ThinkSpace | Eclipses Curriculum

CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

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Overview

This 1-session lesson uses a blend of hands-on models and computer visualizations to help students understand what causes Eclipses. The visualizations are presented using WorldWide Telescope (WWT), a free program that aggregates imagery from the world's most powerful telescopes into a seamless view of the night sky, and offers realistic 3-D views of our solar system, galaxy, and cosmos. The WWT media give students an overview of how the Moon, Earth, and Sun move relative to each other. The hands on and WWT-based activities then help students to connect our Earth-based views of the Moon, to space-based views of the Earth-Moon-Sun system. The goal is to help students visualize and understand why eclipses do not happen every month, and what Sun-Earth-Moon configurations lead to solar and lunar eclipses.

Students will be able to:

- Explain how the Moon's tilted orbit prevents eclipses from happening every month (by raising or lowering the Moon above or below the Earth-Sun line).
    - Because the Moon's orbit is tilted slightly, and because the Moon is far away, Earth rarely blocks sunlight from hitting Moon.
- Explain under what circumstances eclipses can occur
    - If the line of orbital nodes points (this is demonstrated with a hula hoop model - "line of orbital nodes" is not language used with middle school students) toward the Sun, you will get eclipses. This can only happen twice a year.
- Explain the difference between solar and lunar eclipses

SESSION 3: Eclipses

Total Class Time: 45-50min

Activity Sheets (for each student) : Eclipses

Lesson Goals

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- Students can explain the difference between solar and lunar eclipses

Materials

Physical Model

- Lantern/lamp (with shade removed)
- Extension cord if necessary
- Tape to secure loose power cords to the floor. Gaffer's tape works particularly well, but duct tape is fine too.
- 1.5" foam Moon on a dowel or toothpick (for instructor demo)
- Hula hoop

Virtual Model

- Computer to project Session 3 instructional videos
- Projector/Screen
- Speakers

Classroom Setup

- Set up lamp (without a shade) to represent the Sun in the middle of the room.
    - NOTE: The lantern needs to be the only source of light in the room in order for the foam moon and lamp model to work properly. If shades do not adequately darken the room, you may need to tape cardboard or black garbage bags to the windows.
- Tape down any loose power cords on the floor to prevent tripping.
- Connect instructor's computer to projector/screen and speakers.
- Link instructor computer to Session 3 instructional videos.

Materials	Format	Day 1 | Lesson Outline
		1.A 10min
	Teacher Leads Class Discussion (15 min)	**Discussion | Moon Phases vs. Eclipses** 1. Recap Moon Phases. ● Remind students of the four steps for connecting space-based (overhead) perspectives of the Moon to their Earth-based perspective counterparts to predict what phase an Earth-based viewer would see, given an Earth-Sun-Moon scenario. ● Why do we see the phases of the Moon change throughout a month? < as the Moon orbits the Earth, different amounts of the lit up part of the Moon face Earth > 2. What are eclipses? ● Have you heard of eclipses before? What kinds of eclipses do you know about? (It helps to write these terms on the board) ○ Eclipse - something is blocking something else. ○ Solar Eclipse - something is blocking the Sun. ■ If we (people on Earth) are looking at the Sun, what in space could block the Sun from our view? < the Moon > ○ Lunar Eclipse - something is blocking the Moon ■ What did we see blocking the Moon in our lunar cycle model? < the Earth > 3. Phases vs. Eclipses ● An all-too-common misconception among students (and adults who haven't taken middle school astronomy in a while) is that the phases of the Moon are caused by the Earth blocking light from the Sun that would otherwise hit the Moon. Here we look at how often the Earth actually blocks the Moon and when it could happen. ● How often do you think Earth actually blocks light from getting to the Moon? ● When we used the foam ball + lamp to model a full lunar cycle, did any students have trouble making a full moon? What happened, and what did you do to solve it? ○ *After you pass a waxing Gibbous Moon, the model Moon gets blocked by Earth (your head's) shadow. You can make a full Moon by lifting the Moon higher than your head, so Earth's shadow doesn't fall on the Moon.* ● **Why doesn't this happen to the real life Moon? (i.e., how do we ever get full Moons, or why don't eclipses happen every month?)**

