The Great American Eclipse 2024

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Target Grade: 5 grade science

Time Required: 60 minutes

Standards

Next Generation Science Standards (NGSS)

- 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.
- MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion year old history.
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Lesson Objectives

Students will

- Illustrate the positions of the sun, moon, and earth during total solar and lunar eclipses.
- Analyze historical instances of solar eclipses and their cultural significance.
- Demonstrate comprehension of eclipse terminology and concepts through discussions and a pre-assessment worksheet.
- Construct a model representing solar and lunar eclipses, explaining the positioning of celestial bodies and phases of the moon.
- Produce a video demonstration of their model, articulating key features of solar and lunar eclipses.
- Engage in critical thinking about eclipse phenomena, considering factors influencing their observation.

Central Focus

Celebrate April 8, 2024, the Great American Eclipse with this lesson plan! This lesson aims to deepen students' understanding of solar and lunar eclipses through hands-on activities, discussions, and explorations of historical and cultural contexts. By examining the positions of celestial bodies during eclipses, constructing models, and analyzing real-life scenarios, students will develop a comprehensive grasp of eclipse phenomena and their significance.

Key terms: pinhole camera, astronomical distances, exponents, math, decimals, space, moon, planets

Background Information

Teacher background information:

An eclipse occurs when the moon passes between the sun and the earth or when the earth passes between the sun and the moon. An eclipse is a natural phenomenon that occurs when one celestial body passes in front of another, blocking its light. There are two types of eclipses: solar and lunar. A solar eclipse occurs when the moon passes between the sun and the earth, blocking the sun's light and casting a shadow on the earth. A lunar eclipse occurs when the earth passes between the sun and the moon, casting a shadow on the moon and making it appear reddish or orange.

Eclipses have been observed and recorded throughout human history, and have often been associated with myths, legends, and superstitions. Different cultures have interpreted eclipses in different ways, with some seeing them as signs of impending doom or disaster, and others seeing them as powerful omens or symbols of rebirth. Students should be aware of the historical and cultural significance of eclipses, and how different cultures have interpreted and understood them.

Pinhole Camera Extension Activity Background

This activity should be done on a sunny day and the students should work in pairs. They will use a simple pinhole camera to project an image of the sun onto a piece of paper and simple math to calculate how large the sun is. Hint: Try to make the distance between the pinhole viewer and the paper as large as possible while still being able to see the image of the sun.

If you would like to test the camera, hold it a few centimeters away from a lit candle with a piece of white paper on the other side of the candle. You should see an image of the flame projected onto the piece of paper. The image of the flame will be upside down.

Student background information:
For this lesson on solar and lunar eclipses, students would benefit from having some background information related to astronomy, celestial bodies, and basic scientific concepts. Here is an overview of the background information students should have:

Basic Astronomy Concepts: Understanding of the solar system, including the positions and movements of the sun, moon, and earth. - Familiarity with terms such as orbit, rotation, and revolution. - Knowledge of the moon's phases and its relationship with the sun and earth.

Terminology: Definitions of key terms such as solar eclipse, lunar eclipse, celestial bodies, phases of the moon, and eclipse path. - Understanding the difference between solar and lunar eclipses and how they occur.

Historical and Cultural Significance: Awareness of how eclipses have been perceived and interpreted throughout history and across different cultures. - Knowledge of famous historical figures or events related to eclipses, such as Thomas Jefferson's observations or ancient civilizations' records.

Safety Precautions: Awareness of the dangers of looking directly at the sun and the importance of using proper eye protection when observing solar eclipses. - Understanding of alternative methods, such as pinhole cameras, for safely viewing eclipses.

Mathematical Concepts (for Extension Activities): Basic understanding of exponents and scientific notation. - Ability to solve simple mathematical problems involving astronomical distances or sizes. By having this background information, students will be better equipped to engage with the lesson content, participate in discussions, and carry out activities related to solar and lunar eclipses. Additionally, it will help them grasp the scientific principles behind eclipses and appreciate their cultural and historical significance.

