

MOON PHASES AND ECLIPSES

Activity Instructions

<http://ncsciencefestival.org/starparty>

OBJECTIVES

Understand how Earth's motions create the day and year, what causes moon phases, and what causes solar and lunar eclipses

ACTIVITY DURATION

10 minutes for Earth's motions
+10 minutes for moon phases
+10 minutes for eclipses

(Note: Understanding Earth's motions and moon phases provides the basis for understanding eclipses.)

MATERIALS

- "Moon balls" (polystyrene balls)
- Craft sticks
- A light source: the Sun (if doing outdoor version) or a lamp with the shade removed (if doing indoor version)
- Table or stool (if doing indoor version)
- Optional: 8 moon phase cards, hula hoop, eclipse glasses



CHOOSE YOUR SETTING

- **OUTDOOR** version: you'll need a sunny day.
- **INDOOR** version: you'll need a darkened room.

PREPARATION

1. Insert a craft stick into each "moon ball" to make the balls easier to hold and observe. Recommended: Add a little household glue to help the stick stay in the moon ball.



2. *Indoor version:* Remove the shade from a lamp, and place the lamp on a table or stool. You want the bare bulb to be around shoulder level. Choose an interior room that can be made as dark as possible. Once you've handed out the moon balls, your "Sun lamp" should be the only light source.

PROCEDURE

Part 1: How do Earth's motions create the day and year?

1. Ask your audience to sit or stand in a circle (around the Sun lamp, if you're indoors).
2. Tell everyone that we will be talking about three objects in our solar system: a star, a planet, and a moon. Ask them if they can guess which ones (Sun, Earth, and Earth's moon). Give hints: the one star we see in the daytime, the planet we live on, etc.
3. Present a challenge: To sit or stand perfectly still—as still as a statue. What do they feel? Do they feel like they are moving? (Some may say yes, mentioning blinking, breathing, or blood flowing. Note: it is impossible for us to feel Earth's rotation or orbit.) Ask: Why would I say that in fact, we were all moving—that even statues are moving? It's because Earth is moving.
4. Earth moves in two main ways. Does anyone know how it moves? It *rotates* (spins on an axis) and *orbits* (revolves around, moves around) the Sun.

PROCEDURE (CONTINUED)

- Tell everyone: Now we'll all pretend to be Earth—not the real Earth, it's too big. But a scaled-down version, like a globe. First, pretend you're removing your head. Then pick up an imaginary Earth and place it on your shoulders. The top of your head will be the North Pole (point), and here in your throat is the South Pole. Because we're in North Carolina (or whatever state you're actually in), let's make the tip of your nose North Carolina. Imagine a person standing here in North Carolina (the person would be very small on this scale).
- Ask for a volunteer to demonstrate Earth's rotation. They will spin one time. Make sure they spin counterclockwise, or to the left. Ask everyone else to stand and do the same thing.
- Next, turn on the Sun lamp (if outdoors, place yourself in the middle of the circle and pretend to be the Sun). Ask them to make it daytime for their person in North Carolina. (Everyone should face the Sun.) Is it daytime everywhere on Earth? (Point to the back of someone's head.) What about in China? (No, it's nighttime there.) Now make it nighttime in North Carolina. (Everyone should have their back to the Sun, or at least be turned enough away that the North Carolina person couldn't see the Sun.) You can have them rotate counterclockwise a couple of times between daytime and nighttime. Ask students how long they think one *real* rotation takes (1 day, 24 hours). [See additional notes about solar vs. sidereal day if you have sticklers for accuracy.]
- Have a volunteer demonstrate one orbit (revolution) around the Sun. They should walk around the Sun one time counterclockwise. Ask how long the real Earth takes to orbit once (365¼ days, 1 year). Invite everyone to show you one orbit. After the group has mastered orbit, invite them to rotate at the same time they orbit.
- Now tell visitors that the Moon moves in the same ways Earth does. What does the Moon orbit? (Earth.) How long does one orbit of the Moon take? (about 1 month, or “moonth.”) Ask how long they think one rotation of the Moon takes. It is much slower than Earth's rotation. One rotation of the Moon also takes one month. Now let's see how these all work together. [See additional notes about the Moon's orbit and rotation.]
- Ask for 3 volunteers who don't get dizzy easily to demonstrate the motions of Earth and the Moon with an Earth-Moon-Sun “dance.” One volunteer is Earth, one is the Moon, and one is the Sun. Start with the Sun in the middle (slowly rotating counterclockwise). Then add Earth (rotating and orbiting counterclockwise). Finally, add the Moon into the dance (this should be difficult and a bit messy). Tell them you'll show them an easier way than just walking. Have Earth and Moon link left arms facing opposite directions (do-si-do style). The link between them is gravity. Now the Moon can more easily move around Earth while Earth goes around the Sun. (The model isn't completely accurate, but will do the job.)



Part 2: Why does the Moon have phases?

