# My NASA Data - Lesson Plans Modeling Solar Eclipse Geometry

## **Grade Band**

- 6-8
- 9-12

## **Time**

50 minutes

#### **Overview**

In this activity, students will model the geometry of solar eclipses by plotting a few points on a piece of graph paper, and using quarters and a nickel to represent the Sun and Moon (not to scale). The goal for this activity is to visually show how the Sun and Moon move near the eclipse season and how the timing of their arrival determines whether you have a total eclipse, a partial solar eclipse, or no eclipse at all. Learners will create a graph for all three.

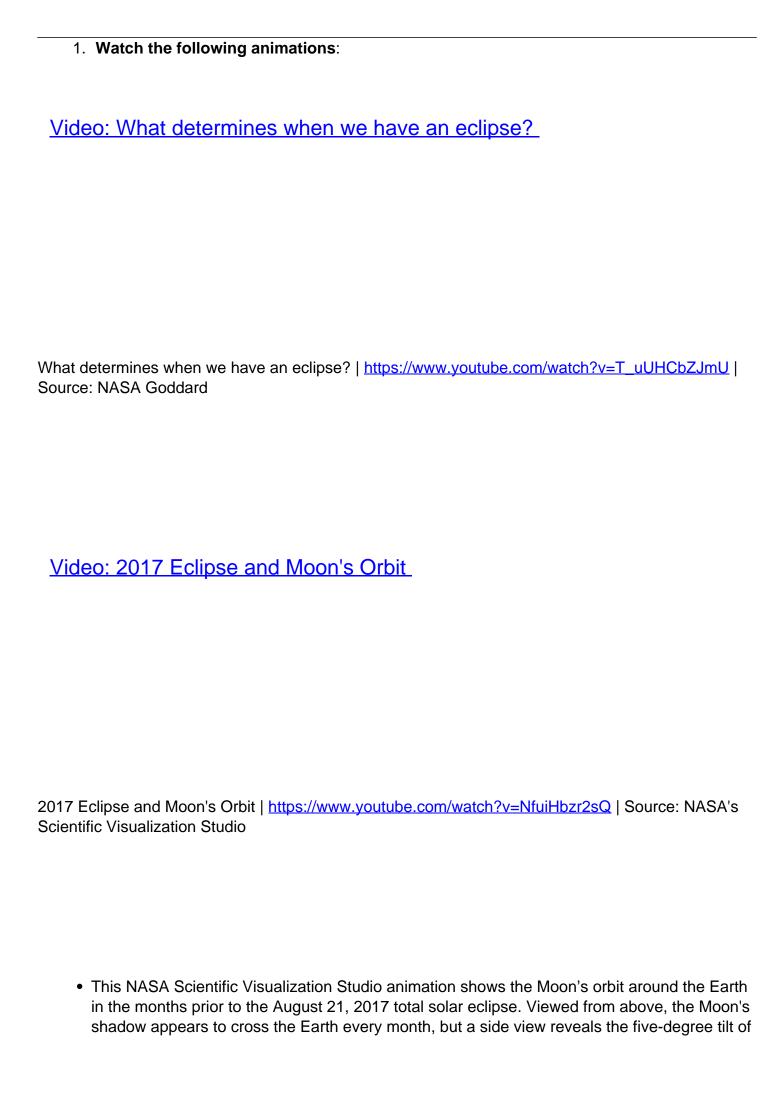
# **Materials Required**

- 1 sheet of 8.5 x 11 graph paper
- 2 disks approximately the size of a quarter, one to represent the Sun and one to represent the Moon at perigee
- One disk approximately the size of a nickel, to represent the Moon at apogee
- Pencil
- Ruler
- Optional Modeling Solar Eclipse Geometry Google Doc OR PDF student sheets.

Teachers who are interested in receiving the answer key, please complete the <u>Teacher Key Request</u> and <u>Verification Form</u>. We verify that requestors are teachers prior to sending access to the answer keys as we've had many students try to pass as teachers to gain access.

## **Procedure**

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



the Moon's orbit. The tilt causes the Moon's shadow to miss the Earth during most New Moons, about five out of six.

- What is an eclipse season?
  - We know that the frequency of eclipses are based on a lot of different factors.
  - The shape of the Moon's elliptical orbit
  - The five-degree tilt of the Moon's orbit
  - Because of the Moon's elliptical orbit, it is sometimes farther from Earth (farthest at apogee) and sometimes closer (closest at perigee).
  - Another factor is the shape of the elliptical orbit of the Earth-Moon System around the Sun. The only time eclipses can occur is around the time of the equinoxes, around March and September. This window when eclipses can occur is about 40 days wide and is known as "eclipse season."
  - But we still don't have an eclipse every equinox because it is all a matter of timing.
     Sometimes, even though the path of the Moon crosses the path of the Sun in the sky, the Moon is either too early or too late to have them overlap.
- Types of Solar Eclipses
  - A total eclipse occurs when the entire Sun is in the Moon's shadow and only the corona can be seen.
  - A partial eclipse occurs when the only part of the Sun is in the Moon's shadow.
  - An annular eclipse occurs when the Moon's shadow is centered on the Sun and the Sun shows up as a ring around the shadow.



