

Light, Shadow, Seasons

Build and test a model of the Sun, Earth, and Moon.

MS-ESS1-1 "Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. Clarification Statement: Examples of models can be physical, graphical, or conceptual."

NAME _____

DATE _____

1 READ AND MARK _____ Read it twice

YOUR JOB Underline the cause of each pattern. Then use the modeling steps to test those explanations. A list of phase names alone is not a model of this system.

Three patterns, one system

- ① **Phases:** Outside an eclipse, sunlight illuminates roughly half of the Moon. As the Moon orbits Earth, we see changing amounts of that lit half. The sequence is new, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, waning crescent, then new again in about 29.5 days. Waxing means the visible lit part grows; waning means it shrinks. At either quarter phase, half of the disk visible from Earth is lit. Earth's shadow does not cause these ordinary phases.
- ② **Eclipses:** A solar eclipse requires a new Moon aligned so its shadow reaches Earth. A lunar eclipse requires a full Moon passing through Earth's shadow. The Moon's orbital plane is tilted about 5 degrees to Earth's orbital plane, so most new and full Moons miss the needed alignment. Favorable alignments return during eclipse seasons, roughly six months apart. A flat model would wrongly suggest eclipses every month.
- ③ **Seasons:** Earth's axis leans about 23.5 degrees from perpendicular to its orbital plane and points nearly the same way throughout a year. As Earth orbits the Sun, the hemisphere tilted toward the Sun receives more direct light and longer days; the other has the opposite season. Between these positions come the equinoxes, with nearly equal day and night. Seasons repeat yearly. Changing distance is not the main cause of Earth's seasons.

2 ANSWER WITH EVIDENCE Use the passage

- 1 After testing, explain how your model distinguishes a half-lit Moon from a half-lit disk seen from Earth.

- 2 What change to a flat Moon orbit prevents an eclipse at every new or full Moon? Explain using a shadow.

- 3 Use your season model to explain why northern and southern summers happen at opposite times.

3 YOUR TURN Your own words

Work in a group of 3; each person must operate and explain every model. Supplies per group: a teacher-set cool LED lamp, small pale ball on a handle, globe with a tilted spin axis and marked equator, removable tape, and pencil. Use a dim room with clear walking space. Look at the balls, not the lamp; never use the Sun. Record short observations below; no extra paper is needed.

1. Design the representations

Choose labels and positions for the lamp as Sun and ball as Moon. Your head represents Earth for phases; the globe replaces it for eclipses and seasons. Keep the lamp fixed and well beyond the Moon's arm-length orbit. Predict one visible phase and one shadow alignment. Record your choices and a limitation of these sizes or distances.

2. Run and revise the phase model

Face the lamp with the Moon at arm's length near its direction. Turn left slowly through a full circle, keeping the ball ahead of you; this is counterclockwise from above your head. Watch from Earth's viewpoint. Lift the ball just enough to miss your head's shadow near full Moon. Identify all eight phases and repeat. Record the sequence, your prediction check, and any adjustment that made the phases clearer.

3. Test both eclipse alignments

Replace your head with the globe. Move the ball between lamp and globe until its shadow falls on the globe; then place it behind the globe in the globe's shadow. Identify both eclipses and their phases. Tilt the ball's orbital path so these shadows usually miss, then return it to alignment. Record both object orders, why a flat orbit fails, and why eclipses can recur without happening every month.

4. Carry Earth through a year

Mark matching northern/southern midlatitude points. Start with the globe's north axis leaning toward the lamp. Carry it counterclockwise (viewed from above the orbit) around the lamp at fixed distance and height, keeping the axis aimed at the SAME wall throughout. Stop every quarter orbit; spin the globe and compare each point's time in light and the angle of the light. Identify northern summer, autumn equinox, winter, spring equinox, then summer. Record the pattern, opposite southern seasons, and one model limitation.

PART 1 • READ AND MARK

Underline the cause of each pattern. Then use the modeling steps to test those explanations. A list of phase names alone is not a model of this system. Accept any marking that follows this job and points at the right text.

PART 2 • ANSWERS

#	QUESTION	ANSWER
1	After testing, explain how your model distinguishes a half-lit Moon from a half-lit disk seen from Earth.	Sunlight lights roughly half the whole ball. At a quarter phase an Earth observer sees only half of the visible disk lit because of the viewing angle. Earth is not casting the ordinary phase shadow.
2	What change to a flat Moon orbit prevents an eclipse at every new or full Moon? Explain using a shadow.	Tilt the Moon orbit relative to Earth's orbital plane. At most new/full positions the Moon's shadow misses Earth or the Moon misses Earth's shadow. Eclipse opportunities recur when alignment is favorable.
3	Use your season model to explain why northern and southern summers happen at opposite times.	With Earth's axis kept parallel to itself during its orbit, one hemisphere tilts toward the Sun while the other tilts away. Directness and daylight duration reverse half a year later; distance alone cannot explain opposite seasons.

PART 3 · YOUR TURN (SAMPLE ANSWER)

Illustrative design: The lamp supplies light; the small ball reflects it. My head gives an Earth observer's view; the globe gives an outside view. Sizes and distances are not to scale. I predict a mostly dark near-side disk near the lamp direction and a lit disk opposite it. I also predict that placing the Moon directly between the lamp and globe can cast a shadow on the globe.

Illustrative phase test: new, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, waning crescent, new. The repeat matches the monthly cycle. Lifting the ball slightly near full removes my head's shadow. The lit hemisphere remains about half the ball while its visible portion changes.

Illustrative eclipse test: Sun-Moon-Earth gives a solar eclipse at new Moon; Sun-Earth-Moon gives a lunar eclipse at full Moon. Tilting the orbit makes most shadows miss. Alignments recur during eclipse seasons rather than every month.

Illustrative season test: north summer/south winter; autumn/spring equinox; north winter/south summer; spring/autumn equinox; repeat. The tilted-toward midlatitude point spends more of a spin in light and receives light more directly. The fixed axis, not a distance change, explains the reversal. A nearby lamp has spreading rays and cannot reproduce exact daylight hours or eclipse dates.

Assess each learner's actual model operation, prediction, observation and explanation. Do not award full credit for copied definitions. The teacher must check lamp/globe visibility first, with the light source at globe-center height and sufficiently far from the small models. Each learner records actual outcomes; the key is illustrative, not a claim of measurements. The model exaggerates sizes, is not suitable for eclipse dates, and omits orbital precession. Scientific background: NASA, Moon Phases (science.nasa.gov/moon/moon-phases/); Why Do Eclipses Happen? (science.nasa.gov/eclipses/geometry/); NASA Space Place, What Causes the Seasons? (spaceplace.nasa.gov/seasons/en/).