What Causes Shadows?

NSES Content Standard D—Earth and Space Science:
*Objects in the sky have patterns of movement. The Sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons.*

**Objectives**
Students will:
- Observe and make shadows of classroom objects.
- Observe that a shadow moves when the object or the light source moves.
- Observe shadows caused by the Sun.
- Describe a shadow's motion by tracing and measuring its position and length over time.
- Describe patterns of shadow movement.
- Describe changes in shadow size over time.

**Explore**
1. Have children (in pairs) remove the following items from the kit: a flashlight, straw and a small piece of clay (the size of a quarter).

2. Supply children with an assortment of small objects such as a ball, pencil, toy figure, etc.

3. Tell children that these are the materials they will be using in this lesson.

4. Have pairs of children write a brief description of the materials that support this lesson. Have children share these descriptions with the class.

5. Have children sit in a circle and shine the flashlight on the assortment of small objects. As children are exploring, ask questions such as: How is a shadow like the object you used to make it? How is the shadow different from the object? How can you change the sizes of shadows? How can you change the shapes of your shadows? How can you make a shadow move?

6. Children should draw pictures of what they see and note any observations in their Science Journal.

**Teacher Background**
A shadow forms when an object blocks light from the Sun or from an artificial light source. Throughout a sunny day, the shadow of an object blocking sunlight will change position and length. In Lesson 1, children observed objects in the sky. They likely observed that the Sun’s position in the sky changes during the day. Children probably can explain that shadows change because the Sun’s position in the sky changes. At this point, children probably do not know the Sun’s changing position is due to...
Earth’s rotation. This idea will be covered in the next lesson.

In this activity, children will explore making shadows and compare shadows of objects to the object itself. They will also learn how to make shadows move. In addition, they will observe and mark the position of outdoor shadows caused by an object blocking sunlight, in a manner similar to sundials. The shortest outdoor shadows always occur close to twelve o’clock noon during standard time, and close to one o’clock during daylight savings time. Depending on your location in your time zone, the shortest shadow might not occur until nearly 30 minutes after noon or one o’clock.

The longest shadows occur at both sunrise and sunset. In the Northern Hemisphere the shortest possible shadow points due north. At sunrise, shadows point in a westerly direction and at sunset shadows point in an easterly direction.

**Vocabulary Development**

*shadow*

Write the word “shadow” on the board and pronounce it. Ask children if they have ever tried to run away from their shadow. How does their shadow resemble them?

**Common Misconceptions**

Children of this age commonly do not pay attention to changes in shadow length during the day, although they might have made observations that shadows change position. Often children do not realize that when they are standing in the shade on a hot day, they are actually standing in a shadow. Children do not have understanding of the cyclic manner in which shadows change during the year, with the shortest shadows at noontime occurring in June, and the longest noontime shadows occurring in December.

**Real World Connections**

Nearly 3000 years ago, Babylonians used knowledge of changing shadows to make the first known sundials. Sundials are marked in hours and time can be told by the position of a shadow cast by a pointer. Sundials are often seen in parks and outside museums. Ancient astronomers often made calendars based on the Sun’s location in the sky and/or the location of shadows.
Objectives
Students will:
• Observe morning shadows caused by the Sun.
• Describe a shadow’s motion by tracing and measuring its position and length over time.
• Describe patterns of shadow movement during the morning.
• Describe changes in shadow size over time.

Materials
Sun Shadows activity sheet (p. 70), straw, piece of clay, 3–4 heavy objects, pencil, ruler, crayons

Explore
After doing the Explore activity, children will know that shadows are made when light is blocked. Children will observe that shadows have a shape similar to the object used to make the shadow. Children will also observe that a shadow will move if either or both the object and light source moves.

Question
Ask children, “How will an outside shadow change during the morning?”

Prediction
• Ask children to predict how a shadow caused by blocking sunlight will change between the start of school in the morning and noontime.
• Children will record their predictions on the Directed Inquiry activity sheet.

