STEM gems

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SOLAR ECLIPSE

big IDEAS

ON MONDAY AUGUST 21, 2017 NORTH AMERICA WILL BE TREATED TO A RARE CELESTIAL EVENT THAT IS TRULY AMAZING TO WITNESS. People in a 70-mile wide path from Oregon to South Carolina will be able to witness a total solar eclipse. People outside the path will be able to witness a partial eclipse, in which the moon will partially cover the sun's disk. The abrupt darkness of a solar eclipse is stunning and quite unlike anything you've ever seen. In addition, the incredible solar corona surrounding the sun, usually hidden from us, is simply awe-inspiring. However, during an eclipse eye safety is very important. You should never look directly at the sun. The sun's UV radiation can burn the retinas in your eyes and cause permanent damage or even blindness. This STEM Gem will show you how to build a simple tool with young people to safely view the sun and solar eclipses.

WHAT IS THE SUN?

The sun is a star. It is the biggest member of our solar system and its mass is the pivot point around which all planets, comets, and asteroids revolve. It provides almost all of the heat and light radiating throughout the solar system and provides enough energy to support life on Earth. The sun formed almost five billion years ago from a vast cloud of gas and dust in the Milky Way Galaxy. The cloud, consisting mostly of hydrogen and helium, eventually collapsed due to the relentless pull of gravity. Deep inside the cloud, hydrogen gas was compressed to higher and higher pressures and ever-increasing temperatures. Eventually, the crushing pressure grew high enough that the protons of hydrogen began to fuse together and make helium nuclei. The nuclear fusion reaction that turned hydrogen into helium released enormous energy and the newborn sun began to shine. Today, the sun is over 860,000 miles in diameter (100 times bigger than Earth and 400 times bigger than the moon). Nuclear fusion at the sun's core continues to turn hydrogen into helium. At its core, the temperature is around 27 million degrees Fahrenheit. This energy radiates out through the sun's interior towards the surface where cooler hydrogen gas absorbs the energy and bubbles upwards. The sun's visible surface, called the photosphere, cools to about 11,000 degrees Fahrenheit and this energy is carried away as light that warms the entire solar system. The sun fuses more than 500 million tons of hydrogen into helium each second; however, its enormous size ensures that the core will not run out of hydrogen for another five billion years.

WHAT IS A SOLAR ECLIPSE?

A solar eclipse happens when the moon moves between the sun and Earth and casts a shadow on Earth. The moon is about one-quarter the size of Earth, so its shadow is not big enough to expand over the entire planet. Therefore, solar eclipses are only visible from within the specific area on Earth where the moon's shadow falls. The area under the shadow constantly moves because both the moon and Earth are in continuous motion. Earth continuously rotates around its axis while it orbits around the sun and the moon is constantly moving around Earth.

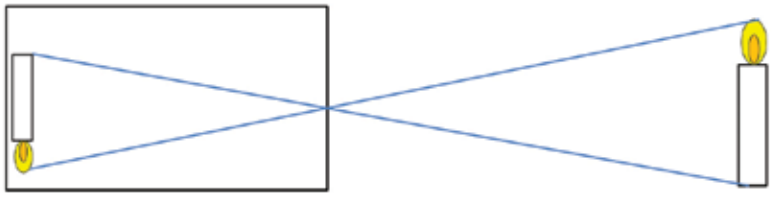
For a solar eclipse to take place, the sun, the moon, and Earth must be aligned in a near perfect straight line – an alignment astronomers call syzygy. A solar eclipse only occurs when the orbit of a new moon brings it close to Earth so it appears bigger and its orbit crosses the orbital plane of Earth and the sun.

During a solar eclipse, the moon casts two shadows on Earth. The first shadow is called the umbra (uhm-bruh). This shadow gets smaller as it reaches Earth. It is the dark center of the moon's shadow. The second shadow is called the penumbra (pi-nuhm-bruh). The penumbra gets larger as it reaches Earth. People standing in the penumbra will see a partial eclipse. People standing in the umbra will see a total eclipse.

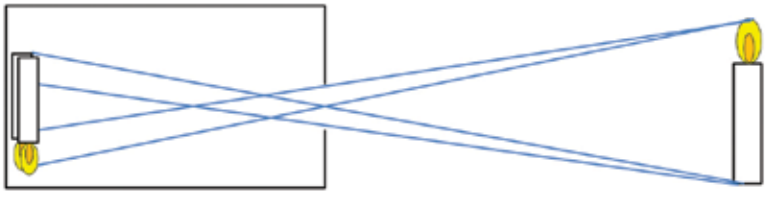
More information about solar eclipses can be found at **https://www.nasa.gov/eclipse**.

HOW DOES A PINHOLE CAMERA WORK?

A pinhole camera is a simple camera with a tiny aperture, or pinhole, in one side instead of a lens. The pinhole acts as a lens to focus light and form an image. Light passes through the hole and projects an inverted image on the screen on the opposite side of the box. Pinhole cameras work because light travels in a straight line. Light from an object travels in all directions. The small pinhole only lets through light rays that are traveling in one direction straight from the object. The image formed is sharp and upside down because only a narrow beam of light from each point on the object can pass through the hole to create a point of light on the screen. The image will be sharp, but dim because only one ray of reflected light from each part of the object makes it through the hole to create the image on the screen. The fact that pinhole cameras create sharp, but dim, images make them perfect for safely viewing the sun.



If the pinhole were enlarged, the image would get brighter, but less sharp. The bigger hole allows more light rays to pass through and illuminate different points on the screen, making the image appear blurry.



SCIENCE talk

ORBIT
The curved path of a celestial object or spacecraft around a star, planet, or moon.

