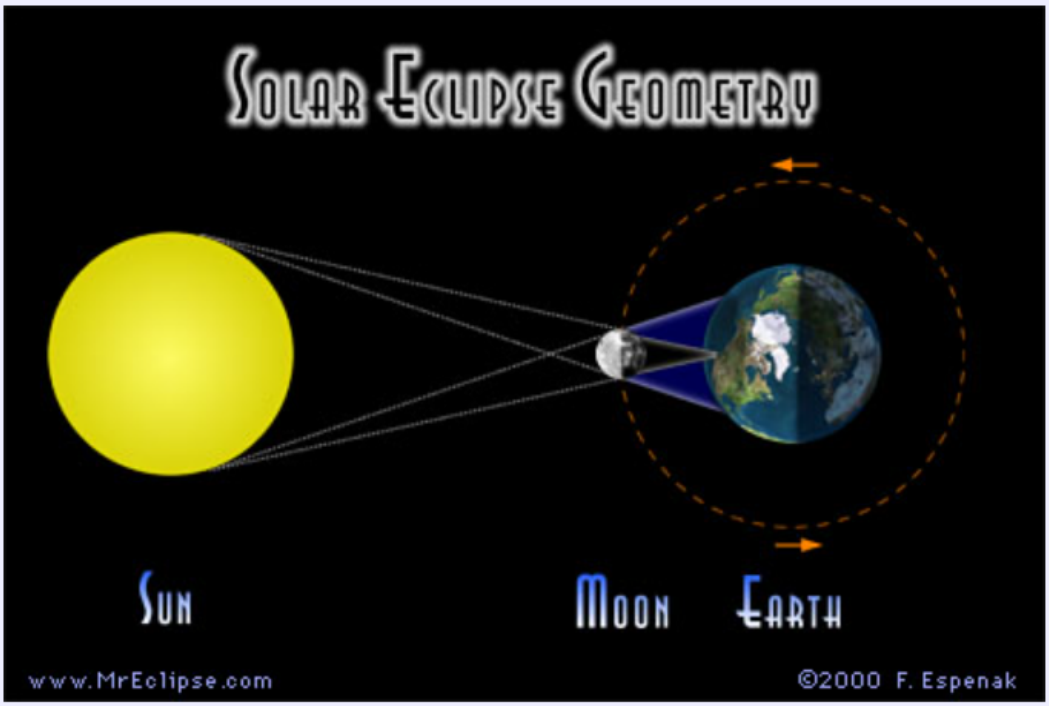
Solar and Lunar Eclipses – Teacher Notes

What is an eclipse?
An **eclipse** happens when a planet or a moon gets in the way of the Sun's light. It is effectively a shadow. On Earth, we can experience two kinds of eclipses: **solar eclipses** and **lunar eclipses**.

Solar Eclipse
A solar eclipse happens when the Moon gets in the way of the Sun's light and casts its shadow on Earth. That means during the day, as the Moon moves between Earth and the Sun it gets darker. It can only occur at a New Moon when the Moon passes between Earth and Sun. The Moon's shadow isn't very big, so only a small portion of places on Earth will be able to view this. If the Moon's shadow happens to fall upon Earth's surface at that time, we see a portion of the Sun's disc covered or 'eclipsed' by the Moon. How much it covers depends on a couple of factors:

- The distance the Moon is from Earth, which varies slightly as the Moon's orbit isn't a perfect circle.
- The geometry of the Sun, Moon, and Earth due to the Moon's orbit being angled to Earth's.



