

## Extensions

### Topic: Does the Moon rotate?

After Part 3, students will understand that the Moon revolves around the Earth and takes about one month to complete an orbit. Students are often surprised to learn that the Moon rotates as it revolves; one rotation also takes about a month. How would students model this?

Divide students into pairs; one student will act as the Earth and the other student will be the Moon. Allow them several minutes to experiment and determine how to model rotation and revolution where both motions have similar periods; this special type of rotation is called *synchronous rotation*. (The Moon student will orbit the Earth student while always facing the Earth. This achieves one rotation for every revolution. If students are having trouble understanding why this works, advise them to watch the Moon student's feet as the Moon student orbits the Earth. They will notice the Moon's toes point to each wall of the classroom during orbit, indicating the Moon rotated one time.)

This extension addresses performance expectation MS-ESS1-1 (NGSS Lead States 2013).

### Topic: Setting and rising times of Moon phases

When will the Moon be in the sky today? Once students understand how to create different phases with the Moon ball (Part 3), they can use this model to answer questions about the phase of the Moon and its position in the sky at different times of day or night. When using the model for this purpose, students should first place their Moon ball in the phase asked for. Then, while keeping their arm and Moon ball in position, students should pivot their body and place the Moon in the correct position on their city's horizon/in their field of view. Students should then take note of the position of the Sun in the sky and determine the time.

For example, ask students, "What time does a full Moon set?" To answer this question, students should create a full Moon, with the Moon on the opposite side of the Earth from the Sun. Then students will pivot their body so they see the Moon out of the corner of their right eye, which corresponds to the western horizon, which models a setting Moon. Once in position, with a setting full Moon in their periphery, students should notice where the Sun is in their sky. In this instance, students will see the Sun out of the corner of their left eye, rising in the east. A full Moon sets at sunrise, or approximately 6 a.m. (See Figure for an illustration of this process.) You may ask students about the setting and rising times of any of the phases, and even for the time a particular phase will reach its highest point in the sky. Note: These times are approximate. The exact rising and setting time of the Moon is also dependent on the Earth's position in its orbit and where the observer is located on the Earth; these effects are not modeled in this activity.

This extension addresses performance expectation MS-ESS1-1 (NGSS Lead States 2013).

### Topic: Eclipses

Divide students into groups of two and pass out a Moon ball to each group. Turn on the Sun lamp and direct students to use their Moon ball to determine how the Earth, Moon, and Sun line up to create solar and lunar eclipses. Ask students, "What phase must the Moon be in? What time of day does each eclipse occur? Why don't we experience a lunar eclipse and a solar eclipse every month?"

### Problem-solving with the model What time does a Full Moon set?

**A** Step 1: Create a Full Moon.

**B** Step 2: Position your body so the Moon is setting.

**C** Step 3: Notice where the Sun is on your city's horizon. What time is it in the city on your nose?



## Figure Title

This extension addresses performance expectation MS-ESS1-1 (NGSS Lead States 2013).

### Topic: Seasonal constellations and the zodiac

Why can we see groups of stars during some seasons and not others? Position students in a circle around the Sun lamp. Each student represents an imaginary grouping of stars; ask them to strike a pose to represent their star pattern (i.e., Joe the baseball player, Hal the disco dancer) (see Figure below).

#### Students striking a pose to create star patterns



Discuss with students the limitations of this model (the model does not show that the stars forming these patterns are located at different distances from the Sun). The student selected to be the Earth revolves around the Sun inside the circle of students. When Earth reaches the position in its orbit that corresponds to each season (covered in Part 4), determine which star patterns are above the city on their nose's horizon in the daytime sky. From the perspective of the Earth, the Sun appears to block different star patterns during different months of the year. When this happens, the Sun is located in between Earth and the star pattern. The student selected to be the Earth should also report which students are visible in the nighttime sky at midnight, at dawn, and at sunset (see Figure, right). Students should understand that the previous season's constellations set in the west just after sunset and the next season's constellations rise in the east before sunrise.

The circle of star patterns formed by students represents the constellations of the zodiac; you may choose to introduce the position of the real zodiac constellations at this stage of the model, replacing the star patterns created by students. As in the first part of this model, the student selected to be the Earth should notice that while moving through one revolution, the student can see different zodiac constellations at different times of year. Point out that other constellations and asterisms, in addition to the zodiac, are visible from Earth, as there are stars surrounding the Earth in all directions. In this model they would be on the ceiling, the classroom floor, etc.

This extension addresses performance expectation MS-ESS1-1 (NGSS Lead States 2013).

### Topic: Positions of the planets

When are the planets visible in the sky? Assign a student to be each of the eight planets. Planets should stand around the Sun, on any side of the Sun in their orbit circle, making sure their relative order from the Sun is correct. (Mercury is the closest to the Sun, Neptune in the farthest, etc.) Students should take turns adopting Earth's perspective and note the planets that are up in the daytime sky and which are visible at night. Asking the planets to move in their orbits (counterclockwise around the Sun), you can determine which planets can only be visible near sunrise and sunset (Venus and Mercury) and which can be viewed at any time throughout the evening. This model helps students understand why a planet's location in the solar system determines the time of day we see them in Earth's sky. You may wish to explain the terms *opposition*, *inferior conjunction*, and *superior conjunction* while students are using this model. This would also be an opportune time to begin a discussion about the role of gravity in the motions within the solar system.

This extension addresses performance expectation MS-ESS1-2 (NGSS Lead States 2013).

#### When can I see it?

- A** These star patterns are visible just after sunset from the city on this student's nose.
- B** These star patterns are visible at midnight from the city on this student's nose.

