Queen's University

Create your own eclipse

Ages: Grades K-12
Main learning outcome(s):
- scale of the Earth and Moon system
- motion of the Earth-Moon-Sun system
- solar eclipses

Additional learning outcome(s):
- lunar eclipses
- phases of the moon

Contents:

Introduction:

Using items you already have at home or in your classroom, you can empower your students to recreate the Earth and Moon system. Use this activity to explore eclipses and the motion of the Earth and Moon. This activity can be expanded to explore phases of the moon and abstract skills such as perspective.

Equipment:

- Measuring tape or metre stick
- Large ball (preferably blue!)
- Small ball (preferably white or gray!), between one quarter and one third the diameter of the large ball
- Toothpicks or skewers (optional)
- Binder clips or tape (optional)
- Flashlight (optional)

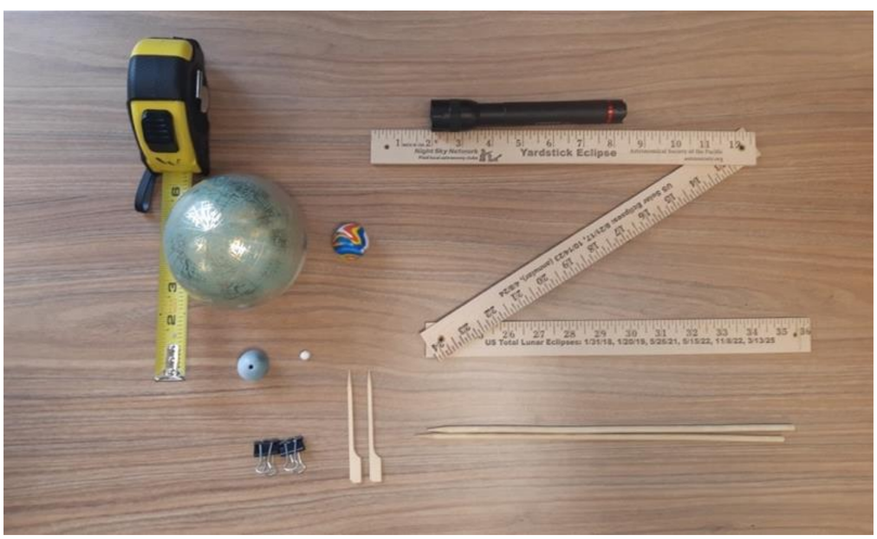


Diagram 1 – Equipment for creating two create-your-own-eclipse demos.

Notes on equipment:

When you are gathering materials, be careful to choose balls that have a similar size difference to the Earth and Moon. You can base this on the diameter of the balls. The small ball should be close to 0.27 (27%) the size of the large ball. A good approximation is a typical bouncy ball (~3cm in diameter) and a 10cm diameter ball, or a typical bouncy ball and a tiny Styrofoam ball (~1cm in diameter). See the Resources section below for common examples you can use.

Depending on the size of the balls you choose, it may be helpful to have toothpicks or skewers, and binder clips handy. For smaller balls, it is helpful to put them on toothpicks for easier manipulation, and similarly for larger balls to be on skewers or sticks. Binder clips are useful for securing toothpick mounted balls, which is further explored in the Setting up section.

If you are doing this activity inside, you may need a flashlight to act as the Sun. If possible, we recommend trying this activity outside on a sunny day and using the actual Sun!

Setting up:

Depending on your students and your classroom, you may have one set of equipment that everyone is taking turns using or you may have multiple sets that groups of 2-3 students are using at the same time. The set-up is the same for every activity set.

Very small demo (Moon ball is smaller than 1cm)

In the case of a very small demo where the Earth and Moon balls are quite small, we recommend sticking the balls on toothpicks and attaching them to a metre stick using binder clips.

With the Earth and Moon balls on toothpicks, place the Earth ball at the 0cm end of the metre stick. The toothpick should be parallel to the markings on the metre stick, with the Earth ball above the metre stick. Secure the toothpick using a binder clip, attaching it from the bottom.

Place the Moon ball on the other end of the metre stick in the same fashion. Where the Moon ball is placed is dependent on the size of the Earth and Moon balls. In general, place the Moon 110 times its diameter from the Earth ball. For example, if the Moon ball is 9mm in diameter, it would be placed 99cm away from the Earth ball – right on the opposite end of the metre stick. If the Moon ball is 7.5mm (0.75cm), secure it at the 83cm mark. You can find more examples in the Resources section.

Diagram 2 – Very small demo assembled.

Regular demo (Moon ball is larger than 1cm)

It may be helpful to secure your Moon and Earth balls on skewers for ease of use. This will prevent hands, arms, and bodies from creating extra shadows in your system.

Mark on the floor or ground where the Earth ball should be. This may be at one end of your classroom. Using a measuring tape, measure how far from the Earth ball the Moon ball should be.

