National Aeronautics and Space Administration

2023 Annular Solar Eclipse US Pinhole Projector Activity

Next Generation Science Standard 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.

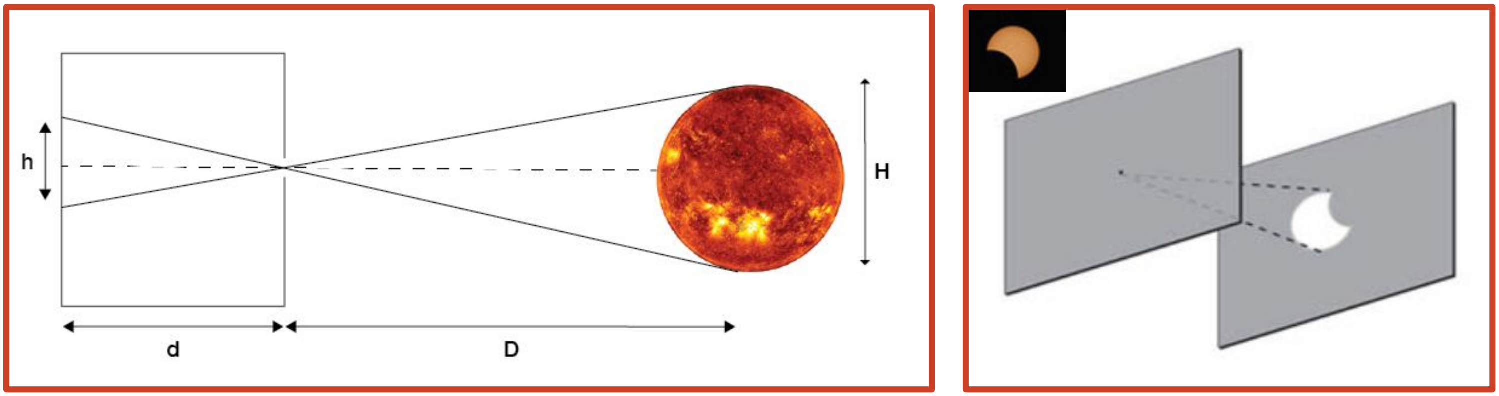
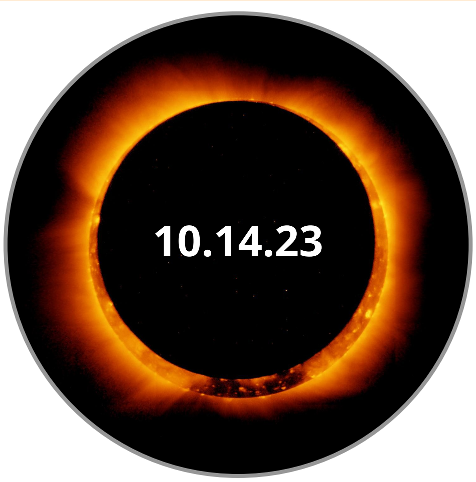


Figure 1. Left diagram shows the relationship between the height of the projected image (h), projection distance (d), distance to the object (D), and the height (diameter) of the Sun (H). See 'Educator Extensions' section for a math equation on how to calculate the Sun's diameter using a pinhole projector. The right diagram shows the shape of the Sun during the partial phase of a solar eclipse through a simple pinhole projector. Credit: NASA

Pinhole projectors allowed early scientists to view the shapes of illuminated objects, like the Sun, by shining the light from the object through a very small hole, projecting the image of the object onto the ground, wall, or other flat surface. Make this easy pinhole projector with your learners, see Figure 2, and have them experiment with the shape and size of the pinhole in this short (25- to 30-minute activity). See educator extensions for more ways to engage your learners.



Credit: JAXA/NASA/SAO/NAOJ

Your back should always be to the Sun when using a pinhole projector. Do NOT look at the Sun through the pinhole!