Total Solar Eclipse

Annular Solar Edipse

Partial Solar Eclipse

From left to right, these images show a total solar eclipse, annular solar eclipse, and partial solar eclipse. A hybrid eclipse appears as either a total or an annular eclipse (the left and middle images), depending on the observer's location.

Credits: Total eclipse (left): NASA/MSFC/Joseph Matus; annular eclipse (center): NASA/Bill Dunford; partial eclipse (right): NASA/Bill Ingalls

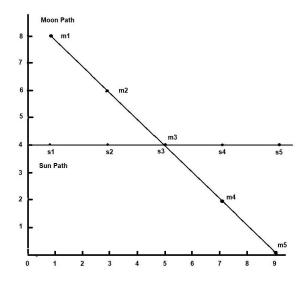
https://mynasadata.larc.nasa.gov/sites/default/files/inline-images/Eclipse%20type%20images 4.png

- 1. Modeling an eclipse: We can demonstrate the geometry and timing of this by just plotting a few points on a piece of graph paper, and using quarters and a nickel to represent the Sun and Moon (not to scale). Depending on the location of the observer on Earth, you may experience a total solar eclipse, a partial solar eclipse, or no eclipse at all. This depends on if the Moon and the Sun cross paths at the same time in the sky and the location of the Moon in its orbit.
  - Set up your graph:
    - 1. We will only be plotting in Q1 so use the entire graph paper for that guadrant.
    - 2. Mark the Origin (0,0) and use the ruler to draw the respective X and Y axis lines.
    - 3. Mark every other line and number the axes 1, 2, 3... up to 10.
  - Model 1 Moon at Perigee

Perigee is where the Moon is closest to Earth in its orbit. Use the quarter-sized disks to represent the Sun and Moon, as the Moon appears bigger in the sky at perigee.

- 1. Plot the following 5 points for the Sun's path:
  - Sun 1: (1,4)
  - Sun 2: (3,4)
  - Sun 3: (5,4)
  - Sun 4: (7,4)
  - Sun 5: (9,4)
- 2. Label the points respectively: s1, s2, s3, s4, s5.
- 3. Use the ruler ruler to draw a straight line through the points. Label this line 'Sun Path'
- 4. Plot the following 5 points for the Moon's path:
  - Moon 1: (1,8)
  - Moon 2: (3,6)
  - Moon 3: (5,4)
  - Moon 4: (7,2)

- Moon 5: (9,0)
- 5. Label the plots respectively, m1,m2,m3,m4,m5.
- 6. Use the ruler to draw a straight line through the points. Label this line 'Moon Path'



'Moon and Sun Paths' mathematical model graph. Credit: NASA

- 7. Place the disk representing the Sun on s1 of the Sun path, and the disk representing the Moon on m1 of the Moon path.
- 8. Move both disks simultaneously from s1 to s2 and m1 to m2.
- 9. Then from s2 to s3 and m2 to m3.
- 10. Then from s3 to s4 and m3 to m4.
- 11. Then from point s4 to s5 and m4 to m5.
- 12. Record your observations at each point in the Data Table 1.

Data Table 1			
Point	Does an eclipse occur? Total or Partial?	Reasoning	
(s1, m1)			
(s2, m2)			
(s3, m3)			
(s4, m4)			
(s5, m5)			

## Model 2 - Moon at Apogee

- 1. Repeat the steps from Model 1, using the nickel-sized disk for the Moon this time.
- 2. Record your observations at each point in Data Table 2.

Data Table 2			
Point	Does an eclipse occur? Total or Partial?	Reasoning	
(s1, m1)			
(s2, m2)			
(s3, m3)			
(s4, m4)			
(s5, m5)			

## • Model 3 - Other positions

Sometimes, even though the path of the Moon crosses the path of the Sun in the sky, the Moon is either too early or too late to have them overlap. Use the quarter-sized disk for the Moon.

- 1. Place the Sun at point: s1.
- 2. Place the Moon at point: m2.
- 3. Move both disks simultaneously from s1 to s2 and m2 to m3.
- 4. Then from s2 to s3 and m3 to m4.
- 5. Then from s3 to s4 and m4 to m5.
- 6. Record your observations at each point in Data Table 3.

Data Table 3			
Point	Does an eclipse occur? Total or Partial?	Reasoning	
(s1, m2)			
(s2, m3)			
(s3, m4)			
(s4, m5)			

- 2. Now that you have graphed your data, answer the following questions.
  - 1. In order for a total eclipse to occur, describe the position of the Sun, Earth, and Moon.
  - 2. Explain what factors need to be in place for a total eclipse to occur
  - Describe the position of the Sun, Earth, and Moon in order for a partial eclipse to occur

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## Sources:

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# **NGSS Three Dimensional Learning**

## **NGSS Disciplinary Core Ideas**

ESS1B: Earth and the Solar System

## **NGSS Crosscutting Concepts**

Cause and Effect

## **NGSS Science and Engineering Practices**

Analyzing and Interpreting Data

## **Learning Objectives**

Students will be able to model the tilt of the Earth-Moon orbital plane

## **Essential Questions**

What conditions are needed for a total or partial solar eclipse?

# **Student Resources**

• <u>Modeling Solar Eclipse Geometry Student Sheets</u>

# **Google Docs Interactive Files**

Modeling Solar Eclipse Geometry - Student Sheets