _____

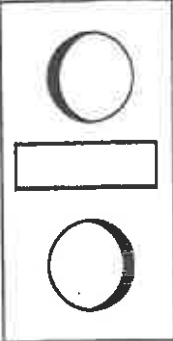
Repeat the entire activity again, moving the Moon around the Earth. Make sure that the dot always faces the Earth as it revolves around the Earth.

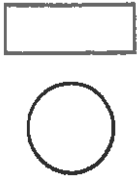
10. Did the dot on the Moon always face the Sun? _____
11. Would an observer on the Sun ever see the back of the Moon (that is, the side with no dot on it) at any point during the Moon's rotation? _____
12. To an observer on the surface of the Sun, does the Moon *appear* to rotate? _____
13. From this activity you should be able to see that the Moon rotates on its axis as it revolves around Earth. To an Earth-bound observer, however, the Moon does not appear to rotate as it revolves around the Earth. For this to occur, the Moon must rotate (faster than/slower than/at exactly the same speed as) _____ it revolves.

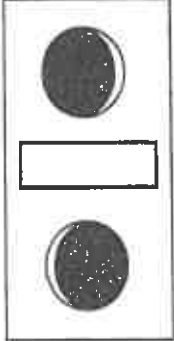
14. In other words, the Moon's rate of rotation is equal to its revolution. Therefore, how many Earth days does it take for the Moon to complete one rotation? _____
15. A day is defined as the amount of time it takes for a body to complete one rotation. A year is defined as the time it takes a body to complete one revolution. A day on the Moon is (shorter than/longer than/exactly as long as) _____ one Moon year. (HINT: Remember — the Moon's rate of rotation is equal to its revolution.)


STUDENT NOTES — THE PHASES OF THE MOON

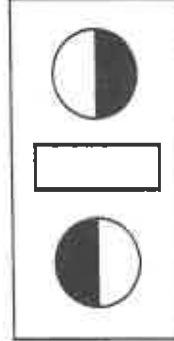
As your teacher explains the phases of the Moon, fill in the spaces in the diagram below. This diagram will serve as your notes.











Note:
These phases are not in the correct sequence.

Waxing:

Waning:

How to tell whether the Moon is in the first or third quarter:

First quarter =

Third quarter =

STUDENT ACTIVITY #2 — THE PHASES OF THE MOON AND THE EARTH

Objective:

- To observe the phases of the Moon, and to observe the Moon and Earth from various perspectives.

Materials Needed:

"Orbit of the Moon" sheet
 Sun model (yellow ball)
 Earth model (blue and black ball)
 Moon model (black and white ball)
 3 caps
 Your notes on the phases of the Moon

Procedure:

- Place each model (Sun, Earth, and Moon) in a cap. This will keep the models from rolling around while you work with them.
- Find the "Orbit of the Moon" sheet. Place the Sun model on the spot on the sheet labeled "Sun". Place the Earth model on the dot labeled "Earth." Make sure you place the Earth model so that the blue side, representing daylight, faces the Sun. Place the Moon model on top of position 1 on the sheet. Make sure you place the Moon model so that black side faces the Earth.
- Keep the following rules in mind throughout this exploration:
 - The white side of the Moon should always face the Sun. In order to achieve this, you must not turn or rotate the Moon.
 - For a portion of this activity, you will be asked to observe the Moon from the perspective of an observer on Earth. As such, you will need to move out of your chair and crouch down to observe the Moon model at eye-level from the Earth's perspective, as shown in Figure 1: You will also need to move around the circle, to a point directly opposite the Moon model, as shown in Figure 2. For instance, when the Moon is at Position 1, you should observe it at eye-level from Position 5.; when the Moon is at Position 2, you should observe it from Position 6, and so on.
 - When identifying each phase of the Moon, be sure to note whether the Moon is waxing or waning, gibbous or crescent, full or new, or first or third quarter, as appropriate.

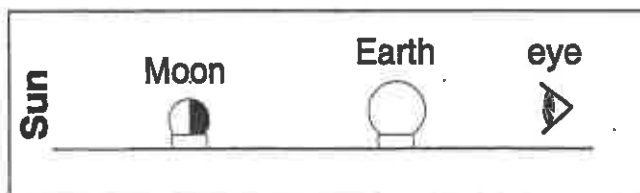


Figure 1

- On Worksheet page S9, answer the questions for Position 1.
- Without rotating the model, move the Moon counterclockwise from position 1 to position 2 along the Moon's orbital path, as shown in Figure 2. Answer the worksheet questions for Position 2.
- Without rotating the model, move the Moon counterclockwise to the next position along the Moon's orbital path, as shown in Figure 2. Answer the worksheet questions for the next position.
- Repeat step 6 for all of the remaining positions on the "Orbit of the Moon" sheet, until you have completed the entire orbit and are back at Position 1. Be sure to answer all the questions for each position and fill in the diagrams on the worksheet (page S12).

