# Lesson 3 | Eclipses and Tides

## Student Labs and Activities

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Launch Lab

LES SON 3: 10 minutes

How do shadows change?

You can see a shadow when an object blocks a light source. What happens to an object’s shadow when the object moves?

Procedure

1. Read and complete a lab safety form.
2. Select an object provided by your teacher.
3. Shine a flashlight on the object, projecting its shadow on the wall.
4. While holding the flashlight in the same position, move the object closer to the wall—away from the light. Then move the object toward the light. Record your observations below.

Data and Observations

Think About This

1. Compare and contrast the shadows created in each situation. Did the shadows have dark parts and light parts? Did these parts change?

2. Key Concept Imagine you look at the flashlight from behind your object, looking from the darkest and lightest parts of the object’s shadow. How much of the flashlight could you see from each location?
Eclipses and Tides

Directions: In this word search puzzle, find and circle the five terms listed below. Then write each term on the line before its definition.

lunar eclipse    penumbra    solar eclipse    tide    umbra

1. the daily rise and fall of sea level
2. the lighter part of a shadow
3. the darker part of a shadow
4. occurs when the Moon moves into Earth’s shadow
5. occurs when the Moon’s shadow appears on Earth’s surface
Lesson Outline

LESSON 3

Eclipses and Tides

A. Shadows—the Umbra and the Penumbra

1. When one object blocks light from another object, a(n) ______________ results.

2. Light from a(n) ______________ source forms a shadow with lighter and darker parts.
   a. The darker central part of a shadow is called the ______________.
   b. In the umbra, light is ______________ blocked.
   c. The lighter part of a shadow is called the ______________.
   d. In the penumbra, light is ______________ blocked.

B. Solar Eclipses

1. When the Moon passes between Earth and the Sun, it casts a shadow on ______________.
   a. During a(n) ______________, the Moon’s shadow passes over Earth’s surface.
   b. A solar eclipse can occur only during a(n) ______________ moon.

2. If you are in the umbra of the Moon’s shadow, you see a(n) ______________ solar eclipse. The Moon appears to ______________ cover the Sun.

3. If you are in the penumbra of the Moon’s shadow, you see a(n) ______________ solar eclipse.

4. The Moon’s orbit is slightly ______________ compared to Earth’s orbit.

C. Lunar Eclipses

1. During a(n) ______________, Earth casts a shadow on the Moon. A lunar eclipse can occur only during a(n) ______________ moon phase.

2. When the entire Moon passes through Earth’s ______________, a total lunar eclipse occurs.

3. When only part of the Moon passes through the ______________ of Earth’s shadow, a partial lunar eclipse occurs.

4. You do not see a lunar eclipse every month because the Moon’s orbit is slightly ______________ compared to Earth’s orbit.
Lesson Outline continued

D. Tides

1. The daily rise and fall of sea level is called a(n) ____________________.

2. The main cause of tides is the gravitational pull of the ____________________ on Earth.
   a. A(n) ____________________ occurs on the side of Earth that is closest to the Moon and on the opposite side of Earth.
   b. ____________________ tides occur at tidal bulges.
   c. ____________________ tides occur between tidal bulges.

3. The ____________________ also affects tides, but not as much as the Moon does.

4. During a(n) ____________________ tide, Earth, the Sun, and the Moon are positioned in a straight line. At this time, high tides are ____________________ than usual, and low tides are ____________________.

5. During a(n) ____________________ tide, Earth, the Sun, and the Moon form a right angle. At this time, high tides are ____________________ than usual, and low tides are ____________________.
What does the Moon's shadow look like?

Like every shadow cast by a wide light source, the Moon’s shadow has two parts.

**Procedure**

1. Read and complete a lab safety form.
2. Working with a partner, use a **pencil** to connect two **foam balls**. One ball should be one-fourth the size of the other.
3. While one person holds the balls, the other should stand 1 m away and shine a **flashlight** or **desk lamp** on the balls. The balls and light should be in a direct line, with the smallest ball closest to the light.
4. Sketch and describe your observations in the Data and Observations section below.

**Data and Observations**

**Analyze and Conclude**

**Key Concept** Explain the relationship between the two types of shadows and solar eclipses.
Eclipses and Tides

Directions: Use the diagram to write the letter of the term that correctly answers each question.

