Casting Shadows: Exploring the Scale Solar Eclipse

**Subject:** Science  
**Grade Level:** 6th-12th

**Materials:**
- 1 meter (yard) stick
- 1 2.5cm (1 inch) ball on a toothpick
- 1 7mm (1/4 inch) bead on a toothpick
- Binder clips to attach toothpicks to yardstick
- Basketballs
- Pins

**Vocabulary:**
- **Solar eclipse:** A celestial event in which the Moon passes between the Sun and the Earth and blocks all or part of the Sun.
- **Lunar eclipse:** A celestial event in which the Earth passes between the Sun and the Moon and blocks the direct sunlight.
- **Umbra:** The darkest part of a shadow. From within the umbra, the Sun is completely blocked by the Moon as in the case of a total solar eclipse.
- **Penumbra:** The weak or pale part of a shadow. From within the penumbra, the Sun is only partially blocked by the Moon as in the case of a partial solar eclipse.

**Learning Targets:**

Students will be able to:
- Make lunar and solar eclipses using a scale model
- Explain the similarities and differences between a lunar and solar eclipse
- Draw a diagram and write a description of a solar and lunar eclipse

**Lesson Objective(s):**

Students will know that:
- Solar eclipses occur when the Moon is between the Earth and the Sun.
- Lunar eclipses occur when the Earth’s shadow covers the Moon.
- During an eclipse, there are two parts of a shadow: the umbra and the penumbra.

Students will understand that:
- A total solar eclipse can only be seen by people within the umbra; those within the penumbra will see a partial eclipse.
- Lunar eclipses occur more easily because the Moon is within the Earth’s umbra, which is three times as large as the Moon.
- Distance affects our perception of an object’s size.

**ENGAGE (Diagram of Eclipses):** Access prior learning / Stimulate interest / Generate questions

Show the students a diagram of a **solar** and **lunar eclipse**. Ask the students to describe what is happening in each diagram.
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Explain that when the Moon creates a shadow, it does so in two parts, the penumbra and the umbra. People within the penumbra will see a partial eclipse because a partial shadow will be over their part of the world. People within the umbra will see a total solar eclipse.

Likewise, when we see a lunar eclipse, the Moon is within the umbra of the Earth’s shadow. Because the Earth’s umbra is three times as large as the Moon, lunar eclipses occur more easily and anyone who can see the Moon at the time of the eclipse will see the lunar eclipse. During a solar eclipse, however, only a small portion of the Earth will be within the umbra of the Moon’s shadow.

Solar eclipses occur about once every 18 months. However, since the umbra is so small and since the earth is mostly oceans and unpopulated areas, it is rare that many people see one. Lunar eclipses occur at an average rate of 1.5 per year with instances of up to 3 in one year.

EXPLORE (Scale Model): Concrete experiences / Describe hand-on, minds-on activities / Describe appropriate background

*Great for outside

Clip the ball at the 10 cm mark and the bead at the 40 cm mark of the yardsticks. The ball and bead should be clipped about 12 inches apart. Hand out the yardsticks with the ball and the bead already attached.

Explain that the ball represents the Earth, and the bead represents the Moon. The size of the ball and the bead are approximately scale to the actual sizes of the Earth and the Moon.

Using the Sun or a very bright light, ask the students to make a lunar eclipse. They must line up the Earth and Moon to cover the Moon in shadow. Check on them and help them line it up. When they have been successful, ask the group if they found it difficult or not. Lunar eclipses happen much easier than solar eclipses.

Have the students flip the stick around and try to create a solar eclipse, casting the shadow of the bead onto the surface of the ball. This will be quite a bit more challenging. You may need to remind them not to look at the Sun. HINT: by looking at the shadow cast on the ground in front of you, you can line up the ball and bead so that you only see the shadow of the ball. This should get you close to seeing the small shadow of the bead on the ball. Once the students are able to make a solar eclipse, ask them if they thought it was difficult.

Now ask the students to slide the bead down to the 85 cm mark on the meter stick. This spacing of 75 cm represents the scale distance between the Earth and Moon. Ask the students to try to make the solar eclipse happen now. Was it easier to make the solar eclipse happen at this distance? Why or why not?
### EXPLAIN (Compare and Contrast Eclipses): Focus student understanding on concepts / Brief and direct explanation of concepts, skills or abilities

Divide students up into small groups and ask them to compare and contrast the lunar and solar eclipses. As a class, create a collaborative Venn diagram to organize the students’ thoughts. Facilitate student discussion so the diagram includes the key concepts learned from the activities.

- Which type of eclipse occurs more often? Why?
- Which eclipse occurs during the day and which one occurs at night?
- What causes a lunar eclipse?
- What causes a solar eclipse?
- Which type of eclipse is more dangerous to watch and why?
- What object casts a shadow during a solar eclipse? During a lunar eclipse?
- What do both types of eclipses have in common?

### ELABORATE (Perceptions with Basketball & Pin): Confronted with a related, but new activity / Requires transfer of concepts, skills or abilities / Student develops a deeper and broader understanding / Apply to daily life / Introduce vocabulary

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For this activity, the students will discover how distance can affect perceptions of the size of an object. To help the students visualize the sizes and distances of the Moon and Sun, go to a basketball court (indoors or outdoors) or an area with plenty of space. Hold up a basketball and explain that it represents the Sun for this activity. Then hold up a pinhead and explain that it represents the Moon.

Ask one student to hold the basketball at one end of the court and ask another student to stand at the other end of the court and hold a pin just under the basket (approximately 86 feet away). Instruct the student holding the pin to hold it 3 inches away from their eye and try to eclipse the basketball with the head of the pin. This student is looking at the pin and basketball from the Earth’s perspective, so this distance of 3 inches represents the scale distance between the Earth and the Moon. If you have multiple basketballs and pins, have several students perform this activity at once and ask the students to switch positions so everyone can have a chance to eclipse the basketball with the pinhead.

Discuss with the students why you can eclipse a basketball with a pinhead from this distance. Compare this to the eclipse we see from the Earth. Discuss what effect distance has on the perceptions of the size of objects.

### EVALUATE (Drawing Diagrams): Throughout / Used to reveal the adequacy of their understanding / New, but related activity that requires knowledge and abilities developed in the instructional sequence

Ask students to draw a diagram of a solar eclipse and a lunar eclipse and to write a description of each, which should include the terms umbra and penumbra. After students complete their diagrams and descriptions, instruct them to work with a partner to discuss their diagrams. If necessary, ask them to make corrections or add information they left out that their partner may have included.
### Resources:
http://dnr.mo.gov/education/solar-eclipse.htm

### Misconceptions:
- Eclipses happen every year in the same place. (On average, there is a solar eclipse once every 18 months, but the location varies because the Earth and Moon are constantly in motion.)
- The Sun during a solar eclipse is more dangerous than usual. (There is no difference in the Sun’s rays during an eclipse and on a normal day. People usually spend more time looking directly at the Sun during an eclipse, which is dangerous, regardless of the day.)

### Extensions:
- Discuss the different layers and features of the Sun. Ask students to draw diagrams of the Sun, labeling the different parts. Include the corona, solar flare, sunspot, photosphere, chromosphere, core, radiative zone, and convection zone. Discuss why you can see the corona during a total solar eclipse.
- Discuss the reasons why we can observe eclipses on Earth, but they do not occur on any other planet in our solar system.