Why Don't Eclipses Happen Every Month?

About the Activities

Create 3D models of the Earth, Moon and Sun and demonstrate solar and lunar eclipses. Show why we do not see eclipses at every full and new Moon.

Photo Credit Fred Espenak

Participants

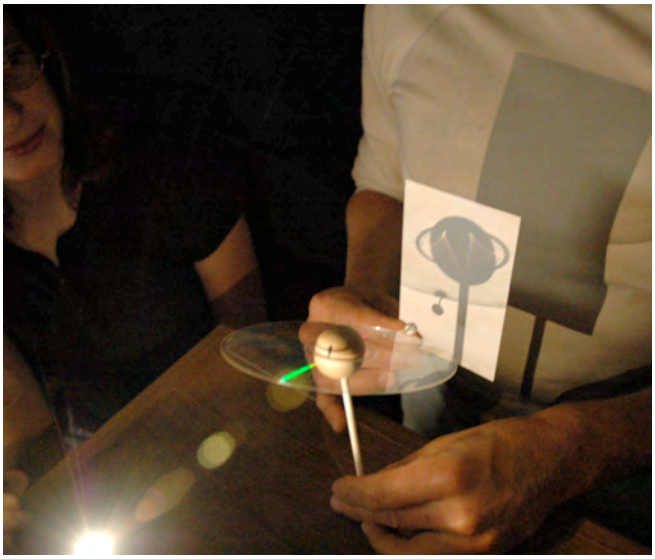
Use this activity with families, the general public, and school or youth groups ages 7 and up.

Location and Timing

Use this activity after dark at a star party or in a darkened classroom. It lasts about 10 minutes.

Topics Covered

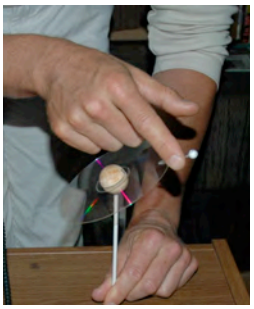
- How eclipses occur
- What the geometry of eclipses look like from space
- The orbit of the Moon



Materials Needed

See Helpful Hints for information about where to find these items.

- Clear plastic disks
- Clay or play dough
- Small ball of StikkiWax® (or clay)
- Flashlight in the "Candle" mode – with the cover removed (or a lamp with a bare bulb)
- White cards
- Skewer sticks
- Marker