1. According to the diagram, what does the light shining on the ball create?
   - A. the Moon
   - B. a Sun-Earth-Moon line
   - C. full moon
   - D. a shadow
   - E. the umbra
   - F. two
   - G. Earth
   - H. the penumbra
   - I. the Sun
   - J. new moon

2. How many parts does the shadow have?

3. What is the central, darker part of a shadow called?

4. What is the lighter part of a shadow where light is partially blocked called?

5. In thinking about a solar eclipse, what does the light source in the diagram represent?

6. In thinking about a solar eclipse, what does the ball in the diagram represent?

7. In thinking about a lunar eclipse, what does the ball in the diagram represent?

8. What must occur for an eclipse to occur?

9. During which part of the lunar cycle can a lunar eclipse occur?

10. During which part of the lunar cycle can a solar eclipse occur?
Eclipses and Tides

Directions: Respond to each statement on the lines provided.

1. Describe the difference between an umbra and a penumbra.

2. Explain what causes a solar eclipse.

3. Explain what causes a lunar eclipse.

4. Explain why lunar eclipses do not occur during every full moon phase.

5. Explain why a solar eclipse does not occur during every full moon phase.
Reading-Comprehension Activity: True or False

Directions: On the line before each statement, write T if the statement is true or F if the statement is false.

1. The shape of Earth’s orbit is nearly circular.
   
2. When an object makes a complete turn on its axis, it is called a revolution.
   
3. Rotation is a wavelike linear motion.
   
4. Summer occurs when Earth is closest to the Sun, and winter occurs when Earth is farthest from the Sun.
   
5. Earth’s axis leans the most toward or away from the Sun during a solstice.
   
6. Earth and other spinning objects spin around a line called a rotation axis.
   
7. An equinox occurs when Earth’s rotation axis is the most toward or away from the Sun.
   
8. The seasons are a result of Earth’s revolution around the Sun and the tilt of Earth’s rotation axis.
Language Study Activity: Compound Sentences

Learning the Skill
Remember that a simple sentence can be made from a single subject and a verb. It can also be expanded to include more than one subject and verb and some descriptive words.

Rain falls.
Rain and snow fall in the mountains at different elevations.

A compound sentence consists of two simple sentences that are combined into one sentence. The two sentences are combined using the conjunctions and, but, for, or, so, or yet.

Rain falls at lower levels, but snow falls at higher ones.

And, but, or, and so have different uses. And joins two ideas. But indicates a contrast or joins two ideas that are different. Or explains a choice between two ideas. So shows results.

Practicing the Skill
Directions: Circle the correct conjunction in each compound sentence.

1. Light is only partially blocked in the penumbra of a shadow, (but/so) it is not as dark in the penumbra as it is in the umbra.

2. Lunar eclipses and solar eclipses occur as the Moon revolves around Earth, (but/and) they are caused by different shadows.

3. The eclipse occurred when the Moon moved into Earth’s shadow, (and/or) the result was a total lunar eclipse.

4. Tides can occur when Earth, the Sun, and the Moon are aligned, (so/or) they can occur when the locations of the Sun, Earth, and the Moon form a right angle.
Eclipses and Tides

Directions: Use your textbook to answer each question.

1. The umbra is the darkest part of a shadow. The penumbra is the lighter part around the edges of a shadow.

   What is the difference between being in the umbra and penumbra of the shadow the Moon casts on Earth during a solar eclipse?

2. A solar eclipse occurs when the Moon’s shadow passes over Earth. A lunar eclipse occurs when the Moon moves into Earth’s shadow.

   Why are solar eclipses visible from a much smaller part of Earth than lunar eclipses?

3. During neap tides, high tides are lower and low tides are higher.

   What causes the Moon to have less of an impact on tides at neap tides?

4. Total lunar eclipses occur only during a full moon. Total solar eclipses occur only during a new moon.

   Why do total eclipses not occur during each full moon and new moon?
Eclipses and Tides

Key Concept  What is a solar eclipse?

Directions: Answer each question or respond to each statement on the lines provided.

1. **Explain** when a solar eclipse occurs.

2. **Explain** what is meant by the umbra.

3. **Explain** what is meant by the penumbra.