PINHOLE CAMERA
A camera with a pinhole aperture and no lens.

SHADOW
A dark area made by a body blocking rays of light from shinning on a surface.

SOLAR ECLIPSE
A solar eclipse occurs when the moon passes between the sun and Earth and the moon fully or partially blocks the sun.

SUN
The star at the center of our solar system that all other objects in the solar system orbit.

engage

What is the sun? *Young people's choice.*

What is the moon? *Young people's choice.*

What is a shadow? *Young people's choice.*

What is a solar eclipse? *Young people's choice.*

Can you safely look directly at the sun or a solar eclipse? *No! Ultraviolet radiation from the sun will hurt your eyes. You need to view the sun using special solar glasses that have a special filter or by using a pinhole camera to look indirectly at the sun. Never look directly at the sun even if you are wearing sunglasses.*

what YOU WILL NEED

FOR THE GROUP:

- **A pushpin** *(for teacher use only)*
- **Tape**
- **Scissors**

FOR EACH CHILD:

- **¼ sheet of white paper**
- **1 cardboard tube**
- **1 small square of aluminum foil**

& before YOU BEGIN

1. Collect at least one cardboard, or paper towel, tube for each young person. Invite families to provide the tubes. The longer the tube used to make a pinhole camera the clearer the image will be. If enough tubes are available, young people can tape two cardboard tubes together or use long mailing tubes.
2. Cut white paper into four equal-size squares, one square for each young person.
3. Tear aluminum foil into squares large enough to cover the end of a cardboard tube. Tear one square for each young person.

EXPLORE & EXPERIMENT

1. **Explain to young people that they are going to make pinhole cameras** so they can safely look indirectly at the sun and observe the solar eclipse happening on August 21, 2017.

2. **Ask young people to move around the room** and create shadows.

3. **Ask young people to explain how a shadow is made.** Share that shadows form when light is blocked from shining on a surface. A shadow forms in the exact shape of the object that is blocking the light. Explain that the fact that light can be blocked in this manner tells us that light travels in straight lines.

4. **Explain that a special camera can be made that utilizes the straight lines in which light travels.** This camera, called a pinhole camera, uses a tiny hole instead of a glass or plastic lens to focus the light into a picture. Pinhole cameras have been used for hundreds of years to create pictures.

5. **Have each young person gather** a cardboard tube, square of aluminum foil, and square of white paper.

6. **Have young people cover one end of their tubes** with a square of aluminum foil and tape in place.

7. **Have young people cut a slot about one-inch long by one-inch wide** on the other end of their tubes. This will be the viewing window.

8. **Have young people create a screen to view images by taping a square of white paper tightly over the open end of the tube where the slot is.** The paper will not form around the tube easily. The simplest way to attach it is by taping one corner at a time to form a tight fit.

9. **Use a pushpin to carefully poke a small, clean hole** in the center of the aluminum foil of each young person's cardboard tube.

10. **If time allows, have young people decorate their pinhole cameras** with a sunny theme.

11. **Now that young people have created pinhole cameras, encourage them to point the pinholes of their cameras at a bright object in the room to discover if any images form on the paper.** Invite young people to share their discoveries. They might not be able to see anything at first as the room might be too bright and the images formed too dim. If so, turn off the lights and have young people point the ends of their cameras toward the light shining through any windows and invite young people to share the results. Pinhole cameras only work well when the object being viewed is bright and far away.

12. **Explain how pinhole cameras work.** If young people saw an image, ask if it was upside down or right side up. Explain that the images seen in a pinhole camera are upside down because as light travels straight through the hole, the top of the object being viewed travels to the bottom of the image being made.

13. **Take young people outside** to a sunny spot.

14 **Instruct young people to align their cameras so that the pinhole is pointing directly toward the sun.** Share with young people that the best way to do this is to hold their tubes in one hand and slowly orientate them so they do not cause a shadow on the ground. When aligned correctly and pointing directly at the sun, young people should no longer see a shadow of the tube on the ground and should only see a shadow of their hands holding the tube. Now, have young people gently move the bottom of their tubes around slightly until a disk of the sun appears on the white paper. Explain that the sun is very far way, so small movements will make it move large distances. Encourage young people to be patient and take their time to find the sun's image.

15 **If the cameras are used to view the sun at times other than during a solar eclipse, young people may be able to see black spots on their images of the sun.** These are known as sunspots. Sunspots are cooler (but still hot!) areas of the sun caused by magnetic storms on its surface.

make THE CONNECTION

Collect a large ball, a small ball, three plastic cups and a flashlight. Challenge young people to set up a model of a solar eclipse using these materials. Ask questions to guide young people in the construction.

- ☐ What could the cups be used for? *Supports to hold the balls and flashlight.*
- ☐ What could the flashlight be used for? *It is bright and gives off light just like the sun.*
- ☐ Is Earth or the moon bigger? *Earth is about four times larger than the moon, so the large ball could be Earth and the small ball the moon.*
- ☐ Is the moon closer to Earth or the sun when it is between Earth and the sun? *It is a lot closer to Earth.*
- ☐ What does each part of the model represent? *The large ball is Earth, the small ball is the moon and the flashlight is the sun.*

To make a model of a solar eclipse, place the small ball in front of the large ball and shine the flashlight on the small ball. A perfect, distinct shadow will be visible on the large ball when all three items are in alignment. This represents how the moon blocks the sun and casts a shadow on part of Earth to create a solar eclipse. Encourage young people to experiment with moving the moon (small ball) and the sun (large ball) to note how the shadow changes.

EXTEND & EVALUATE

Challenge young people to draw a diagram of the alignment of Earth, the moon and the sun during a solar eclipse.