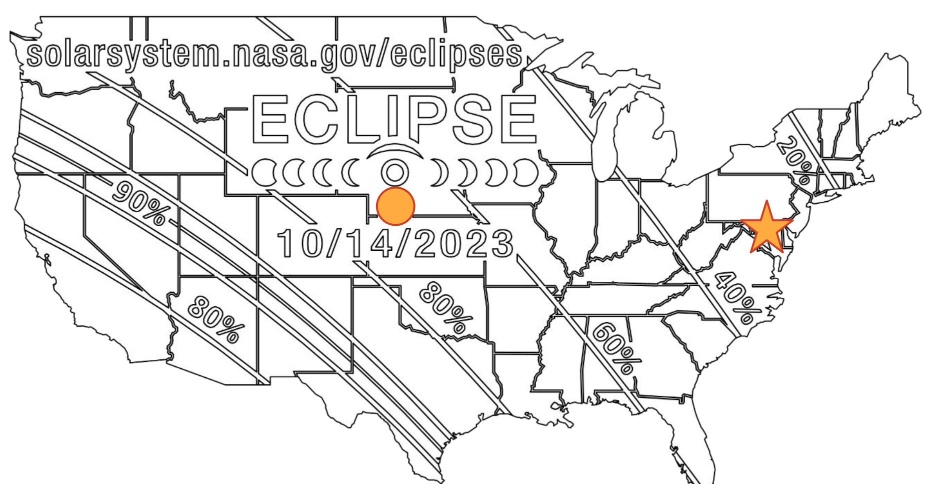


Figure 2. A 2D paper cut US map for the Saturday, October 14, 2023, annular solar eclipse. Not to scale. See Learner Handout. Credit: NASA HEAT/J. Patrick Haas

Remember to never look directly at the Sun without proper safety equipment.

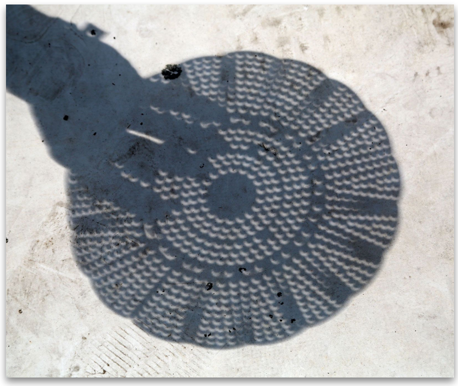
ECLIPSE
2023 THROUGH THE EYES OF NASA

Safety Messaging
Annular Solar Eclipse 10.14.23

Two options for safely viewing a partial or annular solar eclipse:

- Use a pinhole projector or other indirect safe viewing methods.
- Use a solar filter, like solar eclipse glasses.

Indirect Viewing Method: Project images of the Sun using your hands. Credit: AAS



Indirect Viewing Method: Project images of the Sun using a colander. Credit: NASA/Joy Ng

YES!

View the eclipse with special eclipse glasses.

NO!

Regular sunglasses are not safe to view the eclipse.

Direct Viewing Method: Wear solar eclipse glasses. Credit: NASA

Except during the total phase of a total solar eclipse, the Sun is dangerously bright. At all times during an annular or partial solar eclipse, or when no eclipse is occurring at all, view the Sun only through special-purpose solar filters that comply with the transmission requirements of the ISO 12312-2 standard.

Follow these safety guidelines for viewing a annular solar eclipse. Credit: AAS

If you choose to use solar eclipse glasses with your learners, remember that the Sun is never completely blocked by the Moon during an annular solar eclipse. While observing this eclipse, use a filter for the entire duration or utilize an indirect viewing method. People experiencing a partial solar eclipse will also need to wear their solar eclipse glasses for the entire duration of the eclipse.

Learner Handout

Directions:

1. Cut out the 2D paper map in Figure 3 and the box containing 5 different sized circles in Figure 4.
2. Use the **circle** and the **star** hole puncher to punch out the existing shapes in the 2D paper cut map.
3. Use a hole puncher with a shape *other than a circle or star* to punch a hole in the 2D paper cut map somewhere else, such as where you live. Try a **triangle**, **square**, or a **heart**.
4. **Make a prediction!** What shape will the Sun be when it shines through each hole?
5. Standing with your back toward the Sun, hold the map approximately one meter above the ground, out in front of you, to allow sunlight to shine through the holes in the 2D paper cut map onto the ground. Do NOT look at the Sun through the pinhole!
6. Repeat the experiment with the size of the hole using Figure 4.

   Predict: Will the size of the hole affect the projection?