4. What does the Moon appear to do in a total solar eclipse?

5. Where must a person be on Earth to view a total solar eclipse?

6. **Explain** why everyone does not see the same type of eclipse.
### Key Concept Builder

**Eclipses and Tides**

**Key Concept**  What is a solar eclipse?

**Directions:** Answer each question or respond to each statement in the space provided.

<table>
<thead>
<tr>
<th>A Solar Eclipse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a solar eclipse?</td>
</tr>
<tr>
<td>2. Where must an individual be to witness a solar eclipse?</td>
</tr>
<tr>
<td>3. What needs to be true about the orbits of the Moon and Earth for a solar eclipse to occur?</td>
</tr>
<tr>
<td>4. Why is the Moon’s shadow cast on Earth during a solar eclipse?</td>
</tr>
<tr>
<td>5. What is the difference between a total solar eclipse and a partial solar eclipse?</td>
</tr>
<tr>
<td>6. <strong>Explain</strong> the sequence of a solar eclipse.</td>
</tr>
<tr>
<td>7. <strong>Explain</strong> why a solar eclipse does not occur during each full moon.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Elapsed time: 0 h 22 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elapsed time: 1 h 09 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon’s motion</td>
</tr>
</tbody>
</table>

| Elapsed time: 1 h 16 min |

| Elapsed time: 1 h 34 min |

| Elapsed time: 1 h 49 min |
Eclipses and Tides

Key Concept: What is a lunar eclipse?

Directions: Create a drawing in the space below that shows the position of Earth, the Sun, and the Moon during a total lunar eclipse.

Directions: Use your drawing to answer each question on the lines provided.

1. What is a lunar eclipse?

2. Where must Earth be for a lunar eclipse to occur?

3. When do lunar eclipses occur?

4. Where on Earth can a lunar eclipse be seen?

5. What is Earthshine?

6. What is a total lunar eclipse?

7. What is a partial lunar eclipse?
Eclipses and Tides

Key Concept  How do the Moon and the Sun affect Earth’s oceans?

Directions: On each line, write the term or phrase that correctly completes each sentence.

<table>
<thead>
<tr>
<th>The Effect of the Moon on Tides</th>
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</thead>
<tbody>
<tr>
<td>1. Tides on Earth are caused by the difference in ____________________________</td>
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<td>2. A tidal bulge occurs in oceans on opposite sides of Earth because ____________________________</td>
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<tr>
<td>3. Where a tidal bulge occurs, a(n) ____________________________ occurs.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>The Effect of the Sun on Tides</th>
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</thead>
<tbody>
<tr>
<td>4. Compared to the Moon’s effect on tides, the Sun’s effect is about ____________________________</td>
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<tr>
<td>5. During a full moon and a new moon, a(n) ____________________________ occurs.</td>
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<tr>
<td>6. Tides are higher and lower during spring tides because ____________________________</td>
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<tr>
<td>7. A neap tide results in lower high tides and higher low tides because ____________________________</td>
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<tr>
<td>8. In a neap tide, the Moon’s effect on tides is reduced due to the effect of ____________________________</td>
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</tbody>
</table>
Eclipses and Tides

The gravitation between Earth, the Moon, and the Sun results in a cyclic rise and fall of ocean waters on Earth. The tides are caused primarily by the Moon—not the Sun—because the Moon is about 400 times closer to Earth than the Sun is. But there are some complications in this model.

Tide Irregularities

The Moon revolves around Earth, Earth revolves around the Sun, and all are revolving around the center of mass for the Galaxy; as their spatial relations change, they influence the tides differently. Also, Earth is not covered by water—some of it is land. Some ocean waters, such as estuaries, are shallow and protected from vigorous tides. All this means that the tides in every location on Earth are not as regular and predictable as the phases of the Moon and the revolution of Earth.

Spring Tides and Neap Tides

When the Sun, the Moon, and Earth are aligned in that order, the Sun and the (new or full) moon affect the waters of Earth to produce spring tides. These larger-than-normal tides are caused by the Sun and the Moon joining forces. When the Sun and the Moon are at right angles to one another, such as when the Moon is at first quarter or last quarter phase, they produce a neap tide. Neap tides are weaker than normal tides.

False Tides

A rip tide is not a tide in the lunar gravitational sense. This type of tide occurs when storm waves affect the shape of underwater sandbars near shore and a part of the sandbar breaks out. Outflowing currents rush through this gap, sometimes catching swimmers unaware. They are powerless to swim against the current, but they can swim parallel to it. When they are out of the rip area, they can then swim toward shore.

A tidal wave is another event that is not a lunar gravitational tide. Tidal waves are caused by a deep-sea geologic event, such as an earthquake, the collapse of a seamount or the wall of a continental shelf, or the Storm tides, also called storm surges, are swells of water that are pushed ahead of a hurricane. A storm surge often causes more damage to an area than the storm itself, especially when the storm surge coincides with a high tide. Storm tides are caused by storms, not the Moon’s or the Sun’s gravity.

Applying Critical-Thinking Skills

Directions: Respond to each statement.