- Depending on the ages and backgrounds of your audience, you might ask who has ever seen the Moon in the sky. What shapes have they seen it look like? You can hold up the moon cards that correspond to the shapes people say they've seen, and introduce terms for lunar phases such as *crescent*, *quarter*, *gibbous*, *full*.
- Ask why the Moon appears to change shape—that is, why does the Moon have phases? Take guesses. (A common misconception is that Moon phases are caused by Earth's shadow. Another misconception is that the phases are caused when clouds pass in front of the Moon.)
- “Let's find out.” Hand out the moon balls.

PROCEDURE (CONTINUED)

14. Tell everyone that their ball represents the Moon, and remind them their head represents Earth. We're imagining our nose as the place we're in now (e.g., North Carolina) and that a person stands on the tip of our nose looking up at the sky.
15. Confirm that everyone is clear on where the real Earth is (point to the ground or the floor — “we're standing on it”). *If you're outdoors and the real Moon is in the sky:* ask people to point to the Moon.
16. *If indoors:* Turn off all lights except for your Sun lamp, and remind everyone what the bulb represents (the Sun). *If outdoors:* Ask where the real Sun is (point to it in the sky).
17. Have everyone study their moon ball and glance around at their neighbors' moon balls. Ask how much of the Moon is lit up by the Sun—whether or not they can see all of the lit part. (Half of the Moon is lit.)
18. Ask why the Moon shines. That is, why does half of the moon ball look lit? Does the Moon make its own light? (No.) Then where does the light come from? (From the Sun. The Moon reflects sunlight.)
19. Invite everyone to take a minute to experiment on their own with their moon balls. Can they figure out how to make the moon ball change phases?
20. *If outdoors on a sunny day when both the Sun and Moon are visible (see presentation tip #4):* Instruct everyone to hold their moon ball right below the real Moon. Ask how much of their ball appears lit up compared with the real Moon. (About the same.)
21. Show how the Moon orbits Earth, by turning yourself and your moon ball counterclockwise (to the left).
22. Now have everyone orbit their Moon around their Earth head. They should turn their faces and bodies counterclockwise, in addition to their moon balls, so they can see their moon ball the entire time. Ask what they observe. (The phases change!)
23. Have everyone orbit their Moon around their Earth head again, now stopping at various phases. Starting from new moon, the full sequence in order is:
 - New moon (Moon is in the same direction as the Sun; the side of the Moon facing Earth is unlit)
 - Waxing crescent (right sliver of Moon appears lit)
 - First quarter (right half of Moon appears lit) - everyone should be holding their moon balls 90 degrees to the left of the Sun, with their right shoulders pointed at the Sun
 - Waxing gibbous (looks more than half lit, on the right side)
 - Full moon (Moon is opposite the Sun and appears fully lit, unless you've created an eclipse—see presentation tip #3)
 - Waning gibbous (more than half lit, on the left side)
 - Last quarter (left half of Moon appears lit)
 - Waning crescent (left sliver of Moon appears lit)
 - Back to new moon



Image courtesy NASA/JPL-Caltech



Image courtesy NASA/JPL-Caltech

Repeat the phases, emphasizing that in the first half of the cycle, the Moon is *waxing*, or appearing to get more and more lit on its side facing Earth. In the second half of the cycle, the Moon is *waning*, or appearing to get less and less lit on its side facing Earth.

PROCEDURE (CONTINUED)

24. Ask or remind how long it takes the Moon to orbit Earth one time. (About a month—or a “moonth.”)
25. Ask again why the Moon has phases. (We see different amounts of sunlight reflecting off the Moon as the Moon orbits us. That is, the changing positions of the Earth, Moon, and Sun relative to one another cause the Moon to go through phases.)

Part 3: Why do eclipses happen?

(Warning: Make sure your audience understands the concepts in parts 1 and 2 before attempting this section.)

26. Ask a few questions to gauge your students’ prior knowledge, e.g., Does anyone know what the word “eclipse” means? Has anyone ever seen an eclipse? What object does the word “solar” refer to? (The Sun.) What does “lunar” refer to? (The Moon.) [Note: Young children often do not know what “solar” and “lunar” mean.]
27. Tell everyone they’ll use their moon balls to find out why eclipses happen.
28. Ask everyone to make a lunar eclipse - when the Moon passes through Earth’s shadow. They should experiment with making their moon ball go through their Earth head’s shadow. (Note: The phase must be Full Moon for there to be a possibility of a lunar eclipse. Therefore, each person should have their backs to the Sun, with the moon ball held low enough that the shadow of their Earth head falls onto the ball.)
29. Ask where you would have to be on Earth to see a lunar eclipse. (The night side of Earth.)
30. Next model a solar eclipse—when the Moon casts a shadow on Earth.

If indoors: You can have your students/visitors model a solar eclipse themselves. They should hold their moon ball between their Earth head and the Sun lamp, so that the moon ball appears to cover up the Sun. While everyone is making a solar eclipse, have them glance around to observe how the shadow of each person’s moon ball falls onto their Earth head.

If outdoors: CAUTION! You don’t want anyone staring at the Sun. To avoid this, you should be the only one who models a solar eclipse. But be careful not to look directly at the Sun yourself. For example, you can face the Sun with your eyes shut. Choose an adult volunteer to take a moon ball and hold it between your head and the Sun such that the moon ball casts a shadow on your Earth head. (Alternatively, you can wear eclipse glasses made for looking at the Sun safely.) Invite your students/visitors to observe the shadow of the moon ball falling onto your Earth head.