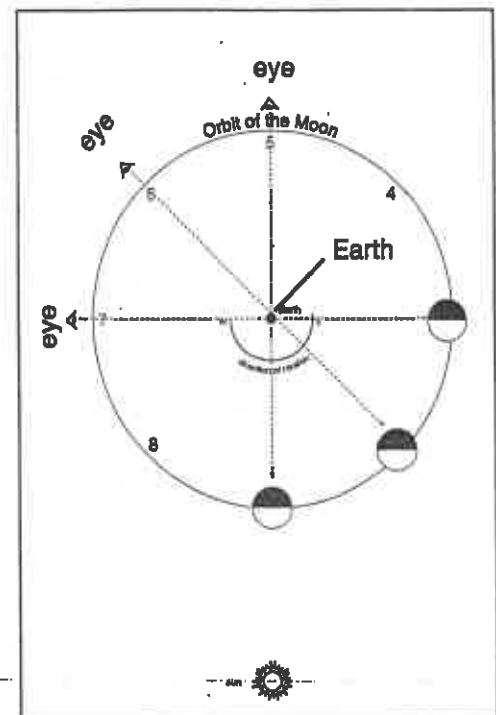


Figure 2

ACTIVITY #2 WORKSHEET: THE PHASES OF THE MOON AND THE EARTH

Name: _____

Date: _____

Class/Period: _____

Position 1

1. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 1, so it shows how the Moon model appears at Position 1, when viewed from above.
2. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 1, so it shows how the Moon model appears at Position 1, when viewed from the perspective of a person on Earth. On the line below the circle at Position 1, write the name of the phase of the Moon in this position.
3. Locate Diagram 3 ("The Earth as viewed from the Moon") on page S12. Use a pencil to fill in the circle at Position 1, so it shows how the Earth model appears at Position 1, when viewed from the perspective of a person on the Moon. On the line below the circle at Position 1, write the name of the phase of the Earth in this position.
4. What is the phase of the Moon in Position 1? _____
5. How many days will pass before this phase will be repeated? _____
6. The time period in question 5, above, is the length of a _____ month.

Position 2

7. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 2, so it shows how the Moon model appears at Position 2, when viewed from above.
8. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 2, so it shows how the Moon model appears at Position 2, when viewed from the perspective of a person on Earth. On the line below the circle at Position 2, write the name of the phase of the Moon in this position.
9. The term used to describe the Moon as the lit portion increases is _____. The term used to describe the Moon as the lit portion decreases is _____.
10. At Position 2, which side of the Moon is lit — the left or the right? _____
11. What is the phase of the Moon in Position 2? _____

Position 3

12. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 3, so it shows how the Moon model appears at Position 3, when viewed from above.
13. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 3, so it shows how the Moon model appears at Position 3, when viewed from the perspective of a person on Earth. On the line below the circle at Position 3, write the name of the phase of the Moon in this position.
14. Locate Diagram 3 ("The Earth as viewed from the Moon") on page S12. Use a pencil to fill in the circle at Position 3, so it shows how the Earth model appears at Position 3, when viewed from the perspective of a person on the Moon. On the line below the circle at Position 3, write the name of the phase of the Earth in this position.
15. At Position 3, the Moon has now completed _____ percent of its orbit around the Earth.
16. In an actual lunar or synodic month, approximately how long does it take for the Moon to travel from position 1 to position 3? (HINT: How many days make up 25 percent of the a lunar cycle?)

17. What is the phase of the Moon in Position 3? _____

Position 4

18. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 4, so it shows how the Moon model appears at Position 4, when viewed from above.
19. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 4, so it shows how the Moon model appears at Position 4, when viewed from the perspective of a person on Earth. On the line below the circle at Position 4, write the name of the phase of the Moon in this position.
20. What is the phase of the Moon in Position 4? Be sure to note whether the Moon is waxing or waning.

Position 5

21. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 5, so it shows how the Moon model appears at Position 5, when viewed from above.
22. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 5, so it shows how the Moon model appears at Position 5, when viewed from the perspective of a person on Earth. On the line below the circle at Position 5, write the name of the phase of the Moon in this position.
23. Locate Diagram 3 ("The Earth as viewed from the Moon") on page S12. Use a pencil to fill in the circle at Position 5, so it shows how the Earth model appears at Position 5, when viewed from the perspective of a person on the Moon. On the line below the circle at Position 5, write the name of the phase of the Earth in this position.
24. The Moon has now completed _____ percent of its orbit around the Earth.
25. In an actual lunar or synodic month, approximately how long does it take for the Moon to travel from position 1 to position 5? _____
26. What is the phase of the Moon in Position 5? _____

Position 6

27. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 6, so it shows how the Moon model appears at Position 6, when viewed from above.
28. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 6, so it shows how the Moon model appears at Position 6, when viewed from the perspective of a person on Earth. On the line below the circle at Position 6, write the name of the phase of the Moon in this position.
29. As the Moon moves from Position 5 to Position 6, does the lit portion appear to increase or decrease?