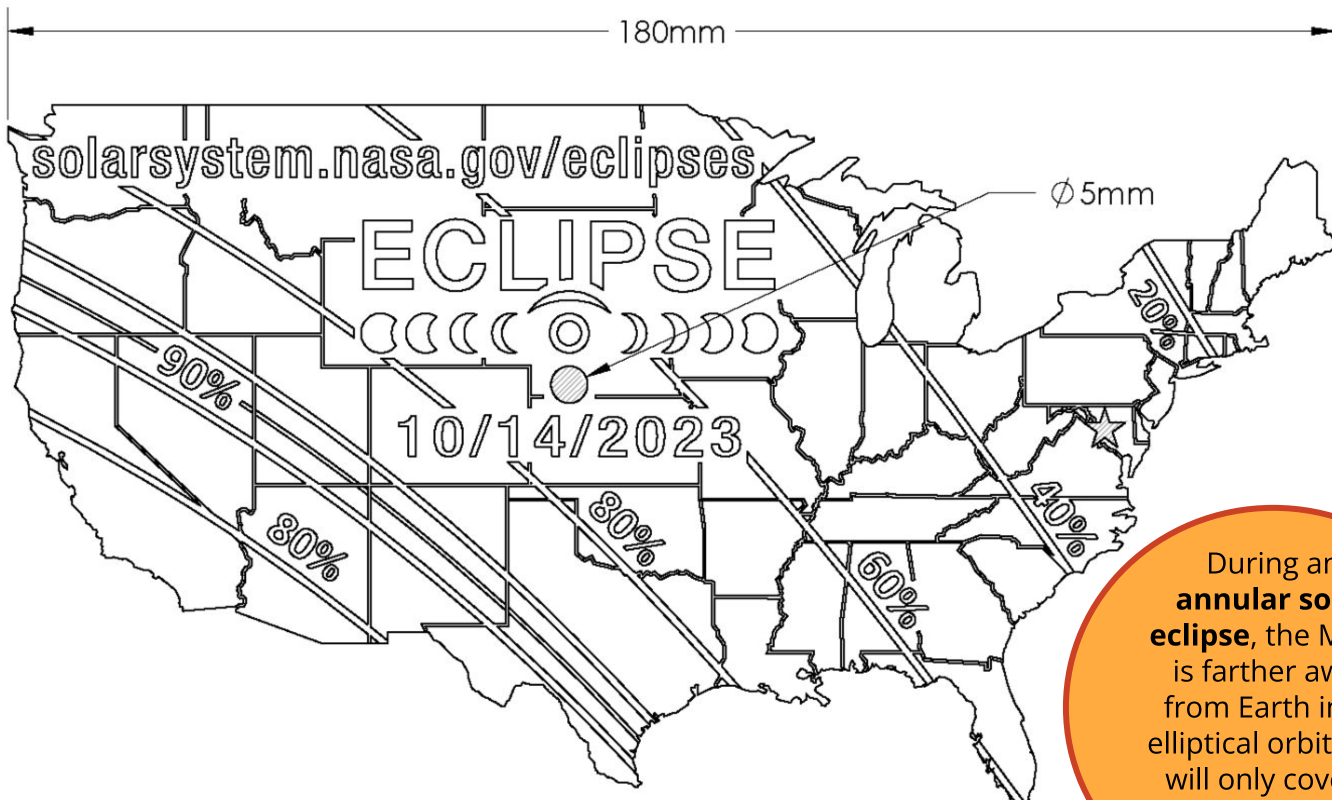


Figure 3: A 2D paper cut US map for the Saturday, October 14, 2023, annular solar eclipse. Credit: NASA HEAT/J. Patrick Haas

During an **annular solar eclipse**, the Moon is farther away from Earth in its elliptical orbit, and will only cover a maximum of 90% of the solar disk.

Materials:

- ❑ Scissors
- ❑ Hole Punchers, 5 mm:
  - ❑ Circle
  - ❑ Star
  - ❑ At least one other shape, e.g., square, triangle, heart

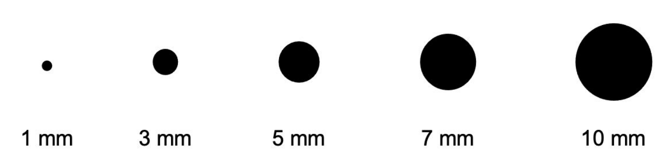


Figure 4: Experiment with sizes by cutting out these different sized circles. Credit: NASA HEAT

Print a 2D paper cut or 3D printed US map pinhole projector using the link below to access files for indirect viewing, or use solar eclipse glasses to view the upcoming annular solar eclipse on Saturday, October 14, 2023!

Remember to never look directly at the Sun without proper safety equipment.

Eclipse Information

solarsystem.nasa.gov/eclipses

ECLIPSE

2023 THROUGH THE EYES OF **NASA**

Pinhole Projector Files

nasa3d.arc.nasa.gov/detail/usa-eclipse-2023

This product is supported by the NASA Heliophysics Education Activation Team (NASA HEAT), part of NASA's Science Activation portfolio.