Materials

Solar and Lunar Eclipse Model (items per group)

- Solar and Lunar Eclipse Model Instruction Packet
- Tape
- Flashlights
- Two empty toilet paper rolls
- Scissors
- Aluminum foil
- Sturdy but bendable wire (about 20 inches)
- Styrofoam ball (the size of an orange)
- Ping pong ball
- A large strip of cardboard (24”x8”)
- Stacks of books or magazines

Instruction

Introduction (20 minutes)

- Ask your students to draw the position of the sun, moon, and earth during a total solar eclipse and a total lunar eclipse.
- Show the videos of the total solar eclipse path for April 8, 2024:
    - https://svs.gsfc.nasa.gov/5219/
- Discuss with students any solar eclipses they have seen or will see soon.
- Explain how solar eclipses have incited fear in civilizations throughout history before they knew the science behind them.
- Discuss some instances and stories of Solar Eclipses throughout history:
    - Thomas Jefferson – http://founders.archives.gov/documents/Jefferson/03-04-02-0217
    - Ancient Civilizations – http://www.windows2universe.org/sun/atmosphere/eclipse_history.html
- Read and discuss the origin myth, "How the Fifth Sun Came to Be."
- Lead a short discussion about eclipses with the following questions:
    - What does solar mean?
    - What does lunar mean?
    - Why did some civilizations fear solar eclipses?
    - What are some fears that you have overcome after you learned the science behind the fear?
    - How could knowledge be powerful in ancient times?
- Provide students with a copy of the Total Solar Eclipse Viewing Path worksheet. Ask them to plot the path of the viewing area during the total solar eclipse that will occur on April 8, 2024.

Explore (20 minutes)

- Divide the class into small groups and provide them with the Solar and Lunar Eclipse Model Instruction Packet and materials.
- Discuss what each object represents in the model and how to build the basic structure for the model.
- Instruct groups to create their model of a solar eclipse and lunar eclipse.
- While students work, ask them the following questions about their model:
    - During a solar eclipse, what would you see if you stood on the moon and looked at the earth?
    - What is the phase of the moon during a solar eclipse?

Explain (10 minutes)

- Ask groups to create a video demonstration of their model of a solar and lunar eclipse. In the demonstration, the students should provide the following information:
    - For the Solar Eclipse
        - What is the placement of the sun, moon, and earth during a solar eclipse?
        - To view, should you look at the moon or sun?
    - For the Lunar Eclipse

        - What is the placement of the sun, moon, and earth during a lunar eclipse?
        - To view, should you look at the sun or moon?
- Once students have finished, instruct them to submit their video.
- Select a few groups to present their video. Provide time for the class to question results and ask follow-up questions.
- Lead a short class discussion on the following questions:
    - How would a solar eclipse change on Earth if the moon was smaller than it is now?
    - What other factors, other than the size of the sun and moon, determine how a solar and lunar eclipse is viewed from the Earth?
    - What would you see if you were on the moon during a solar eclipse?
    - What would you see if you were on the moon during a lunar eclipse?
    - Do eclipses occur on other planets?

Closure (5 minutes)

- Ask your students to redraw the position of the sun, moon, and earth during a total solar eclipse and a total lunar eclipse. This is the same question as the pre-assessment at the beginning of the lesson.

Extension Activities

Pinhole Camera

- Lead a brief conversation to about the dangers of looking at eclipses without proper eye protection.
    - Remind students to never look at the sun directly. It will damage their retinas. There are no pain receptors in the retina, so one cannot feel the damage being done.
- Explain to students they will build a pinhole camera to view the sun, without directly looking at it.
- Provide each student with the Pinhole Camera Instructions and the materials needed.
- Allow students building time.
- Once the cameras are built, take students outside to test out their product.
- Return to the classroom and lead a brief discussion on how the pinhole camera works.
- Show the following video to explain how the camera works: https://youtu.be/dvmRO5IjW_I

Exponents in Space

- Have students work in groups to solve the following math problem: The sun is about 10^{11} meters from Earth. Sirius, another star, is about 10^{17} meters from Earth. How many times farther away from the Earth is Sirius when compared to the sun?
- Discuss with students the answer.
- Instruct students to imagine the sun as the size of a yoga ball, 75cm in diameter. Have students identify objects in the room that would represent the size of the earth.
    - Sun = 1,390,000km