Geometry of the Sun, Earth and Moon During an Eclipse of the Sun
The Moon's two shadows are the penumbra and the umbra.
(Sizes and distances not to scale)

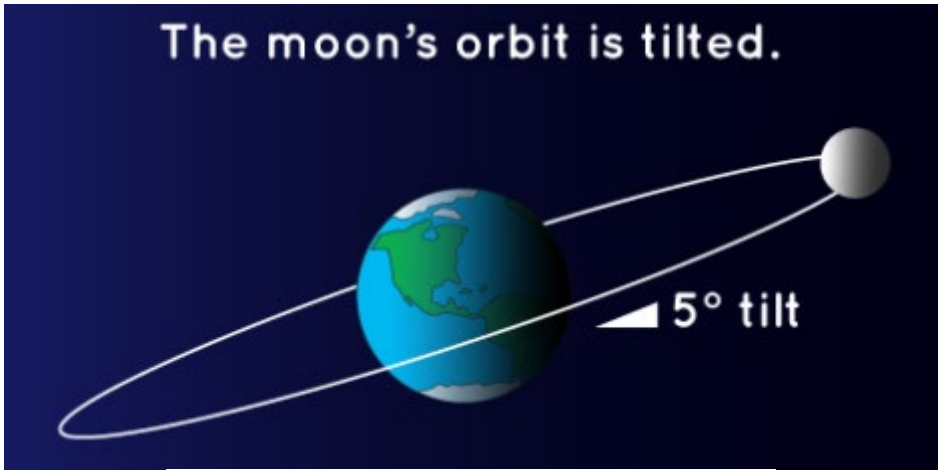
(Espenek, 2020)

The moon's shadow (and all others to some extent) has two parts:
Umbra - the dark, inner shadow
Penumbra - the outer lighter shadow

If the umbral shadow passes over you, you will experience a total eclipse of the Sun.

Total Eclipse in Kansas, 2017

Because the Moon's orbit around Earth is tilted 5 degrees to Earth's orbit around the Sun, the Moon's shadow usually misses Earth as it passes above or below our planet at New Moon.



Tilt of the Moon in relation to the Sun (NASA, 2022)

A **total eclipse** happens about every 18 months somewhere on Earth. **A partial eclipse**, when the Moon doesn't completely cover the Sun, happens at least twice a year somewhere on Earth.

On April 20, 2023, Exmouth in WA will experience a total eclipse of the Sun. Click the link below to see the path of the Sun's shadow over Earth that day. **Totality** will only last a few minutes, but it promises to be an awe-inspiring experience:

SE2023Apr20H.GIF (250×270) (nasa.gov)

CAUTION

Never look directly at the Sun, even for a second. It will damage your eyesight forever.

Try this interactive from NASA Jet Propulsion Laboratory's relating to the 2017 total eclipse in Kansas, USA - https://eyes.jpl.nasa.gov/eyes-on-eclipse.html

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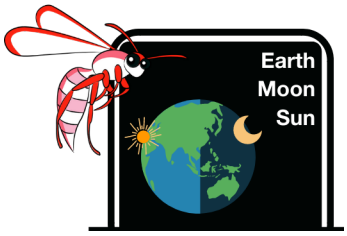

Indigenous perspectives on Solar Eclipses

In most Aboriginal cultures, the Sun is a woman, and the Moon is a man. It seems many Aboriginal groups had a firm understanding that during a solar eclipse, an object was covering the Sun, although many explanations were presented as to what that object was and why it covered the Sun.

The Yuwaalaraay people of north-western New South Wales believe the Sun Woman, *Yhi*, is constantly pursuing the Moon Man *Bahloo*, who has rejected her advances. Sometimes Yhi eclipsed Bahloo, trying to kill him in a jealous rage. However, the spirits that held up the sky intervened and drove Yhi away from Bahloo.
The Wirangu people of South Australia believed the solar eclipse on 21 September 1922 was caused by the hand of *maamu-waddi*, a spirit man that covered the earth during the eclipse for the privacy of the sun woman and moon man while they were *guri-arra* – "husband and wife together".