NP-2023-4-052-GSFC-01

EDUCATOR EXTENSIONS

Math Extension

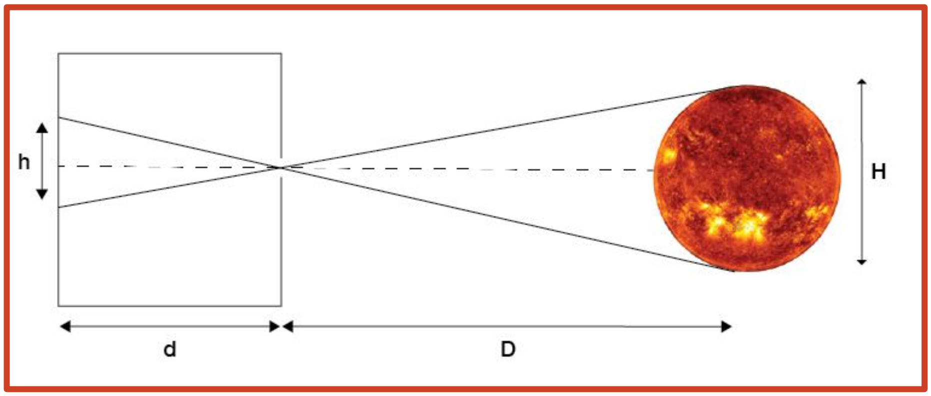
Calculate the diameter of the Sun using measurements taken with a pinhole projector.

Common Core Math Standard 6.RP.A.1 - Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

For a pinhole projector, the relationship between the Sun's height, the Sun's distance from Earth, the projection distance, and projection image height can be expressed as an equivalent ratio:

$$\frac{H}{D} = \frac{h}{d}$$

H = Height of the Sun
D = Distance to the Sun
h = Height of the projected image
d = Projection distance



Relationship between projection image height h, projection distance d, Sun distance D, and Sun height (diameter) H

To calculate height (Diameter) of the Sun (H):

1. **Define (d):** The pinhole projector is held about 1 meter (m) above the ground, which is the projection distance **(d)**.

   (d) = 1m

2. **Define (h):** The hole in your pinhole projector has a diameter of 5 millimeters (mm), creating a projection of the Sun on the ground of about 9mm in diameter, when you hold the pinhole projector 1 meter above the ground. We will use 9mm as the height **(h)** value.

   → To convert millimeters (mm) to meters (m), divide the **(h)** value by 1000.

   (h) = .009m

3. **Define (D):** The average distance from you (on Earth) to the Sun **(D)** is about 150 million kilometers (km), or 1.5 x 10^{11} meters (m).

   (D) = 1.5 x 10^{11} m

4. **Calculate (H):** Using the values for **D, h, and d,** calculate the diameter of the Sun **(H)** using the equation above. *Make sure to use scientific notation. For example, to enter 1.5 x 10^{11} into a computer/smartdevice calculator, type "1.5" [the "EE" button] "11". Or ask your instructor how to use the scientific notation feature on your specific calculator model.

5. **Try it!** Go outside and use your pinhole projector to measure **(d)** and **(h)**. Do you get the same result for **(H)**?

Remember to always keep your back to the Sun when using a pinhole projector. Do NOT look at the Sun through the pinhole!

This product is supported by the NASA Heliophysics Education Activation Team (NASA HEAT), part of NASA's Science Activation portfolio.

Make a Prediction!

Print and cut these prediction slips to encourage your learners to make predictions like NASA scientists do.

Make a prediction by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

The projection of the Sun through the  hole will be in the shape of a - -

The projection of the Sun through the  hole will be in the shape of a - -

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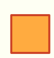
The projection of the Sun through the  hole will be in the shape of a - -

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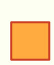
The projection of the Sun through the  hole will be in the shape of a - -

The projection of the Sun through the  hole will be in the shape of a - -

The projection of the Sun through the  hole will be in the shape of a - -

Show What You Know!

Print and cut these assessment slips for a quick, easy way to see what your learners discovered.

Show what you know by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

The projection of the Sun through the ○ hole was in the shape of a - -

The projection of the Sun through the ☆ hole was in the shape of a - -

The projection of the Sun through the □ hole was in the shape of a - -

The projection of the Sun through the △ hole was in the shape of a - -

The projection of the Sun through the ♡ hole was in the shape of a - -

Show what you know by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

The projection of the Sun through the ○ hole was in the shape of a - -

The projection of the Sun through the ☆ hole was in the shape of a - -

The projection of the Sun through the □ hole was in the shape of a - -

The projection of the Sun through the △ hole was in the shape of a - -

The projection of the Sun through the ♡ hole was in the shape of a - -

Show what you know by using hole punchers on the - - lines to show the shape of the projection of the Sun through each hole:

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