1. Summarize at least three main influences on tidal movements.
2. Compare surfing in an incoming neap tide to surfing in an incoming spring tide.
3. Infer at least one reason why rip tides, tidal waves, and storm tides became associated with gravitational tides.
Eclipses and Tides

Eclipses

Observers on Earth experience two types of eclipses—lunar and solar. When the Moon or Earth falls into the other's shadow, an eclipse occurs.

When a full moon revolves into the shadow of Earth, a lunar eclipse can occur. That means the Sun, Earth, and the Moon are aligned in that order. The Earth then casts a deep shadow around the Moon, called the umbra. The lighter part at the edges of the umbra is called the penumbra. This shadow falls into space in a lunar eclipse.

Rarely, a new moon aligns with Earth and the Sun—the Sun, the Moon, and Earth, in that order. This alignment creates a solar eclipse. The Moon can barely block the Sun on a narrow spot on Earth where the Moon’s umbra falls. The penumbra extends farther, but the eclipse is only partially outside the umbra. A total eclipse of the Sun can be observed in one location for only a few minutes—and then only once every 200 years or so.

Directions: Draw a sketch of a solar eclipse. Add these labels to your drawing—Sun, sunlight, Moon, umbra, penumbra, total eclipse, partial eclipse, and Earth.
Phases of the Moon

The Moon appears slightly different every night of its 29.5-day lunar cycle. The Moon’s appearance changes as Earth and the Moon move. Depending on where the Moon is in relation to Earth and the Sun, observers on Earth see only part of the light the Moon reflects from the Sun.

Question
How do the positions of the Sun, the Moon, and Earth cause the phases of the Moon?

Materials
foam ball pencil lamp stool

Safety

Procedure

1. Read and complete a lab safety form.
2. Hold a foam ball that will represent the Moon.
   - Make a handle for the ball by sticking a pencil about two inches into the ball.
   - Your partner will represent a person on Earth. Have your partner sit on a stool and record observations during the activity.
3. Place a lamp on a desk or other flat surface.
   - Remove the shade from the lamp. The lamp represents the Sun.
4. Turn on the lamp and darken the lights in the room.
   - Do not touch the bulb or look directly at it after the lamp is turned on.
5. Position the Earth observer’s stool about 1 m from the Sun.
   - Position the Moon 0.5–1 m from the person on the stool so that the Sun, Earth, and the Moon are in a line.
   - The student holding the Moon holds the Moon so it is completely lit up by the light on one half.
   - The observer records the phase and what the phase looks like in the data table on the next page.
6. Move the Moon clockwise about one-eighth of the way around its “orbit” of Earth. The observer swivels on the stool to face the Moon and records the phase.
7. Continue the Moon’s orbit until the Earth observer has recorded all the Moon’s phases.
8. Return to your positions as the Moon and Earth observer. Choose a part in the Moon’s orbit that you did not model. Predict what the Moon would look like in that position.

Check if your prediction is correct.

9. **Explain** Use your observations to explain how the positions of the Sun, the Moon, and Earth produce the different phases of the Moon.

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**Lab Tips**

- Make sure the observer’s head does not cast a shadow on the Moon.
- The student holding the Moon should hold the pencil so that he or she always stands on the unlit side of the Moon.
Analyze and Conclude

10. The Big Idea Why is half of the Moon always lit?

Why do you usually see only part of the Moon's lit half?

11. Draw Conclusions Based on your observations, why can you not see the Moon from Earth during the new-moon phase?

12. Summarize Which parts of your model were waxing phases, where the Moon looks like it is getting bigger?

Which parts were waning phases, where it looks like the Moon is getting smaller?

13. Think Critically During which phases of the Moon can eclipses occur? Explain.

Communicate Your Results

Create a poster of the results from your lab. Illustrate various positions of the Sun, the Moon, and Earth, and draw the phase of the Moon for each. Include a statement of your hypothesis on the poster.
Phases of the Moon

The Moon appears slightly different every night of its 29.5-day lunar cycle. The Moon’s appearance changes as Earth and the Moon move. Depending on where the Moon is in relation to Earth and the Sun, observers on Earth see only part of the light the Moon reflects from the Sun.

Question
How do the positions of the Sun, the Moon, and Earth cause the phases of the Moon?