Among other Aboriginal communities, the eclipse was attributed to various objects or actions, including a large black bird called *tia* for the Arrernte community or spun possum fur for the Luritja community (both of Central Australia). To some Aboriginal groups in Southwestern, Western Australia, a solar eclipse is caused by *mulgarguttuk* (sorcerers) placing their *booka* (cloaks) over the Sun, while to some other groups they move hills and mountains to cover the Sun. A similar view is held by (unspecified) Aboriginal people of the Central Desert who call a solar eclipse *bira waldurning* and claim it is made by a man (*waddingga*) covering the Sun with his hand or body.

A number of Aboriginal words and descriptions of solar eclipses have also been found. This shows that Aboriginal people did observe some total and partial eclipses and the memory of these events remained strong in many areas. Aboriginal people understood the mechanics of the sun-earth-moon system and the relationship of lunar phases to events on the Earth. The Yolngu people of Arnhem Land demonstrate in their oral accounts that they understood that the Sun and Moon move in an east to west motion, the Moon goes through repeated phases that affect the ocean tides, the Earth is finite in space, and the Moon covers the Sun during a solar eclipse.

Great video resources
National Geographic Solar Eclipse 101 https://youtu.be/cxrLRbkOwKs
Veritasium Total Solar Eclipse https://youtu.be/G10m2ZZRH4U

Solar Eclipse Vocabulary
Eclipse - An eclipse occurs when one heavenly body such as a moon or planet moves into the shadow of another heavenly body.
Penumbra - The penumbra is the weak or pale part of the Moon's shadow. From within the penumbra, the Sun is only partially blocked by the Moon as in the case of a partial eclipse. This contrasts with the umbra, where the Sun is completely blocked resulting in a total eclipse.
Solar - Relating to Sun.
Solar eclipse - A solar eclipse occurs when the Moon moves between the Sun and Earth, casting a shadow on Earth.
Total solar eclipse - A solar eclipse in which the Moon's umbral shadow traverses Earth (the Moon is close enough to Earth to completely cover the Sun). During the maximum phase of a total eclipse, the Sun's disk is completely blocked by the Moon.
Totality - The maximum phase of a total eclipse during which the Moon's disk completely covers the Sun. It can last from a fraction of a second to a maximum of 7 minutes and 32 seconds.

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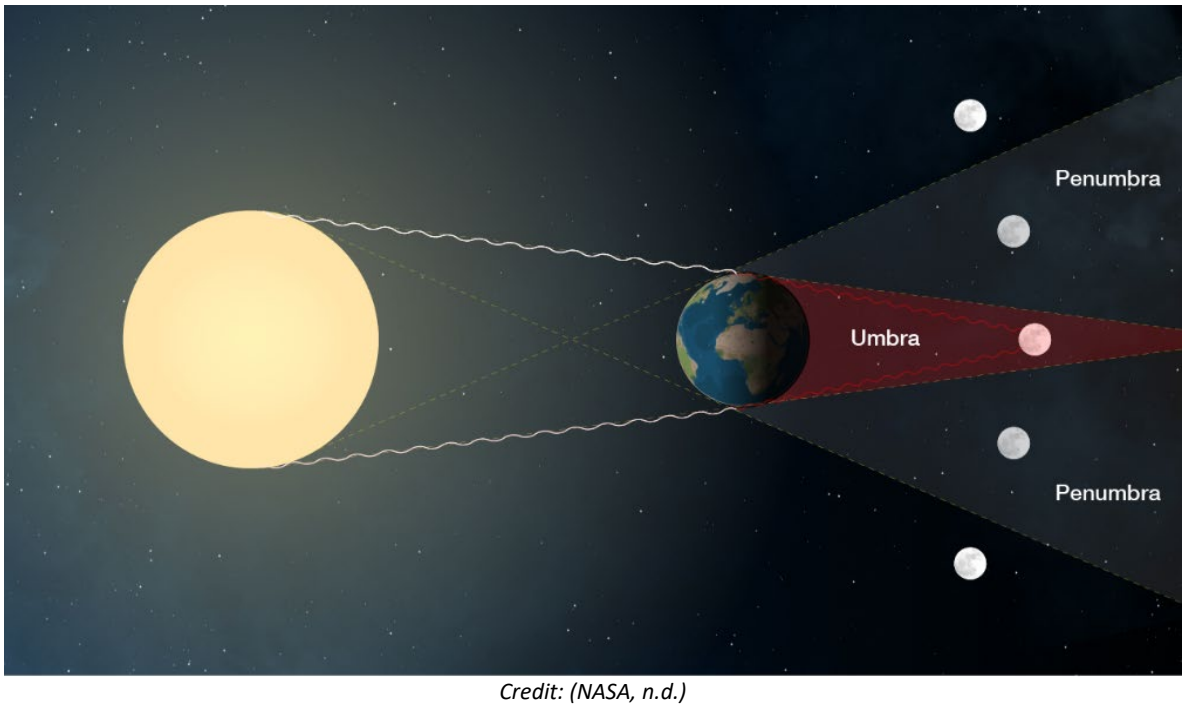
Umbra - The umbra is the darkest part of the Moon's shadow. From within the umbra, the Sun is completely blocked by the Moon as in the case of a total eclipse. This contrasts with the penumbra, where the Sun is only partially blocked resulting in a partial eclipse.