- Yoga ball = 75cm
- Earth = 12,742km
- Answer: 0.7cm (about the size of a pencil eraser)

Differentiation

- Student choice: provide different options for students to design their model, such as creating a drawing, slide show, stop motion, etc.
- Diverse groups: use mixed ability grouping to allow students to work with peers at different levels and challenge each other.
- Additional resources: offer additional resources or readings for students who need extra support or who are more advanced. Encourage students to research eclipses throughout history.
- Alternative communication: offer different ways for students to participate in class discussions, such as writing down their thoughts or sharing their ideas verbally.
- Timing: provide additional timing for components of the lesson plan to provide ample time for all students to complete each task.
- Use small-group instruction to provide targeted support to students who need additional help or to challenge more advanced students.

Assessment

Formative assessments:

- Pre-assessment drawing: This is a pre-assessment that helps the teacher understand what the students already know about eclipses.
- Prior knowledge discussion: This encourages students to share their experiences and knowledge about eclipses, and helps the teacher understand what the students know and what misconceptions they may have.
- Eclipses throughout history discussion: This helps students understand the significance and impact of eclipses throughout history, and how different cultures have interpreted them.
- Model-making probing questions: This helps students think more deeply about the models they are building and apply their knowledge of eclipses to answer specific questions.

Summative assessment:

- Solar and lunar eclipse model: This requires students to apply their knowledge of eclipses and create a video that demonstrates their understanding of the topic.
- Exit ticket: The teacher can use the final model to gauge understanding of the lesson and measure growth between the pre-assessment and exit ticket.

Sources

Components of this lesson plan were adapted from the following sources:

- http://www.jpl.nasa.gov/edu/learn/project/how-to-make-a-pinhole-camera/
- http://www.unawe.org/activity/eu-unawe1302

- https://www.nasa.gov/mission_pages/sdo/news/solarballet2.html#V5sJ22iAOkoNASA/SDO/SteeleHill
- http://www.nextgenscience.org/sites/default/files/Appendix-L_CSS Math Connections 06_03_13.pdf

This lesson was originally written for the 2017 eclipse and revised for 2024.