Materials
foam ball  pencil  lamp  stool

Safety

Procedure
1. Read and complete a lab safety form.
2. Hold a foam ball that represents the Moon. Make a handle for the ball by inserting a pencil about two inches into the ball. Your partner will represent an observer on Earth. Have your partner sit on a stool and record observations during the activity.
3. Place a lamp on a desk or other flat surface. Remove the shade from the lamp. The lamp represents the Sun.
4. Turn on the lamp and darken the lights in the room.
   \[ \text{Do not touch the bulb or look directly at it after the lamp is turned on.} \]
5. Position the Earth observer’s stool about 1 m from the Sun. Position the Moon 0.5–1 m from the observer so that the Sun, Earth, and the Moon are in a line. The student holding the Moon holds the Moon so it is completely illuminated on one half. The observer records the phase and what the phase looks like. Draw a data table below to record all observations.
Lab B continued

6. Move the Moon clockwise about one-eighth of the way around its “orbit” of Earth. The observer swivels on the stool to face the Moon and records the phase.

7. Continue the Moon's orbit until the Earth observer has recorded all the Moon's phases.

8. Return to your positions as the Moon and Earth observer. Choose a part in the Moon's orbit that you did not model. Predict what the Moon would look like in that position, and check if your prediction is correct.

9. Explain Use your observations to explain how the positions of the Sun, the Moon, and Earth produce the different phases of the Moon.

Lab Tips
- Make sure the observer's head does not cast a shadow on the Moon.
- The student holding the Moon should hold the pencil so that he or she always stands on the unlit side of the Moon.

Analyze and Conclude
10. The Big Idea Why is half of the Moon always lit? Why do you usually see only part of the Moon's lit half?

11. Draw Conclusions Based on your observations, why is the Moon not visible from Earth during the new-moon phase?
12. **Summarize** Which parts of your model were waxing phases? Which parts were waning phases?

13. **Think Critically** During which phases of the Moon can eclipses occur? Explain.

**Communicate Your Results**
Create a poster of the results from your lab. Illustrate various positions of the Sun, the Moon, and Earth, and draw the phase of the Moon for each. Include a statement of your hypothesis on the poster.

**Inquiry Extension**
The Moon is not the only object in the sky that has phases when viewed from Earth. The planets Venus and Mercury also have phases. Research the phases of these planets and create a calendar that shows when the various phases of Venus and Mercury occur.
Understanding Tides

**Directions:** Use the information and data from the Lab Phases of the Moon to perform this lab.

You have observed the phases of the Moon by changing the relative positions of models of the Sun, Earth, and the Moon. Use the skills and knowledge you have gained to examine the relationships of the Sun, Earth, and the Moon more closely. You and a partner will look at tide charts and the phases of the Moon for a month’s worth of days, and you will predict the corresponding positions of the Sun, Earth, and the Moon.

Please note that you must complete Lab B before beginning Lab C. Also, have your teacher approve your design and safety procedures before beginning your experiment.
Chapter Key Concepts Builder

The Sun-Earth-Moon System

End-of-Chapter Practice

Directions: Work with a small group to create a five-minute puppet show for elementary students on one of the concepts presented in the chapter. Here is what you will need to do to complete this activity:

- As a group, make a list of the concepts presented in the chapter. Determine which concept will be used for the puppet show. Decide which type of puppets you will use.

<table>
<thead>
<tr>
<th>Concepts in Chapter:</th>
<th>Type of Puppets:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts for Puppet show:</td>
<td>• Arm puppets</td>
</tr>
<tr>
<td></td>
<td>• Sock puppets</td>
</tr>
<tr>
<td></td>
<td>• Hand puppets</td>
</tr>
<tr>
<td></td>
<td>• Other:</td>
</tr>
</tbody>
</table>

- Then,

<table>
<thead>
<tr>
<th>As a group, decide who will do the following:</th>
<th>Divide the responsibilities for the activity, such as:</th>
<th>List the steps the group will need to take to accomplish this activity. Include time for practicing the puppet show.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• write the script</td>
<td>• creating the puppet stage</td>
<td></td>
</tr>
<tr>
<td>• gather the puppets</td>
<td>• creating the puppets, if necessary</td>
<td></td>
</tr>
<tr>
<td>• gather needed props</td>
<td>• writing the script</td>
<td></td>
</tr>
<tr>
<td>• be the puppeteers</td>
<td>• making arrangements for the puppet show</td>
<td></td>
</tr>
<tr>
<td>• be prop movers or create sound effects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Present the puppet show to your class for suggestions for improvement. Then present it to younger students.

Your puppet show should accomplish the following:

• present the concept in an understandable manner
• give everyone in the group a chance to participate in some way
• be creative
• be interesting