Student Procedure
1. Start the activity as early in the morning as possible (around nine o’clock works well).
2. Have children work with a partner.
3. Give each group a copy of the Sun Shadows activity sheet (see p. 70), a straw, and a small piece of clay (the size of a quarter).
4. Show children how to stick the base of the straw into the piece of clay. Make sure the straw is secure.
5. Go outside and place the Sun Shadows activity sheet on a sunny sidewalk or playground location.
6. The position of the activity sheet should face south. Use the compass rose as a directional guide.
7. Place the piece of clay (with the straw in it) in the circle on the activity sheet.
8. Have children use 3–4 items that will serve as paperweights to hold the paper in place (do this in case the wind moves the paper during the activity).

9. A shadow of the straw will appear on the paper.

10. Have children use a pencil to draw a line along the entire length of the shadow on the paper and write the time on the line.

11. Children should repeat marking the length of the shadow every hour until twelve o’clock noon. (Children should make at least three observations before noon.)

12. Have each pair measure the shadow lengths with a ruler and record their data in the chart on the Directed Inquiry activity sheet.

13. Have children create a bar graph on a piece of graph paper. Tell children that the centimeter axis should be as long as the longest shadow they measured.

**Conclusion**

Ask children questions such as:

- How did the shadows change during the morning?
- Why do you think the shadows changed?*
- Is there a pattern to where the shadows were and their lengths?
- At what time was the shadow the shortest?
- Why do you think the shortest shadow occurred at this time?

**Explanation**

Children should notice that the shadow moved and got shorter each hour. As the Sun’s position in the sky gets higher in the sky during the morning, the shadow gets shorter. Also, as the Sun’s position moves in the sky, the shadow moves in the opposite direction.

**More Questions**

- Ask children, “If you could do this activity again, what would you change?”
- Note the responses on the board. For example, children may suggest conducting the experiment over several days to determine if shadow length and position changes much from day to day.
- The following Guided Inquiry activity exemplifies the procedures a child would follow in order to answer a scientific question.

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* Conclusions not on the activity sheet.
**Objectives**
Students will:

- Observe afternoon shadows caused by the Sun.
- Describe a shadow’s motion by tracing and measuring its position and length over time.
- Describe patterns of shadow movement during the afternoon.
- Describe changes in shadow size over time.

**Materials**
Sun Shadows activity sheet (p. 70), straw, piece of clay, 3–4 heavy objects, pencil, ruler, crayons

Based on the Directed Inquiry activity, children will know that shadows move in a constant direction and get shorter towards noon.

**Question**
Ask children, “How will an outside shadow change during the afternoon?”

**Hypothesis**
- Have children create a hypothesis that predicts how afternoon shadows change.
- Children will record their hypothesis on the Guided Inquiry activity sheet. The hypothesis should read similar to the following: “If a shadow gets (shorter) during the morning, then it will continue to get (shorter) in the afternoon.”

**List of Variables**

- **Manipulated or Independent Variable**—The thing you change. (The time of observation.)
- **Responding or Dependent Variables**—What you observe as a result of the change. (The shadow positions and lengths.)
- **Controlled or Constant Variable**—Everything else is the same. (The location of the Sun Shadows activity sheet and the straw in the piece of clay are the same and they remain in sunlight.)

**Student Procedure**
1. Start the activity as early in the afternoon as possible (around one o’clock would work well).
2. Have children work with a partner.
3. Children should use the same materials used in the Directed Inquiry activity: Sun Shadows activity sheet, a straw, and a small piece of clay (the size of a quarter).
4. Go outside and place the Sun Shadows activity sheet on a sunny sidewalk or playground location.
5. The position of the activity sheet should face south. Use the compass rose as a directional guide.
6. Place the piece of clay (with the straw in it) in the circle on the activity sheet.
7. Use 3–4 items that will serve as paper-weights to hold the paper in place (do this in case the wind moves the paper during the activity).
8. A shadow of the straw will appear on the paper.