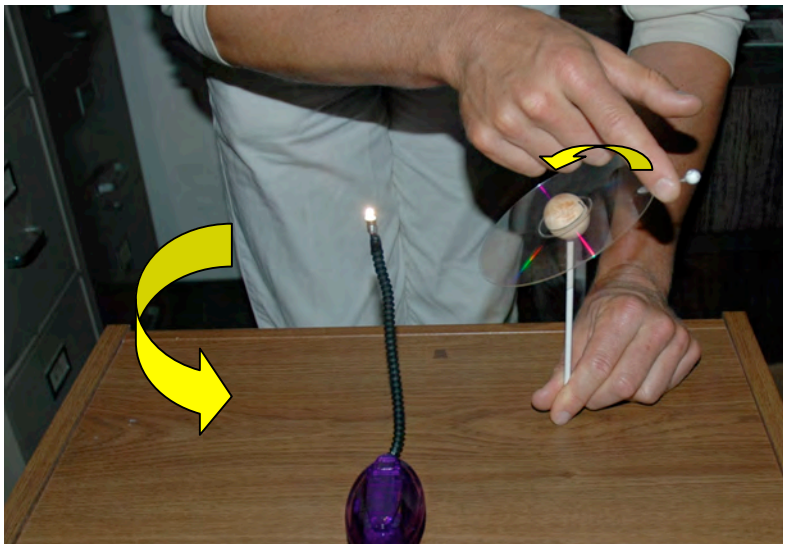
Assembly Instructions

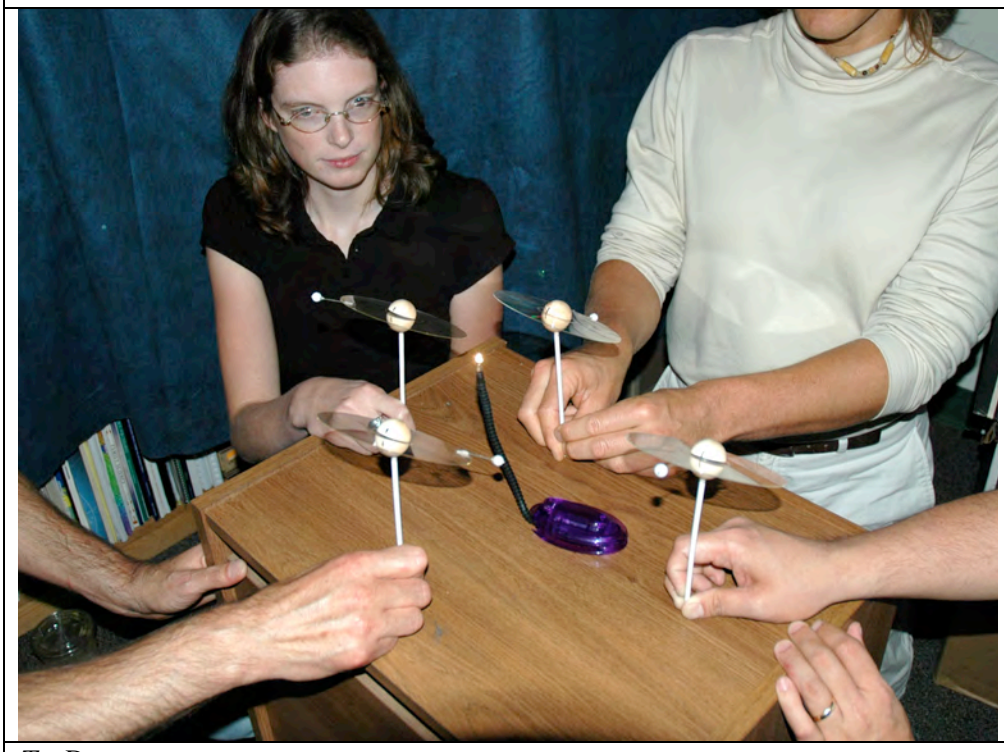
Make Earth-Moon Plastic Disks:

(*See Helpful Hints for information about where to find these items.*)

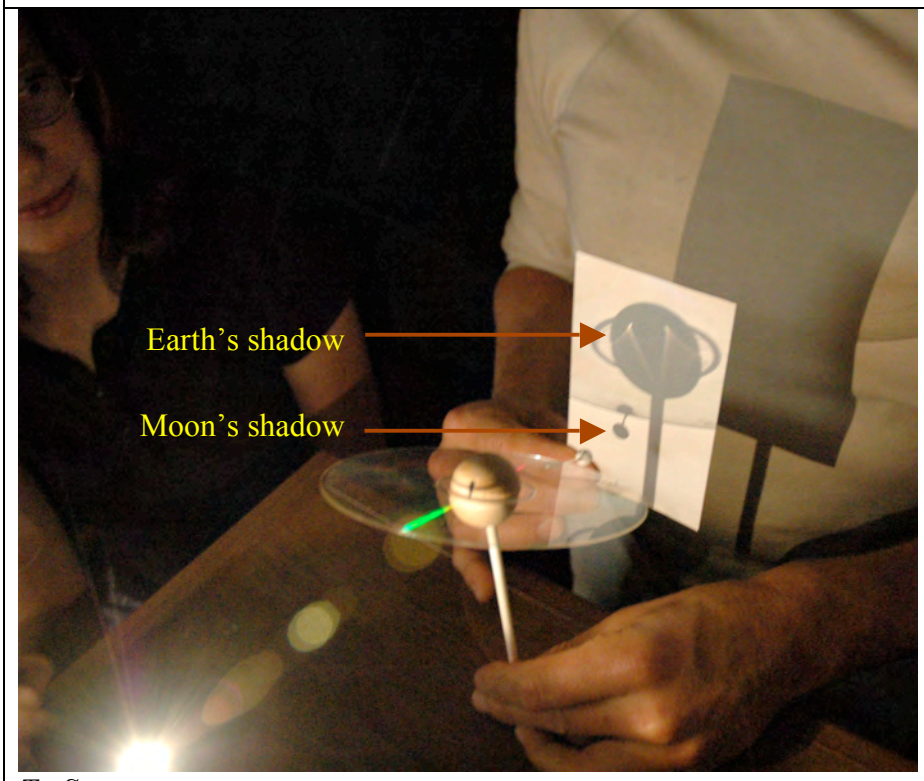
- Form two half globes out of clay and squeeze them together in the center of the clear disk (as shown right) to represent the Earth. The ball should be about one inch in diameter.
- You can use 1/4" balls of Stikkiwax® (or clay) to make the Moon (just make a small ball and place it on the edge of the disk. To change its position, just pick it up and put it at another place on the edge of the disk). The Moon will not "orbit".
- Insert a skewer stick in the center Earth ball at about a 30-degree angle.
- With a marking pen, place a mark on the high side of the Earth ball (see picture below)
- Make four of these.