30. What is the term used to describe your answer to question 29? _____
31. What is the phase of the Moon in Position 6? _____

(continued on next page)

Position 7

32. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 7, so it shows how the Moon model appears at Position 7, when viewed from above.
33. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 7, so it shows how the Moon model appears at Position 7, when viewed from the perspective of a person on Earth. On the line below the circle at Position 7, write the name of the phase of the Moon in this position.
34. Locate Diagram 3 ("The Earth as viewed from the Moon") on page S12. Use a pencil to fill in the circle at Position 7, so it shows how the Earth model appears at Position 7, when viewed from the perspective of a person on the Moon. On the line below the circle at Position 7, write the name of the phase of the Earth in this position.
35. The Moon has now completed _____ percent of its orbit around the Earth.
36. In an actual lunar or synodic month, approximately how long does it take for the Moon to travel from position 1 to position 7? _____
37. What is the phase of the Moon in Position 7? _____

Position 8

38. Locate Diagram 1 ("The Moon in orbit as viewed from above") on page S12. Use a pencil to fill in the circle at Position 8, so it shows how the Moon model appears at Position 8, when viewed from above.
39. Locate Diagram 2 ("The Moon as viewed from Earth") on page S12. Use a pencil to fill in the circle at Position 8, so it shows how the Moon model appears at Position 8, when viewed from the perspective of a person on Earth. On the line below the circle at Position 8, write the name of the phase of the Moon in this position.
40. What is the phase of the Moon in Position 8? _____

Position 1 (at completion of orbit)

41. What is the phase of the Moon when it has returned to Position 1? _____
42. From new moon back to new moon means that the Moon has completed one _____ month.
43. Explain why the Moon appears to go through a cycle of phases.

ACTIVITY #2 WORKSHEET: THE PHASES OF THE MOON AND THE EARTH (continued)

Instructions for filling out this worksheet are on pages S9-S11.

Diagram 1

The Moon in Orbit As Viewed From Above

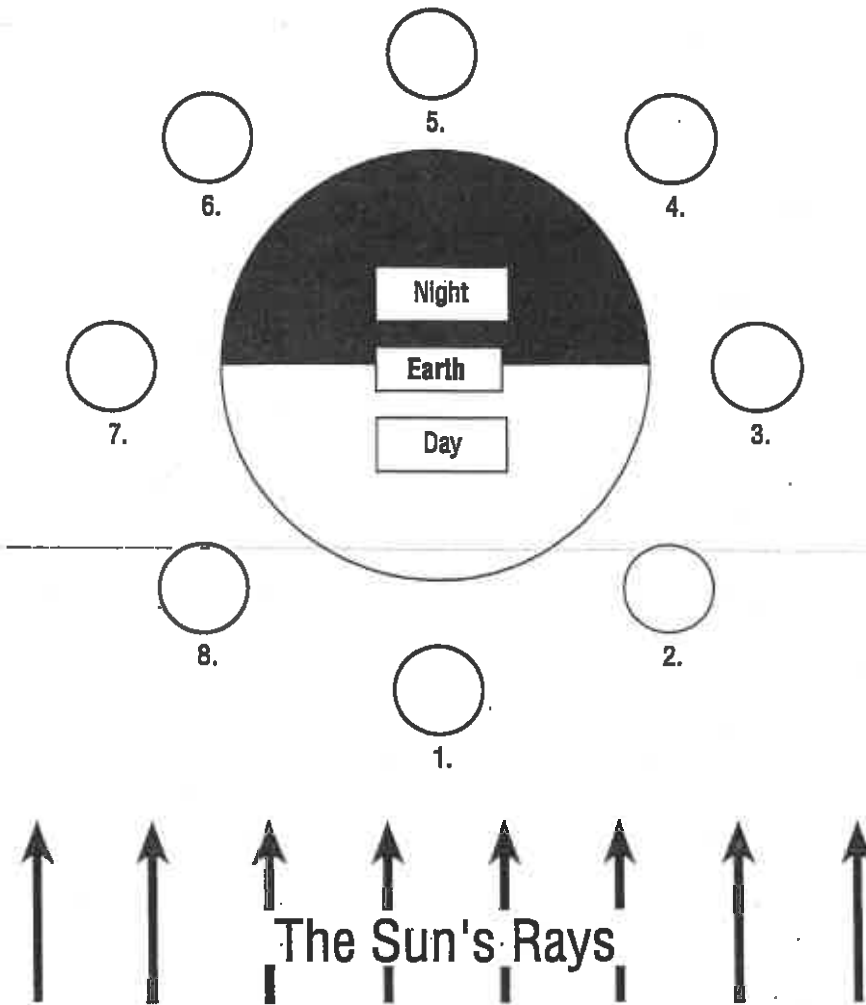


Diagram 2

The Moon Viewed From the Earth



1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____

Diagram 3

The Earth Viewed From the Moon



1. _____ 3. _____ 5. _____ 7. _____