Lunar Eclipse

A lunar eclipse happens when Earth gets in the way of the Sun's light and casts its shadow on the Moon. That means at night, if the Earth moves between the Moon and the Sun, the Moon appears to have a bite taken out of it. If it is a total lunar eclipse the Moon turns an eerie red colour, this is also known as a Blood Moon. A lunar eclipse can only occur during a full moon.

Credit: Public domain



Credit: (NASA, n.d.)

Solar and Lunar Eclipses – Teacher Notes

The Earth's shadow (and all others to some extent) has two parts:
Umbra - the dark, inner shadow
Penumbra - the outer lighter shadow

Because the Moon's orbit around Earth is tilted 5 degrees to Earth's orbit around the Sun, Earth's shadow may miss the Moon or only partially cover the Moon. Two to four times a year the Moon passes into some portion of the Earth's shadow and a partial or total lunar eclipse occurs. If you live on the night-time half of Earth when the eclipse happens, you will be able to see it.

There are three different types of lunar eclipse:
Total lunar eclipse

The Moon moves into the darker, inner part of Earth's shadow, or the umbra. Some of the sunlight passing through Earth's atmosphere reaches the Moon's surface, lighting it dimly. Only the longer wavelength red and orange light makes it through Earth's atmosphere to the Moon (blue wavelengths scatter away) making the Moon appear red during totality. The more dust or clouds in Earth's atmosphere during the eclipse, the redder the Moon appears. Just like at sunset. If the Earth had no atmosphere the Moon would be completely black at totality.

Partial lunar eclipse

The Moon passes through only part of Earth's umbra. The shadow grows and then recedes without ever entirely covering the Moon.

Penumbral lunar eclipse

The Moon passes through Earth's penumbra, or the faint outer part of its shadow. The Moon dims so slightly that it can be difficult to notice.

An initiative supported by Woodside Energy and AusEarthEd

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In 2022, there were two total lunar eclipses visible in Australia, this won't happen again until 2032 and then immediately again in 2033. In 2023, there will be only one partial eclipse visible in Australia. For the full list of upcoming lunar eclipses, to 2035, click here.