31. Ask where you would have to be on Earth to witness a solar eclipse. (The part where the Moon’s shadow crosses. Everyone there would see the Sun blocked out by the Moon. We hope everyone there is observing the partial phases of the eclipse safely, such as with eclipse glasses.)
32. Ask whether eclipses happen every month. Is there a lunar eclipse at every Full Moon? Is there a solar eclipse at every New Moon? (No. Usually the Moon, Earth, and Sun aren’t perfectly aligned. The Moon’s orbit around Earth is tilted 5 degrees compared with Earth’s orbit around the Sun—you can hold up a hula hoop around your head to model the Moon’s orbit and then tilt it slightly to demonstrate the tilt. Usually at Full Moon the Earth’s shadow passes above or below the Moon, and there is no lunar eclipse. And usually at New Moon the Moon passes above or below the Sun, and there is no solar eclipse. Also, our model is not to scale, and you’re probably finding it easier than it should be to cause eclipses.)



PROCEDURE (CONTINUED)

33. Tell your students/visitors about upcoming eclipses. NASA's Eclipse Web Site at <https://eclipse.gsfc.nasa.gov/eclipse.html> provides dates and maps for solar and lunar eclipses.
34. Remember how everyone pretended to remove their heads (step 5)? Invite them to put their heads back on.

PRESENTATION TIPS

1. Always turn counterclockwise (to the left). This makes Earth rotate in the correct direction (from west to east) and makes the moon phases change in the correct order.
2. Help everyone arrange themselves so their own shadows don't inadvertently create eclipses for one another. *For the indoor version of the activity:* have people spread out into a large circle around your "Sun lamp."
3. To avoid creating a lunar eclipse at every full moon, have everyone lift their moon ball up high, out of the Earth's shadow created by their own bodies—but not so high that they can't see their moon ball.
4. *For the outdoor version:*
 - a. When is it easiest to make all the phases look correct? When the Sun is not too high in the sky (within roughly 2 hours after sunrise or before sunset). Then you can orbit your Moon in a plane level with the horizon and make all the phases look right. However, if the Sun is more than about 20 degrees above the horizon, you'll need to adjust the plane in which you orbit your moon ball around your body to make all the phases look more convincing. For example, if you orbit the moon ball level with the horizon when the Sun is high in the sky, you'll never get a full moon, since the moon ball needs to be on an almost straight line on the opposite side of your head from where the Sun is.
 - b. When will the real Moon be visible in the daytime sky? In the morning if the phase is within a few days of last quarter. Or in the afternoon if the phase is within a few days of first quarter.
5. Note that the Sun-Earth-Moon model will not be to scale. The Moon is about 30 Earth diameters away from Earth. A moon ball held at arm's length from your Earth head is not nearly far enough away to represent this distance to scale.
6. Remind everyone that it is not safe to look directly at the Sun, and they must *never* use binoculars or a telescope to look at the Sun (exception: solar telescope or telescope with a proper solar filter that is properly attached).
7. It's possible to do later parts of the activity without doing the earlier parts, but make sure everyone understands the relevant concepts first.



ADDITIONAL NOTES

- Earth's rotation. It takes 24 hours for the Sun to return to its highest point in the sky (solar day), but only 23 hours and 56 minutes for Earth to rotate when measured relative to the "fixed" stars (sidereal day). Learn more at <http://earthsky.org/astromy-essentials/what-is-sidereal-time>
- Moon's orbit. The Moon's orbit takes roughly a month. More precisely: It takes the Moon 27.3 days to get back to its starting point with respect to the stars (one sidereal month). It takes a little longer, 29.5 days, for the Moon to complete a full cycle of phases (one synodic month).

ADDITIONAL NOTES (CONTINUED)

- Moon's rotation. Students or visitors will often know (correctly) that the Moon always shows the same face to Earth. But they also often assume (incorrectly) that therefore, the Moon doesn't rotate. In fact, the Moon *must* rotate once during each orbit in order for the Moon to keep showing the same face to Earth. If the Moon didn't rotate, we on Earth would get to see every side of the Moon at some point.

You can demonstrate this by pretending your head is the Moon and orbiting yourself around a volunteer Earth. First, show students what not rotating looks like (pick a wall or other distant object and keep your face/feet aimed at that object as you orbit Earth). Then show them what really happens: rotate once for every orbit by keeping your face and feet locked toward Earth as you orbit.

MORE RESOURCES

“Why Does the Moon Have Phases?” (2-minute video demo)
<http://www.youtube.com/watch?v=7QxIoRNPXUI>

“Why Do Eclipses Happen?” (6-minute video demo)
<http://www.youtube.com/watch?v=gcco9T9ycg>

You can also find both videos at <http://www.youtube.com/user/NightSkyNetwork>

CREDIT

We are grateful to the NASA Night Sky Network (<http://nightsky.jpl.nasa.gov/>) and the Astronomical Society of the Pacific for granting permission to modify materials they created.