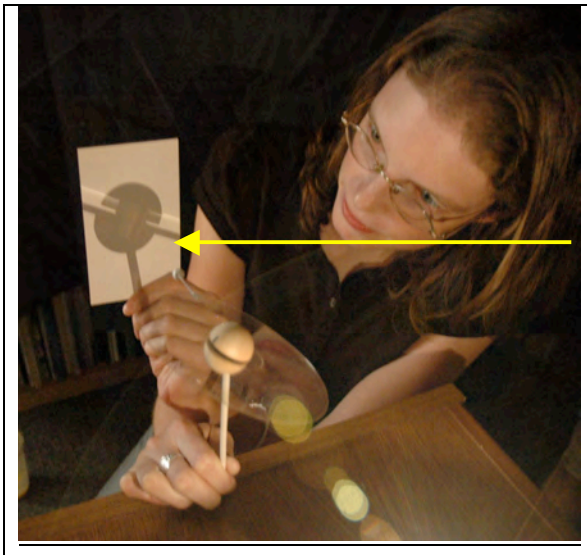
Why don't eclipses happen every month?

Leader's Role	Participants' Role (Anticipated)
To Do: **(NOTE: A snakelight is being used for this activity but a small flashlight with the cover removed works as well. The Earth-Moon disks must be held at about the same height as the light bulb.)** *To Say:* The Moon's orbit is tilted, compared to Earth's orbit around the Sun. Here's what that means. The Earth and Moon orbit the Sun together like this. One full orbit is one year. *To Do:* Demonstrate Earth's orbit around the light Sun and move the Moon in orbit around the Earth at the same time.  (**NOTE:** The Moon's tilt is actually only about 5 degrees, but for this model, the tilt is being exaggerated to about 30 degrees for clarity). *To Say:* The size of the Earth and Moon are to scale, but they are too close to each other. So this model is not completely to scale. We're also exaggerating the tilt of the Moon's orbit so it is easier to see. The Moon's orbit around Earth is actually tilted only about 5 degrees from Earth's orbit around the Sun. Also, the Moon and Earth would be much farther apart in a scale model. Here's a disk for each of you to have your own Earth-Moon system.	Take Earth-Moon disks
To Say: Let's have each of you stand at different points in Earth's orbit around the Sun, representing different times of the year. Hold your Earth and Moon so the Moon's orbit is oriented the same direction and tilt for all the positions. Hold your sticks perpendicular – straight up and down. See the little mark on the side of the Earth ball? Everyone should have that mark facing THAT direction *(point in a selected direction)*.	Participants arrange themselves

Leader's Role	Participants' Role (Anticipated)
	Participants orient their Earth-Moon disks.
To Do: If using the flashlight Sun, have the participants hold their disks within a couple feet of the light. This allows you to have four people comfortably around the light. If you are using a light bulb, they can be up to 5 feet away from the light. This allows you to have a few more people holding Earth-Moon disks (if you have made additional disks) Make sure no one is standing or holding their disk such that their own shadow is falling on their own disk or anyone else's disk.	
LUNAR ECLIPSE: *To Say:* Now let's see if anyone has a lunar eclipse. What phase is the Moon when you have an eclipse of the Moon? Right. Move your Moon so it is full – on the opposite side of the Earth from the Sun. *To Do:* Check that each person moves his/her Moon bead around to full Moon position. (You may need to help people figure this out – move it to the side of the disk opposite the Sun from the Earth)	Full Moon Moves Moon to correct position on the disk.

Leader's Role	Participants' Role (Anticipated)
 Note that all Moons are positioned on the opposite side of the Earth from the Sun. **Make sure everyone still is holding their stick perpendicular and that the mark is pointed in the right direction.**	
To Say: We'll use this card to check the alignment of the shadows. *To Do:* Hold white card opposite the "Sun" and within an inch of the edge of the disk such that the shadow of the "Moon" and the shadow of "Earth" fall on the white card.	

