2017 Eclipse: Research-Based Teaching Resources

Lecture Tutorial: Modeling Eclipses

Description: This guided inquiry paper-and-pencil activity helps students to understand the geometry of solar eclipses by drawing proportional sketches of the Earth and Moon system from various perspectives. This resource is designed to supplement *Lecture-Tutorials for Introductory Astronomy* for lecture-style classrooms.

Prerequisite:

- Understand the phases of the moon.

This resource was developed by J. Bailey, R. Vieyra, and S. Willoughby. The co-authors acknowledge useful discussions with B. Ambrose, X. Cid, and R. Lopez, and the support of a subcontract from the NASA Heliophysics Education Consortium to Temple University and the AAPT under NASA Grant/Cooperative Agreement Number NNX16AR36A.

Learning Sequence:

Section 1: Drawing a Scale Model

If the Earth-Moon distance is 510 mm, then:

The Moon is 4.6 mm diameter

Earth is 17 mm diameter

1. On the back of two sheets of paper, draw out Earth, the Moon, and the proper distance between them using the scale above.

2. The Sun is about 400 times farther from Earth compared to the Earth-Moon distance. Using the scale you just drew, how far away would the Sun be located from Earth?

Section 2: Considering Solar Eclipses

3. A solar eclipse can occur when the Sun, Earth, and Moon are all within a plane, such as this piece of paper. Is it the case that one of these objects is not always in the plane of the paper? If so, which object? Why?

4. Because an eclipse requires all three objects to be in one plane, we can consider two of the objects at a time. First consider the plane made by Earth and the Moon. This is the plane you have created in Section 1. Next consider the plane made by Earth and the Sun. This is the plane that is typically considered when determining when a solar eclipse can occur.
   a. How do these two planes need to align for an eclipse to be visible from Earth? (A sketch might be useful.)

   b. Is this answer consistent with your response to question 3?

This resource was developed by J. Bailey, R. Vieyra, and S. Willoughby. The co-authors acknowledge useful discussions with B. Ambrose, X. Cid, and R. Lopez, and the support of a subcontract from the NASA Heliophysics Education Consortium to Temple University and the AAPT under NASA Grant/Cooperative Agreement Number NNX16AR36A.

5. Consider the following conversation between students regarding eclipses.

   Student #1 - Earth is in the plane created by the Moon and the Sun. Because all three objects are within the plane of the paper, eclipses occur whenever the Moon is between Earth and the Sun.

   Student #2 - Well, I don't think that's quite right. I think that the Moon is typically not in the plane created by the Sun and Earth, and that's why we don't have a solar eclipse every month.

   Student #3 - The Sun is really far away from Earth compared to the Moon. Because of that large distance, it is really unlikely for the Sun to line up perfectly with the Moon and Earth so that the Moon casts a shadow on Earth's surface. The shadow must be tiny because of the big distances.

   With which student(s) do you agree? With which student(s) do you disagree? Explain your reasoning.

6. The Moon's orbit is tilted at about 5 degrees with respect to the plane formed by Earth and the Sun. Draw a scale model of this as viewed from the solar system edge-on. To make it all fit on one piece of paper, use a scale that is ½ of the scale used in question 1. In other words, take the scale that you used before and divide each value by 2.

   a. New Earth Diameter_____

   b. New Moon Diameter_____

   c. New Earth-Moon distance_____

   d. New Earth-Sun distance_____

This resource was developed by J. Bailey, R. Vieyra, and S. Willoughby. The co-authors acknowledge useful discussions with B. Ambrose, X. Cid, and R. Lopez, and the support of a subcontract from the NASA Heliophysics Education Consortium to Temple University and the AAPT under NASA Grant/Cooperative Agreement Number NNX16AR36A.

7. Draw in this space, making sure you include the tilt of the Moon's orbit in this edge-on view.

8. Describe in your own words why solar eclipses do not occur each month. Include a description based on just the alignment of the three bodies, as well as a discussion about the two planes discussed in Section

This resource was developed by J. Bailey, R. Vieyra, and S. Willoughby. The co-authors acknowledge useful discussions with B. Ambrose, X. Cid, and R. Lopez, and the support of a subcontract from the NASA Heliophysics Education Consortium to Temple University and the AAPT under NASA Grant/Cooperative Agreement Number NNX16AR36A.