Great video resources
National Geographic Lunar Eclipse 101 https://youtu.be/VW2xRR75lKE

Lunar Eclipse Vocabulary
Eclipse - An eclipse occurs when one heavenly body, such as a moon or planet, moves into the shadow of another heavenly body.
Lunar- relating to the Earth's moon.
Lunar eclipse - A lunar eclipse occurs when the Moon moves into the Earth's shadow and is either partially or totally in shadow.
Partial Eclipse - A partial lunar eclipse happens when only part of the Moon enters Earth's shadow. What people see from Earth during a partial lunar eclipse depends on how the Sun, Earth and Moon align.
Penumbra - The penumbra is the weak or pale part of the Earth's shadow. From within the penumbra, the Sun is only partially blocked by the Earth as in the case of a partial eclipse. This contrasts with the umbra, where direct sunlight is completely blocked resulting in a total eclipse.
Total lunar eclipse - A lunar eclipse in which the Earth's umbral shadow traverses the Moon so it is completely covered in shadow.
Totality - The maximum phase of a total eclipse during which the Earth's disk completely covers the Moon.
Umbra - The umbra is the darkest part of the Earth's shadow. From within the umbra, direct sunlight is completely blocked by the Earth as in the case of a total eclipse. This contrasts with the penumbra, where the Sun is only partially blocked resulting in a partial eclipse.
Blood moon – the common name given to the red appearance of the Moon during a total lunar eclipse. This occurs when refracted light from the red end of the spectrum is cast onto the lunar surface.

References

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Solar and Lunar Eclipses – Teacher Notes

Student Activity

Aim

Calculate the relative size of the Moon and the distance from Earth to the Moon.
To build a scale model of Earth and the Moon using a tennis ball and modelling clay.
To model eclipses of the Sun and Moon.

Materials per group:

- Tennis ball
- Plasticene, Blu tack or other modelling clay
- Ruler
- Torch
- Metre rule
- String
- Toothpick
- Piece of A4 paper

Method

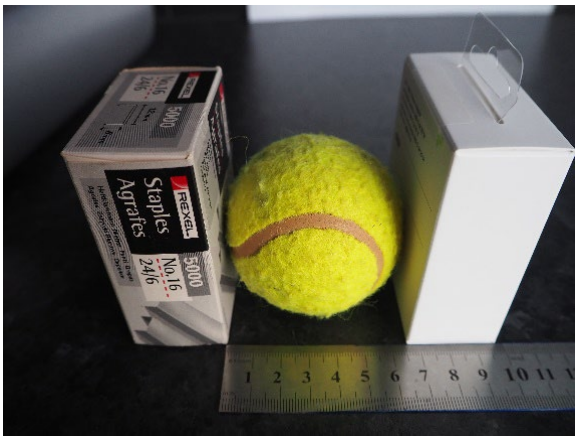
1. Conduct an internet search for the following:

   The diameter of Earth 12,742 km

   The diameter of the Moon 3,475 km

   The distance between Earth and the Moon 384,400 km

   The distance between our Sun and Earth 149.13 million km



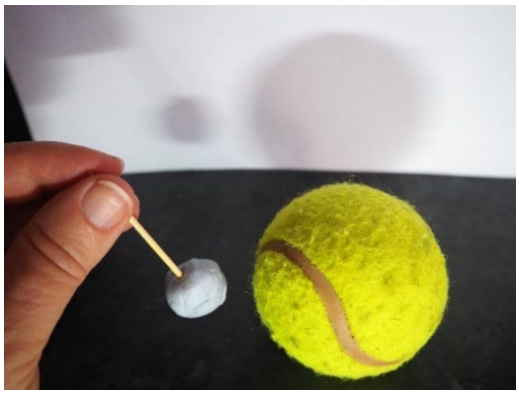
2. Get your partner to help you find the diameter of a tennis ball by placing it between two flat sided, upright objects such as two pencils or boxes and measuring the gap.

3. If the tennis ball represents Earth, calculate the size of the Moon at this scale.
answers will vary but tennis balls are usually ~6.7cm in diameter.