As for the very small demo, this should be 110 times the size of the Moon ball. For example, if you are using a 3cm bouncy ball as the Moon ball, it should be 3.3m away from the Earth ball. Mark on the floor or ground where the Moon ball should be. You can find more examples in the Resources section.

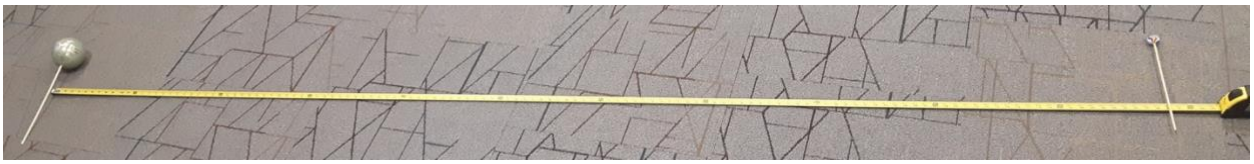


Diagram 3 - Regular demo assembled, with a 3cm bouncy ball (right) and 10.16cm (4 inch) ball (left) spaced 3.3m apart.

If you are outside, you should make sure the Earth and Moon balls are lined up with the direction of the Sun, such that the shadow from the Moon ball falls in the direction of the Earth ball. You may find it helpful to trace out a circle around the Earth ball for the Moon ball to follow, so your students can move the Moon ball around its "orbit".

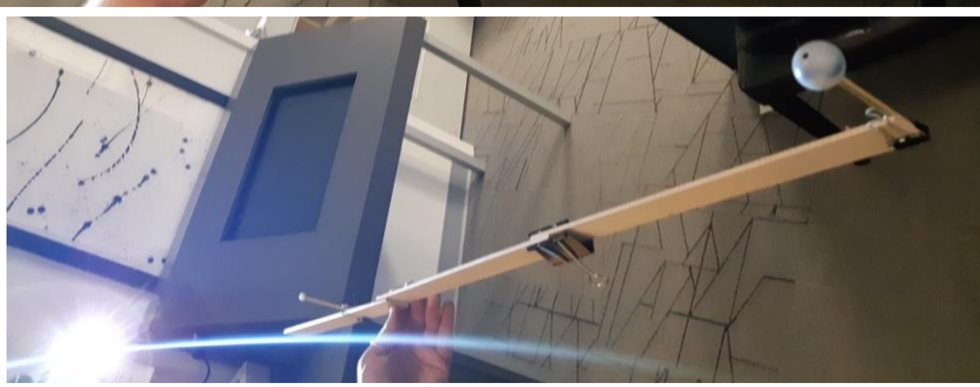


Diagram 4 - A flashlight on the left points towards the very small demo system, with the Moon ball in the middle and the Earth ball on the right so that the Moon ball will cast a shadow in the direction (and hopefully on) the Earth ball.

One student can hold the Earth ball and another the Moon ball. The student holding the Moon ball will then move the Moon ball, while the student holding the Earth ball will watch for the eclipse to occur and give direction to the student holding the Moon ball. If the Moon ball and Earth ball are secured to a metre stick, one student holds and manipulates the metre stick.

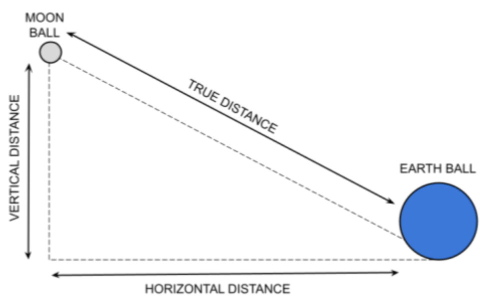
Creating an eclipse:

If you are inside, set up your flashlight on a stable, horizontal surface pointing parallel to the Earth-Moon system you have created.

Move the Moon ball up or down (inclination) and side to side (along its "orbit") to cast a shadow from the Moon ball onto the Earth ball.

⇒ **Tip:** encourage your students to try it out on their own for a while. If you notice they are struggling, you can suggest they line up the shadows on the ground or opposite wall. Lining up the Earth ball and Moon ball shadows will force them into alignment.

⇒ **Tip:** If you are using a flashlight, encourage students to create their eclipse at least a few metres away from the flashlight. This will create a better shadow.



⇒ **Tip:** If you are outside, account for how high the Sun is in the sky. This may mean the Moon ball needs to be held high for its shadow to fall on the Earth ball. The Moon ball's vertical height from the ground adds to its distance from the Earth ball, and so it will need to be moved closer horizontally. Doing this activity in the early morning will minimize the inclination of the Moon ball. Otherwise, a step ladder may be needed.

Guiding questions:

These questions are great for in-class discussions or can be used as lab report questions. If you decide to use these in a lab setting, consider encouraging students to think about the question, writing down or stating a hypothesis, and if possible, testing out their prediction using the activity equipment. Encourage students to write observations or take photos to document their findings, and if applicable, combine their results in a lab report or written reflection.