1.B 20min

Materials

- Hula hoop
- Lamp/lantern
- Foam moon

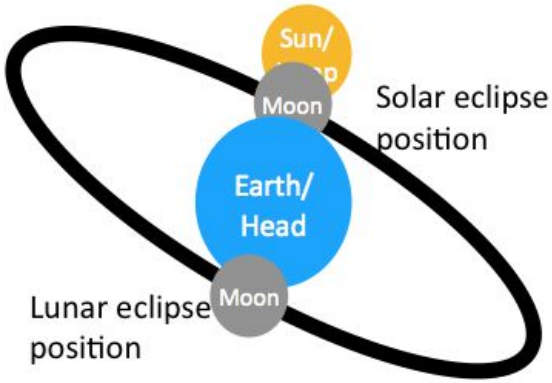
Physical Model
Instructor Demo

Physical Modeling | The Moon's Axis and Eclipses

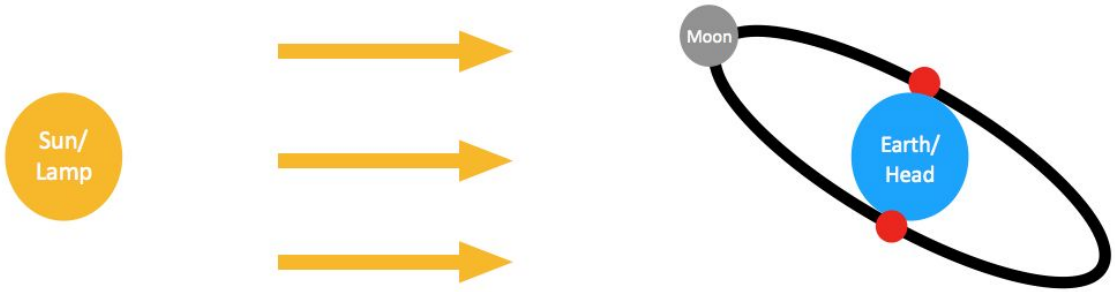
4. The Moon's Tilted Orbit
   - Take the hula hoop and hold it around your (the instructor's) head, with your head at the center. Your head represents the Earth, and the hula hoop represents the Moon's orbit. The Sun is represented by the lamp in the middle of the room.
   - Show with the hula hoop that the Moon's orbit is tilted. (For this demo, put the high side of the hula hoop orbit at the "full moon" location and the low side of the orbit at the "new moon" location, as in the diagram below). When the Moon is in the full moon position, it is above the Earth-Sun line and does not get blocked by the Earth, so you get a full Moon.
     - (In the diagram, the red dots represent where you should hold the hula hoop with your hands. If you imagine a line connecting those red dots, that is what is known as the "line of nodes." Students don't need to be familiar with that vocabulary. We just need the language to describe the demo below).

   - To make this demo work, you have to hold the hula hoop at an awkwardly large angle, about 45 degrees. The real life Moon's orbit is not tilted that much. It is only tilted by about 5 degrees.
   - Ask students - how can the real life Moon not be blocked by the Earth if the orbit tilt is only 5 degrees?
     - *Remember to consider the scale. If the Earth were 6" in diameter, the moon's orbit should be 15' in radius, or 30' in diameter. The hula hoop representing the Moon's orbit would be too big to fit in the classroom. At the correct scale, a 5 degree tilt would be enough to lift the Moon above the Earth-Sun line.*

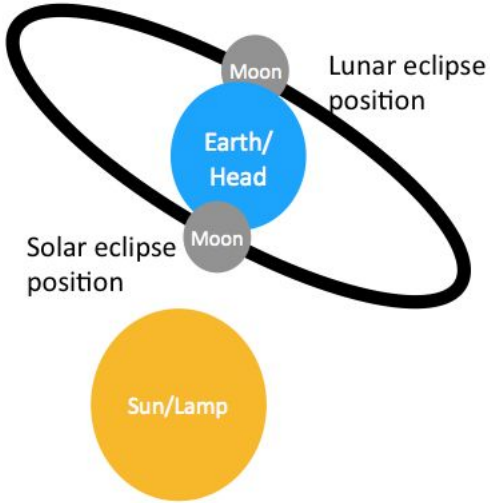
5. When Can Eclipses Happen?
   - Ask students to consider - when can eclipses happen?
   - While you are still holding the hula hoop to represent the Moon's orbit around Earth (your head), start orbiting around the Sun slowly, being sure to hold the hula hoop with the orbital line of nodes pointing in the same direction consistently (in the same way that the Earth's tilt always points in the same direction). Ask students to tell you to stop when you reach a time of year when eclipses might happen.
   - Orbit to a location 3 months later, when line of nodes should be pointing right at the Sun.



   - Students will usually tell you to stop here.
     - Consider: what happens at the new moon position when the Earth is at this location?
       - *< Moon blocks sun - solar eclipse >*
     - Continue to orbit Moon around hula hoop. What happens at the full moon position at this Earth location?
       - *< Earth blocks Moon - lunar eclipse >*
   - Keep orbiting Earth. Is there another time of year when eclipses could happen?
     - *Sometimes students will stop you 3 months later. Show that this is not an eclipse season. The Moon is below the Earth-Sun line at full moon and above the Earth-Sun line at new moon*



- *At the point that is 6 months after the previous eclipse season, you can get eclipses.* Demonstrate the lunar cycle at this 2nd point.



- Consider: what happens at the new moon position when the Earth is at this location?
  - *< Moon blocks sun - solar eclipse >*
- Continue to orbit Moon around hula hoop. What happens at the full moon position at this Earth location?
  - *< Earth blocks Moon - lunar eclipse >*

	Teacher Leads Class Discussion	**Recap | Eclipses** 6. Frequency of Eclipses ● How often can eclipses happen? ○ *< 6 months apart, and twice a year. Eclipses only happen when the line of nodes – that is, the axis of the Moon's tilted orbit – is oriented along the Earth/Sun line >*
1.C 15min		
WWT Eclipse Video Segment	**WWT Video on computers**	**Video | Eclipses** 7. Eclipse Video ● Students watch the WWT instructional video that covers eclipses. There are no questions or prompts for students to perform any tasks during this segment, but the information will be relevant to the Activity Sheet questions that students will complete next.
Activity Sheets (one per student)	**Activity Sheet**	**Activity Sheet | Question #1** 8. Students use the information, concepts and skills they've learned over the full three days to complete all pages of the Activity Sheet. ● (Answer key for teachers) 1a. Moon 1b. Sun 2i. A 2ii. New 2iii. C 2iv. Full 3a. Ruby. Lunar eclipses do not happen every month. The Moon's orbit is tilted, and the Moon is far away from Earth, so the Moon is almost always a little bit above or below a line connecting the Earth and the Sun. Because of this, the Earth usually does not block the Sun's light from reaching the Earth, and we see a full Moon almost every month. Twice a year, it is possible to get a lunar eclipse.

		3b. 

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