HINT: Diameter of Earth / diameter of the Moon = 12,742/3,475

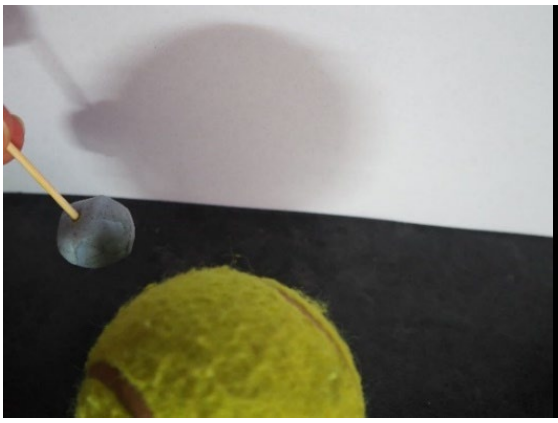
Now divide the diameter of the tennis ball by the calculated amount _~1.83cm

4. Use your calculations to create a plasticene (or similar) ball to represent the Moon at this scale.
5. Repeat Method 2 to check the diameter of the scaled down Moon is accurate.
6. Prop your torch so that it shines straight onto a paper screen about 60cm away. Stick a toothpick into your model Moon and rest your Earth on the desk just in front of the paper screen.
7. Orbit your Moon around the tennis ball Earth just in front of the paper screen, so you can see shadows.



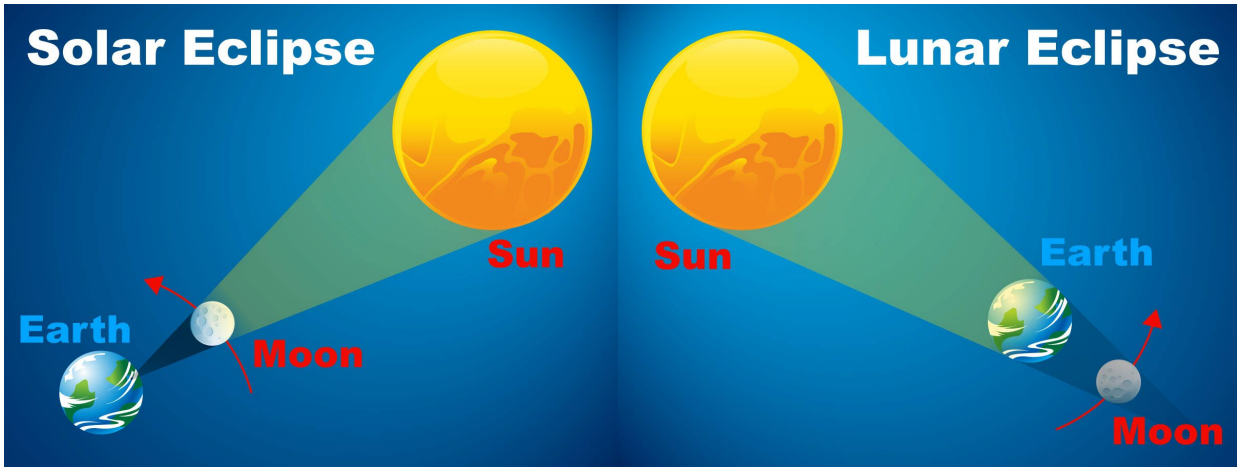
- What phase is the Moon in before the eclipse? Full moon

- Using the photo below, **draw the Moon** as it would appear at this point during a lunar eclipse.



8. In a solar eclipse, the Moon casts its shadow across Earth. Model this event then draw a labelled diagram in the observations box below.

9. In a lunar eclipse, Earth casts its shadow across the Moon. Model this event then draw a labelled diagram or take a photo and paste it in the observations box below*.



Credit: NASA Solar Eclipse/ Luna Eclipse

Solar Eclipse Lunar Eclipse

10. In reality, the Moon and Earth are much further apart. Using the distance between the Moon and Earth (you researched earlier), calculate the distance between the tennis ball and the plasticene ball needed, to be in the correct scale.