9. Use a pencil to draw a line along the entire length of the shadow on the paper and write the time on the line.

10. Repeat marking the shadow every hour until three o’clock if possible. (Children should make at least three observations after twelve o’clock noon.)

11. Have each pair measure the shadow lengths with a ruler and record their data in the chart on the Guided Inquiry activity sheet.

12. Have children create a bar graph on a piece of graph paper. Tell children that the centimeter axis should be as long as the longest shadow they measured.

Conclusion
Ask children questions such as:

• How did the shadows change during the afternoon?

• Why do you think the shadows changed?*

• Is there a pattern to where the shadows were and their lengths?*

• What time in the afternoon was the shadow the longest?

• Why do you think the longest shadow occurred at this time?

• Help children observe how the shadows got shorter during the morning and increased in length in the afternoon by comparing the morning chart and bar graph to the afternoon chart and bar graph. Point out that the shadows were about the same distance apart each hour during the day.

Explanation
Children should notice that the shadow moved and got longer each hour after one o’clock. As the Sun’s position in the sky gets lower in the afternoon, the shadow gets longer. Also as the Sun’s position moves in the sky, the shadow moves in the opposite direction.

More Questions
• Ask children, “If you could do this activity again, what would you change?”

• Note the responses on the board. For example, children may suggest predicting where the next shadow will appear on the paper and its length before each afternoon recording.

Full Inquiry Teacher Notes
Expect a variety of student ideas. Some might suggest experimenting to find out whether or not shadows change the same way every day. Others might want to try the activities again in another month or two. Some might also suggest trying the activity when the Moon is bright in the sky and see if shadows change in a similar way.

Question: How will an outside shadow change during the morning?

Prediction: Predict how a straw shadow changes during the morning:

* Conclusions not on the activity sheet.
Procedure:

1. Get the following materials: Sun Shadows activity sheet, a straw, and a small piece of clay (the size of a quarter).
2. Stick the bottom of the straw into the piece of clay. Make sure the straw doesn’t move.
3. Place the Sun Shadows activity sheet on a sunny sidewalk or playground location.
4. The paper should face south. Use the compass rose on the paper as a guide.
5. Place the piece of clay (with the straw in it) in the circle on the paper.
6. Use 3–4 heavy objects to hold the paper in place.
7. A shadow of the straw will appear on the paper.
8. Use a pencil to draw a line along the entire length of the shadow on the paper.
9. Write the time on the line.
10. Repeat marking the length of the shadow every hour until twelve o’clock noon.

Materials:

- Sun Shadows activity sheet
- straw
- piece of clay
- 3–4 heavy objects
- pencil
- ruler
- crayons
Data Collection: Write the shadow lengths in the chart below.

<table>
<thead>
<tr>
<th>Time</th>
<th>Shadow Length in Centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>nine o’clock</td>
<td></td>
</tr>
<tr>
<td>ten o’clock</td>
<td></td>
</tr>
<tr>
<td>eleven o’clock</td>
<td></td>
</tr>
<tr>
<td>twelve o’clock</td>
<td></td>
</tr>
</tbody>
</table>

Where did the line move to on the paper?

Make a bar graph of the shadow lengths like the one below. Make sure your centimeter side is as long as the longest shadow that you measured. Use different colored crayons for the different times.

Conclusion: Answer these questions.

How did the shadows change during the morning?  

At what time was the shadow the shortest?  

Why do you think the shortest shadow occurred at this time?  

Explanation: State your explanation for these results.  

Name: ________________________________
More Questions:________________________________________________________________________

Question: How will an outside shadow change during the afternoon?