1) Think about the Moon's orbit around Earth, and the rotation of the Earth. Which direction is the Earth rotating?

⇒ **Hint:** Think about the direction the Sun moves across the sky from our perspective on Earth. It rises in East, sets in West, but this is the Earth rotating. Earth rotates in the opposite direction of the perceived motion of the Sun - from West to East or counterclockwise as seen from the North pole.

2) Which direction is the Moon's orbit around the Earth?

⇒ **Hint:** Same as the Earth's rotation, West to East or counterclockwise.

3) With this information, which direction is the Moon moving as it eclipses the Sun, as seen from Earth?

⇒ **Hint:** The Moon moves East to West in the sky from our perspective on Earth, and the shadow it casts during an eclipse moves West to East. Check out solar eclipse tracking maps to verify, such as TimeAndDate.

4) Could you create a solar eclipse that moves in the opposite direction, as seen on Earth? i.e., one where the Moon appears to move from West to East, and the shadow travels from East to West?

⇒ **Tip:** This is very tricky! Recommended for older students, Grade 6 and up.
⇒ **Hint:** This is possible at very far North and very far South latitudes. In these cases, the shadow from the Moon does not fall on the face of Earth closest to it, but on the opposite side over the pole.

5) How far North or South would you need to be to potentially witness this "opposite direction" solar eclipse?

⇒ **Hint:** Same question as "How far North or South do you need to be to see the Sun for 24 hours straight at some point in the year?" Some students may realize this must be at least the Artic and Antarctic Circles, at just over 66 degrees North and South respectively.

6) The Moon's orbit is not a perfect circle, and neither is the Earth's orbit around the Sun. What would a solar eclipse look like in each of the following scenarios? Describe or draw what you think would happen.
   a) Moon is furthest from Earth, Earth is furthest from Sun
   b) Moon is furthest from Earth, Earth is closest to Sun
   c) Moon is closest to Earth, Earth is furthest from Sun
   d) Moon is furthest from Earth, Earth is closest to Sun

⇒ **Tip:** For older students, this is a great opportunity to talk about annular solar eclipses and terms used for planetary and satellite orbits, such as aphelion (when Earth is closest to the Sun), perihelion (when Earth is farthest from the Sun), apogee (when the Moon is closest to the Earth), and perigee (when the Moon is farthest from the Earth)
⇒ **Hint:** When the Moon is closest to the Earth, it appears larger and takes up more sky. When it is further away, it appears smaller and takes up less sky. Likewise for Earth, when it is closer to the Sun the Sun appears larger and when it is further away the Sun appears smaller. These differences can be as much as a 10% change in size from our perspective here on Earth. When the Moon is further away, we see an annular eclipse, where a ring or annulus of the Sun is still visible around the Moon. When the Moon is closer, we see a total solar eclipse, where the Sun is completely blocked out.

Additional activities using the same equipment:

Create a lunar eclipse

Investigating Question: A solar eclipse occurs when the Moon casts its shadow on the Earth. What happens during a lunar eclipse?

Create a lunar eclipse using the activity materials. Is this easier or harder than creating a solar eclipse? Why or why not?

Phases of the Moon

Investigating Question: What happens when there isn't a lunar or solar eclipse occurring?

Position the Moon ball at different points around the Earth ball and sketch, describe, or take a photo of what you see from the Earth ball's perspective. Remember that the Moon's orbit is counter clockwise as seen from the North (or above). Connect what you see to names of the phases of the Moon. Can you make a prediction of where and when (night, day, morning, evening) you will see different phases of the Moon?

Resources and More:

Moon ball diameter	Earth ball diameter	Distance between Earth ball and Moon ball
0.8cm	3cm	88cm
1cm	3.7cm	1.1m
3cm	11.1cm	3.3m
5cm	18.5cm	5.5m
10cm	37cm	11m

Table 1 - Examples of Earth and Moon ball and system sizes. Approximates are OK!

The Moon's diameter is 3476km, and is on average 384,400km away from Earth (source: CSA). The Earth's diameter is 12,742km (source: CSA). Comparing the diameter of the Moon to the diameter of Earth, the Moon's diameter is 27% that of Earth. The distance between the Earth and Moon is slightly more than 110 times the diameter of the Moon (110.5 times).

This activity has many formal kits and content made by astronomers and educational professionals. The "very small demo" is based on the Astronomy Society of the Pacific eclipse kit.

You can find great eclipse resources and astronomy education resources from Discover The Universe, in addition to the Royal Astronomy Society of Canada.

This resource was created by Charles Woodford and Connor Stone on behalf of Queen's University with support from the Department of Physics, Engineering Physics, & Astronomy and the Arthur B. McDonald Canadian Astroparticle Physics Research Institute.