The distance between Earth and the Moon 384,400 km
The diameter of the Moon is 3475km Therefore there are approximately 110 Moons needed to cover the distance between the Earth and the Moon. (384,400/3475 = 110.6) Moons. If your plasticene moon is 1.8cm in diameter x 110.6 = 199.11cm

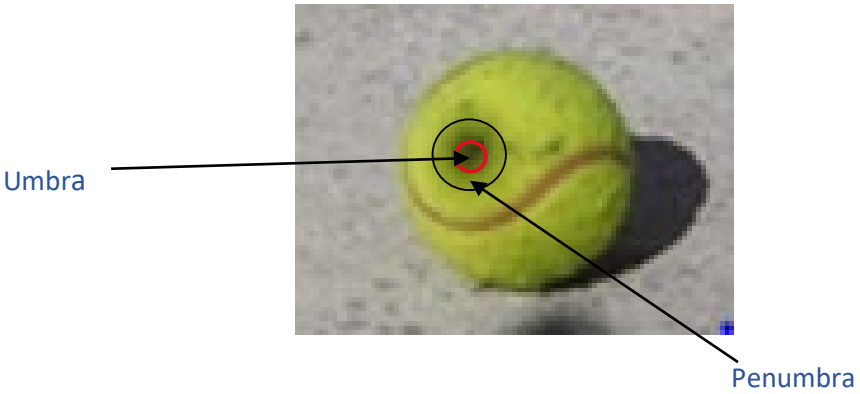
11. Cut a piece of string about 20cm longer than the length calculated in the step above. Hold one end of the string on the tennis ball Earth and have another student hold the other end of the string to the plasticene Moon.

12. Model a solar eclipse, at the correct scale (for Earth and Moon distances), by standing in direct sunlight with your Earth on a flat, light-coloured surface. Hold the Moon the correct distance away by pulling the string tight. Now let the string go and holding on to the toothpick cast a shadow from your Moon onto your Earth.

- Does the Moon's shadow cover the whole Earth? Why?

  No, its shadow is too small to cover the Earth because the Moon is so far away

- If you look closely at the photo above, there are two parts to the Moon's shadow. A lighter outer ring (penumbra) and a darker inner circle (umbra). In the box below draw the Earth with the Moon's shadow on it and label the different parts.



- Can every observer on the daytime side of Earth see the eclipse? Why?

  No, the shadow is too small and only covers a small section of the Earth.

13. Now swap the Moon and Earth over and put the Moon on the ground and, holding the Earth, model a lunar eclipse.

- Can Earth's shadow cover all the Moon? Why?

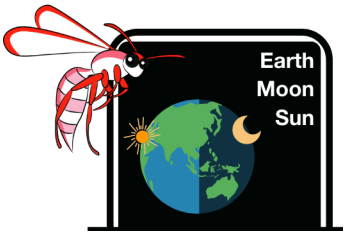
  Yes, the Earth's shadow more than covers the Moon because it is so big compared to the Moon

- Can every observer on the nighttime side of Earth see the eclipse?

  Yes, everyone that can see the Moon can see the eclipse. The Moon will be on the nighttime side of Earth when the eclipse occurs.

14. Your Earth and Moon models have so far used a torch to model the Sun. If you wanted to make your model include the Sun (torch) positioned at the correct distance from Earth, calculate how far away the torch would have to be from Earth.

The distance between our Sun and Earth 149.13 million km and the diameter of Earth 12,742 km. Therefore nearly 12,000 Earths would fit between them. (11703.8x) If your tennis ball is 6.5cm then you would have to hold your Sun 76,074 cm away or 760m away.



15. Do you think the torch you have would work as a model Sun from your calculated distance. Why?

No, torches are not powerful enough to work from that distance.

Discussion

Using your knowledge of solar and lunar eclipses, fill in the missing words below.

Solar eclipses occur when the Moon casts a shadow on the Earth.

Lunar eclipses occur when the Earth casts a shadow on the Moon.

Extra/ Alternative activities

*Take a series of photos as your Moon is eclipsed by your Earth and vice versa and turn it into a short looping video using iMovie or other movie making software.

Watch the video that accompanies this activity.