Hypothesis: If __________________________________ then ____________________________________________

What one thing will you change? ____________________

What will you observe or measure? __________________

What variable will you keep the same? _______________

Procedure:
1. Get the following materials: Sun Shadows activity sheet you used in the Directed Inquiry Activity, a straw, and a piece of clay (the size of a quarter).
2. Stick the bottom of the straw into the piece of clay. Make sure the straw doesn’t move.
3. Place the Sun Shadows activity sheet on a sunny sidewalk or playground location.
4. The paper should face south. Use the compass rose on the paper as a guide.

Materials:
- Sun Shadows activity sheet
- straw
- piece of clay
- 3–4 heavy objects
- pencil
- ruler
- crayons

Materials:__________________________________________________________

What one thing will you change? ____________________

What will you observe or measure? __________________

What variable will you keep the same? _______________

Materials:__________________________________________________________
5. Place the piece of clay (with the straw in it) in the circle on the paper.

6. Use 3-4 heavy objects to hold the paper in place.

7. A shadow of the straw will appear on the paper.

8. Use a pencil to draw a line along the entire length of the shadow on the paper.

9. Write the time on the line.

10. Repeat marking the length of the shadow every hour until three o’clock.


**Data Collection:** Record your data in the chart below. Use your recorded data to decide if your hypothesis was correct.

<table>
<thead>
<tr>
<th>Shadow length in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>one o’clock</td>
</tr>
</tbody>
</table>

Where did the line move to on the paper?

Make a bar graph of the shadow lengths like the one below. Make sure your centimeter side is as long as the longest shadow that you measured. Use different colored crayons for the different times.

**Conclusion:** Answer these questions.

How did the shadows change during the afternoon? _____________________________
# Using Scientific Methods

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ask a Question</td>
</tr>
<tr>
<td>2.</td>
<td>Make a Hypothesis</td>
</tr>
<tr>
<td>3.</td>
<td>Control Variables</td>
</tr>
<tr>
<td>4.</td>
<td>Plan and Test Your Hypothesis</td>
</tr>
<tr>
<td>5.</td>
<td>Collect and Record Data</td>
</tr>
<tr>
<td>6.</td>
<td>Conclusions</td>
</tr>
<tr>
<td>7.</td>
<td>Explanations</td>
</tr>
<tr>
<td>8.</td>
<td>More Questions</td>
</tr>
</tbody>
</table>

1. **Ask a Question**
   - Ask an important question.

2. **Make a Hypothesis**
   - State your hypothesis in the form of an *If...then* statement.

3. **Control Variables**
   - List the independent/manipulated variable, the dependent/responding variable, and the controlled/constant variables.

4. **Plan and Test Your Hypothesis**
   - Write the procedure you will follow in order to test your hypothesis.

5. **Collect and Record Data**
   - Decide which form of data collection and record keeping is best suited for your activity.

6. **Conclusions**
   - State your conclusions for the activity.

7. **Explanations**
   - Explain what happened during the activity and why you think this happened.

8. **More Questions**
   - Ask additional questions you wish to investigate.
Question: How will an outside shadow change during the morning?

Steps:

1. Draw a line along the entire length of the shadow on the paper.
2. Write the time on the line.
3. Repeat marking the length of the shadow every hour until twelve o’clock.
4. Measure the shadow lengths with a ruler. Record your data.
5. Make a bar graph of the shadow lengths.
6. Use different colored crayons for the different times.

The paper should face south.
Lesson 2 • Guided Inquiry Activity

**Question:** How will an outside shadow change during the afternoon?

**Hypothesis:** If a shadow gets _________ in the morning, then it will continue to get _________ in the afternoon.

**Steps:**
1. Draw a line along the entire length of the shadow on the paper.
2. Write the time on the line.
3. Repeat marking the length of the shadow every hour until three o’clock.
4. Measure the shadow lengths with a ruler. Record your data.
5. Make a bar graph of the shadow lengths.
6. Use different colored crayons for the different times.
7. The paper should face south.

Materials

- pencil
- piece of clay
- straw
- 3-4 heavy objects
- ruler
- crayons

Sun Shadows activity sheet