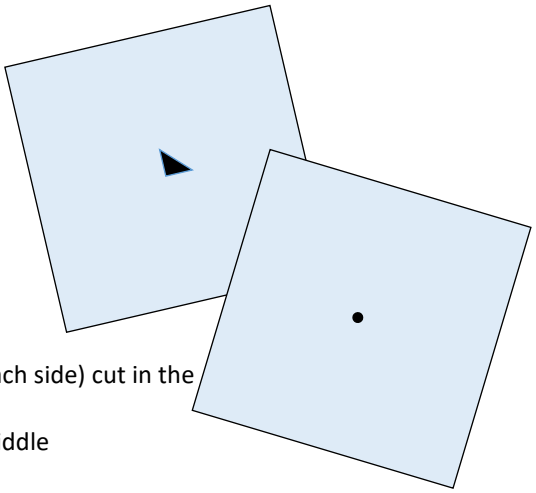
LIGHT AND SHADOWS AND PINHOLE IMAGES

Ages 10-14, grades 5-8



Description

In this activity, students will discover how a small hole can be used to make an image.

Materials

- A cardboard square (about 10 cm on a side) with a triangle (about 1 cm each side) cut in the middle.
- A second cardboard square with a small (few mm diameter) hole in the middle
- 3 LED finger lights or LED keychain lights
- Bare filament bulb, preferably with a long straight filament (like a fish tank bulb)
- Optional, for pinhole viewer: Small cardboard carton, aluminum foil, wax paper

Watch our video on how to make the pinhole viewer: https://youtu.be/mxY9ouCx_UE

LED finger lights are sold in dollar and big box stores, and they are different colors which makes it easier to track each bulb's path. If you can't find a bare long filament bulb any bare filament bulb will do, or use a spiral compact fluorescent bulb. It's easier to explain a long filament being made up of a row of very, very tiny light bulbs.

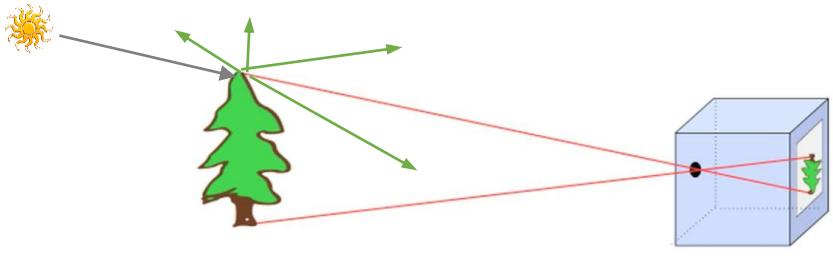
Background and Misconceptions

When light travels from a source (like a light bulb or the sun), it moves in straight lines unless it encounters a material where it may be absorbed, reflected or refracted (a change of direction as it passes through the material). By passing light through a small opening it is possible to create an image without a lens. This is called a *camera obscura* (for "dark room") or pinhole image.
Be sure students predict what they will see before they try each of the activities. If the observation doesn't agree with the prediction, ask them to figure out why before proceeding to the next activity.

Teacher Guided Questions to Inquiry

Use these questions to get students started on their own inquiry. The activities will walk students through the steps of forming a pinhole image. More information is available at www.lasertechonline.org/Light_and_Shadows.html

1. **How does light travel and how do you know?** (In empty space, light travels in straight lines. When we draw these lines we call them "rays". You can sometimes see rays when sunlight passes through clouds or through a window into a dusty room.) The rays are light traveling in straight lines.)
2. **Look at one object in the room. What are all the sources of light that illuminate it?** (There can be many sources- sunlight through a window, room overhead lights, light leaking in from a corridor, an illuminated computer monitor, etc. Illumination and reflection are important to vision as well as camera operation.)
3. **How does light reflect from a rough object, say, a person's face?** (Many students - and adults- think only mirrors reflect light. But rough objects such as skin, cloth, trees and wood also reflect light. In this case the reflection is *diffuse*, or, in all directions. This allows an object to be seen from many vantage points at once.)
4. **Can you make an image without a lens?** (People have known for more than a thousand years that light passing through a tiny hole can project an image onto the wall of a darkened room. Light from the sun striking the top of the tree below is reflected in all directions (only a few are shown). Only a very small cone of rays is able to pass through the tiny hole and these rays strike the back of the box near the bottom. In the same way, light from the bottom of the tree strikes the back of the box near the top. You can make the same argument for all the rays from points along the tree facing the box. Because the hole is so small, the rays from the top and bottom do not overlap and an upside-down image is formed on the back of the box.)



Guided Inquiry

Activity 1: How does light travel?

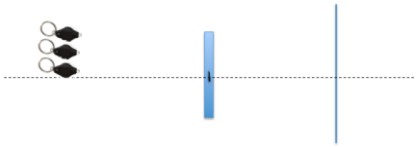
1. Place the cardboard with the triangle hole about 30 cm from a wall, and the LED about 30 cm to the other side. *What will you see on the wall? Make your prediction by drawing or writing what you think you will see.*
2. Move the LED up. *What will you see on the wall?* Move the LED down. *What will you see on the wall?*

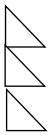
The triangle on the wall moves down when the LED moves up and vice versa.

3. How does light travel from the LED to the wall? What happens to rays that don't go through the hole?

Activity 2: Two, three and millions of LEDs

1. Suppose you use two LEDs, one above the other. *What will you see on the wall?* How about three LEDs? (You will need a friend to help with this.) *What will you see on the wall?*



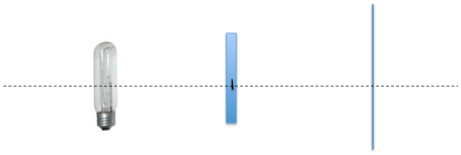


You will see one triangle for each LED.

2. What if you used thousands of bulbs in a row? You can't actually do this, but think about what you would see.

Activity 3: Pinhole image

1. A light bulb filament can be thought of as millions of points of light (like LEDs) strung together. Replace the LEDs with a bare long filament (or other bare filament) light bulb. Turn off the lights to help you see the image better. *What will you see on the wall?*
2. Make the room as dark as you can and replace the triangle hole with the small round hole. Look carefully at the image on the wall. What do you notice?



The large triangle image will be fuzzy, with a pointed triangle top. The small hole makes a dimmer but sharper image. The image is upside down!

Activity 4: Pinhole viewer (Optional)

1. Make sure the carton is solid, with no place for light to leak in. If there are small holes at the corners, cover them with electrical tape.
2. Make a small (about 3 cm) square hole on one side. Make a larger (about 15 cm) square hole on the side opposite. Seal up the box.
3. Cut a square of waxed paper larger than the large square and tape it over the hole.
4. Make a pinhole: Use a very sharp pencil to poke a small hole (2-3 mm) in a 5 cm square of aluminum foil. The hold should be smooth and round. Tape the foil hole over the smaller hole in the box.
5. Point the pinhole toward a source of light and look at the screen on the other side. Describe the image- is it upside down or right side up?

Analysis Questions

1. How does light travel?
2. Under leafy trees you can sometimes see overlapping round circles of sunlight. What are these? Where do they come from? Why are they crescent shaped during an eclipse?