Charting the Total Solar Eclipse Viewing Path

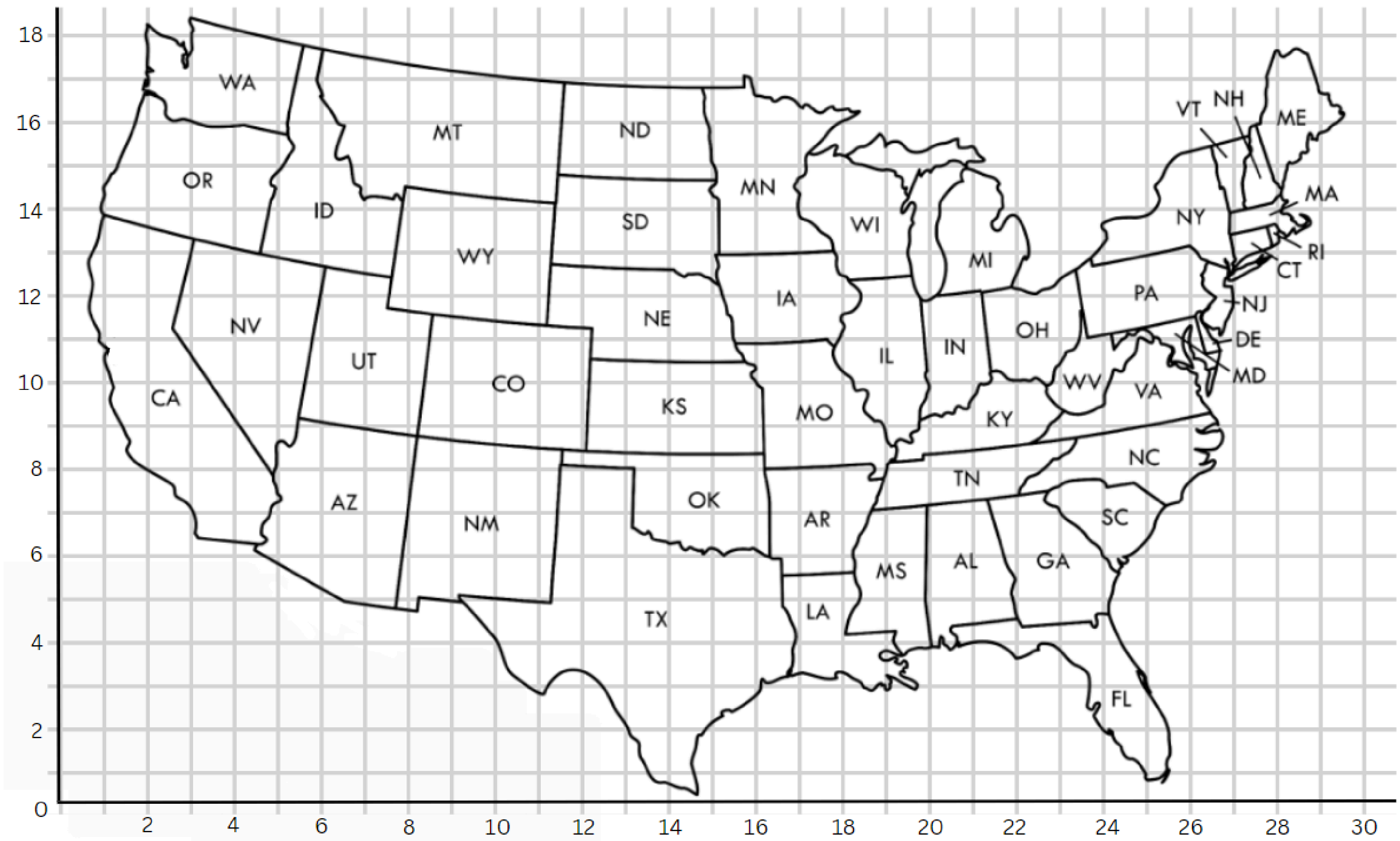


Chart the path of the viewing area of the total solar eclipse that will occur on April 8, 2024.

Time of Viewing	(X,Y) Coordinates	Location
1:42 p.m. CDT	(15,5)	Dallas, Texas
1:47 p.m. CDT	(16,6	Idabel, Oklahoma
1:52 p.m. CDT	(17.5, 7)	Little Rock, Arkansas
1:52 p.m. CDT	(18, 8.5)	Poplar Bluff, Missouri

Question: What patterns do you see with the X and Y axes?

Time of Viewing	(X,Y) Coordinates	Location
2:04 p.m. CDT	(20.5, 9.5)	Evansville, Indiana
3:15 p.m. EDT	(22.5, 12)	Cleveland, Ohio
3:18 p.m. EDT	(23.5, 12.5)	Erie, Pennsylvania
3:20 p.m. EDT	(25, 14)	Buffalo, New York

Question: Based on the data you have plotted, estimate where and when the total solar eclipse will be viewable in Burlington, Vermont. Burlington is close to the top of Vermont.

Solar and Lunar Eclipse Model Instructions

Materials:

- Tape
- Flashlights
- Two empty toilet paper rolls
- Scissors
- Aluminum foil
- Sturdy but bendable wire (about 20 inches)
- Styrofoam ball (the size of an orange)
- Ping pong ball
- A large strip of cardboard (24”x8”)
- Stacks of books or magazines

Instructions

1. Take one cardboard tube and make a series of small (2 cm deep), even, vertical cuts around the circumference of each end.

2. Bend the cut pieces out at each end and stand the tube upright; the cut edges should fan out like a flower.

3. Fasten one end of the cardboard tube to the cardboard strip with adhesive tape to create the base of the model, ensuring the tube is at least 30 cm from one end of the cardboard strip.

4. Using adhesive tape, fasten one end of the cardboard tube to the cardboard strip to create the base of the model. The tube should be at least 30cm from one end of the cardboard strip.