Leader's Role	Participants' Role (Anticipated)
 *To Say:* You can also hold your hand in this same position to check the shadows of your own disk.	
To Do: At each location, ask if the shadow of Earth is falling on the Moon. In all but two positions, they will discover that the Earth's shadow falls above or below the Moon's shadow. In only those two positions (or times of the year) can eclipses occur.	



Earth and Moon shadows are lined up!

SOLAR ECLIPSE: *To Do:* Next, have your visitors move their Moon so it is at new Moon – on the same side of the Earth as the Sun. Ask who has a solar eclipse – where the Moon is casting a shadow directly on the Earth. Use the card or their hand to check the alignment of the shadows. They will discover that the same two people have a solar eclipse. Almost every time there is a lunar eclipse, a solar eclipse would have occurred either two weeks before or two weeks after the lunar eclipse. *To ask:* So why don't we have eclipses every month?	The tilt of the Moon's orbit!
Presentation Tip: The most common mistake your visitors will make is not having their Moon orbits pointed in the same direction. Another common mistake is rotating the white stick instead of moving the Moon bead around the Earth ball to change the position of the Moon. A few may have a problem figuring out where to place their Moon to make it a full or a new Moon.	

Helpful Hints

Where to find the materials:

1. Clear plastic disks: save the top and bottom protective disks that come with stacks of CDs or DVDs. Or try a CD/DVD replicator or photo shop – call and ask them to save some for you.
2. Use modeling clay or Play Dough (see recipe below) to make the Earth-centers.
3. StikkiWax®: office supply store
4. White cards: office supply

Play Dough: purchase commercial children's clay or make your own (adapted from http://www.cooks.com/rec/doc/0,1611,147171-236192,00.html):

Play Dough Recipe

4 c. flour
4 c. boiling water
1/4 cup cream of tartar
2 cups salt
1/4 cup salad oil
Food coloring (optional)

Place all ingredients except hot water in a large bowl and stir. Pour in hot water and mix together with a spoon until well combined. When the dough has cooled, place the dough on a lightly floured surface and knead it to a smooth consistency. This dough is not sticky and does not dry out unless left open to the air for several days. Store in a sealed container (plastic tubs are good).

Background Information

Moon's Rotation

Does the Moon rotate? Why does the Moon always keep the same face to Earth? What does the other side of the Moon look like?
A discussion of these topics can be found here:
http://www-spof.gsfc.nasa.gov/stargaze/SMoon.htm

Eclipses

Everything you ever wanted to know about Solar and Lunar Eclipses:
http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

Schedule of Lunar Eclipses:

Date	Eclipse Type	Umbral Magnitude	Total Duration	Geographic Region of Eclipse Visibility
2007 Mar 03	Total	1.238	01h14m	Americas, Europe, Africa, Asia
2007 Aug 28	Total	1.481	01h31m	e Asia, Aus., Pacific, Americas
2008 Feb 21	Total	1.111	00h51m	c Pacific, Americas, Europe, Africa
2008 Aug 16	Partial	0.813	-	S. America, Europe, Africa, Asia, Aus.
2009 Feb 09	Penumbral	-0.083	-	e Europe, Asia, Aus., Pacific, w N.A.
2009 Jul 07	Penumbral	-0.909	-	Aus., Pacific, Americas
2009 Aug 06	Penumbral	-0.661	-	Americas, Europe, Africa, w Asia
2009 Dec 31	Partial	0.082	01h02m	Europe, Africa, Asia, Aus.
2010 Jun 26	Partial	0.542	02h44m	e Asia, Aus., Pacific, w Americas
2010 Dec 21	Total	1.262	03h29m	e Asia, Aus., Pacific, Americas, Europe

Umbral magnitude is the fraction of the Moon's diameter obscured by Earth's Umbra (the darkest part of Earth's shadow). For penumbral eclipses, the umbral magnitude is always less than 0. For partial eclipses, the umbral magnitude is always greater than 0 and less than 1. For total eclipses, the umbral magnitude is always greater than or equal to 1.

A **penumbral eclipse** occurs when the Moon only passes through the Earth's penumbra (the outer portion of the Earth's shadow).