5. Attach the larger ball to the top of the tube using tape or glue; this ball represents the Earth.

6. Cover the smaller ball with aluminum foil, shiny side out; this will represent the Moon.

7. Insert one end of the wire into the top of the Earth so that the wire stands vertically.

8. Measure approximately a finger’s length along the wire and bend it at a right angle to create a horizontal arm.

9. About halfway between the Earth and the far end of the cardboard strip, measure a finger’s length along the wire and bend it downwards at a right angle, towards the cardboard base.

10. Insert the other end of the wire into the Moon, ensuring the Moon's equator is at the same height as the Earth’s equator

Video Creation

11. Use the model and film a video to demonstrate solar and lunar eclipses:
    a. For a solar eclipse: Stand facing the flashlight and swing the wire around until the Moon casts a shadow on the Earth; dim the lights in the room if necessary. Show how the shadow moves by slowly rotating the wire.

    b. For a lunar eclipse: Stand facing the flashlight and swing the wire so that the Moon is behind the Earth, ensuring no light hits the Moon, demonstrating the Earth casting a shadow over the Moon.

Insert link for final video:

Pinhole Camera Instruction

Materials

- Card stock (2 pieces)
- Aluminum foil
- Tape
- Pin, paper clip, or pencil

Safety note:

Your pinhole camera will let you see an image of the Sun that is safe to look at. Never look at the sun directly. It will damage your retinas. There are no pain receptors in your retina, so you will not feel the damage being done.

Instructions

1. Cut a 1-inch to 2-inch square or rectangular hole in the middle of one of the pieces of cardstock.

2. Tape a piece of aluminum foil over the hole.

3. Flip over your paper and use your pin, paper clip, or pencil to poke a small hole in the aluminum foil.

4. Place your second piece of cardstock on the ground and hold the piece with aluminum foil above it (foil facing up). Stand with the Sun behind you and view the projected image on the card stock below! The farther away you hold your camera, the bigger your projected image will be. To make your projection a bit more defined, try putting the bottom piece of cardstock in a shadowed area while you hold the other piece in the sunlight.

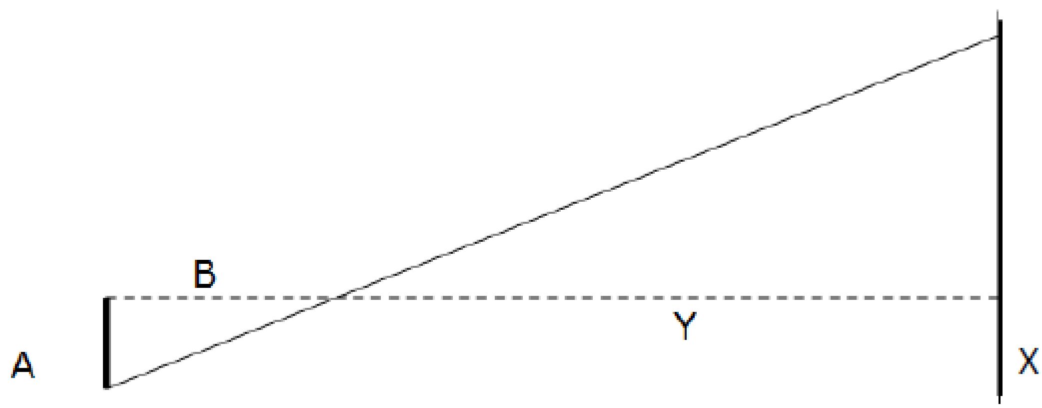
Measurements

1. Using your ruler, measure the following:
   a. The distance from the pinhole (in the foil) to the white paper

   b. The diameter of the image of the sun on the paper

2. There is a mathematical law, which states,

$A=X$
$B=Y$



The diameter of the sun can be calculated using this ratio. In our Situation,

A = the size of the projected image of the sun
B = the distance between the pinhole and the paper
X = the size of the sun
Y = the distance between the pinhole and the sun (140 million km)

The accepted diameter of the sun is $1.4x10^6$ km (1.4 million km)

Write out the equation so that the diameter of the sun is equal to $1.4x10^6$ km