Eclipse Shadow Simulator

An activity to prepare people for the eclipse of 2017

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Background

Almost everyone in North America will be in a position to experience a total or a deep partial solar eclipse, weather permitting. While many people are planning to travel to the path of totality, most people do not have the compelling interest to travel, or lack the time and means to make a special trip. For these people, the partial eclipse is still accessible and worthwhile experience. Planetariums can publicize ways to experience the eclipse and host events that include eclipse glasses, and telescopes, filtered or projected. Making and observing eclipse shadows is another activity that planetariums can encourage people to do.

Why Eclipse Shadows?

- People can observe eclipse shadows whether they are in the path of totality or not.
- People can easily and inexpensively take an active part in planning and creating eclipse shadows.
- Eclipse shadows can be unusual and surprising, inspiring wonder and curiosity.
- Making and observing eclipse shadows is a safe way to experience a solar eclipse.
- Photos of eclipse shadows are a way to record and share an eclipse experience.

What can an eclipse shadow simulator do for planetarium visitors?

- Inform visitors of an active way to experience the upcoming eclipse.
- Let visitors “rehearse” making eclipse shadows so that they will be prepared.
- Give visitors a hands-on experience of light and shadow.

What are the limitations of the eclipse shadow simulator?

- The eclipse shadow simulator, as described here, is not a good explanation for the mechanism of an eclipse. While the shadows and the experience of making them is authentic, the scale, position and motion of the Sun and Moon are all wrong. Use other methods to demonstrate what actually causes a solar eclipse.

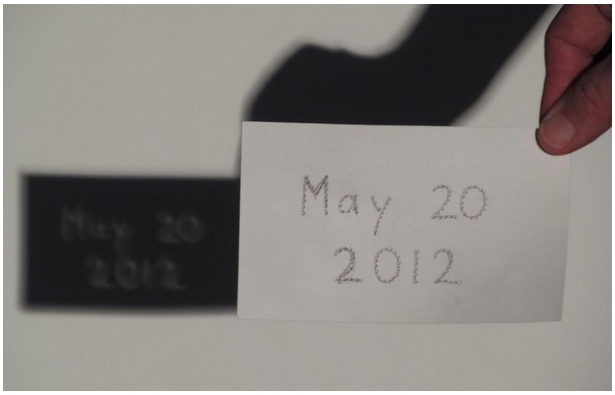
About Eclipse Shadows

Most people know that the shape of a shadow has a lot to do with the shape of the object that is blocking the light. For instance, a person’s shadow is shaped roughly like the person. A shadow’s shape, however, is also influenced by the shape of the light source. This is particularly noticeable around the edges of shadows and also for shadows cast on a surface

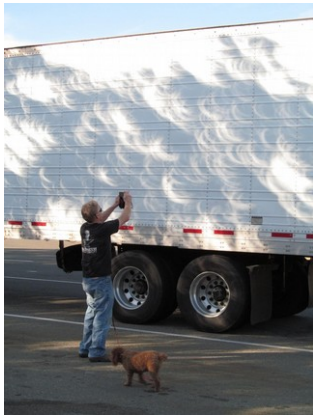
that is far from the object that is making the shadow, such as the shadow on the ground of leaves of a tall tree. The ultimate example is the shadow of a pinhole. Whatever the shape of the hole, the shadow takes the shape of the light source. This is the basis for the pinhole camera.

The shape of the sun appears to us as a disk. If the sun were a point, all shadows caused by sunlight would have sharp edges. As it is, shadows caused by sunlight have edges that are fuzzy. Light from the sun that passes though a small hole does not make a point-like spot, but causes a patch of light that is disk shaped, like the sun appears to us. This can be seen if you let sunlight shine through a pinhole onto a smooth surface. The closer pinhole is to the surface that the shadow is cast on, the smaller the spot, and the more it is shaped like the hole. The farther the pinhole is fromt the surface, the larger (and dimmer) the spot is, and the more it is shaped like the “disk” of the sun. This happens naturally when sunlight filters through the small spaces between the leaves of trees and makes circular spots of sunlight among the shadows of the trees on the ground.

During the partial phases of an eclipse the sun appears as a disk with a bite out of it. When the bite is large, the edges of shadows become strangely non-uniform. Sunlight passing through small holes makes crescent shapes rather than circles. The small holes may be natural, like the spaces between the leaves of trees, or they may be made intentionally. Eclipse shadows that are “found” and eclipse shadows that are created intentionally are both interesting.



Pinhole shadows showing the date made with a pushpin and an index card.

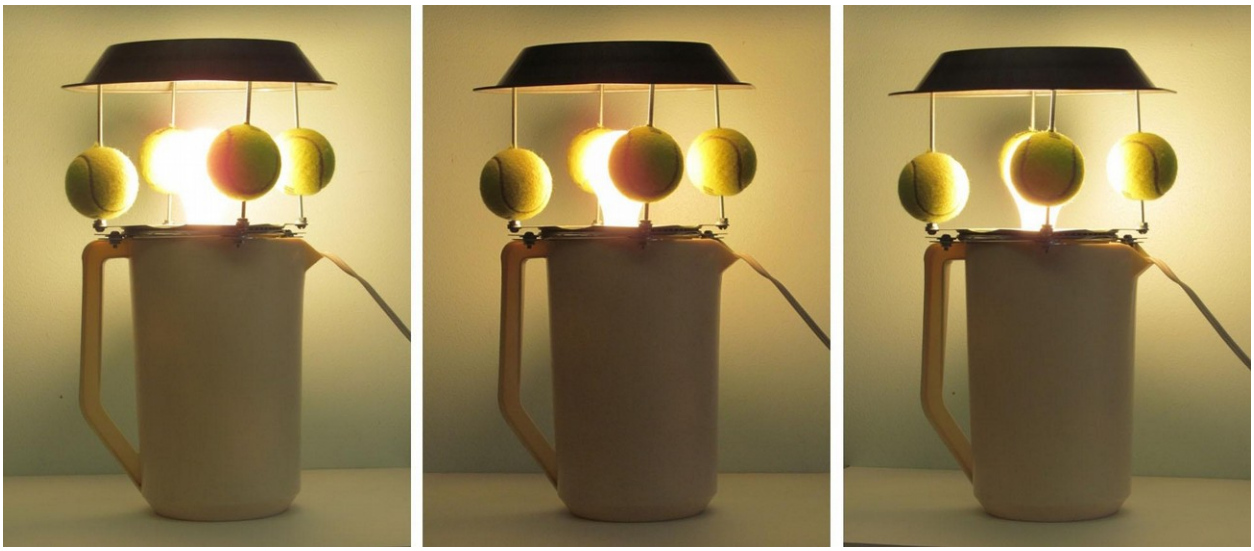


A white truck happened to park in the shadow of some trees—A lucky arrangement.

The Eclipse Shadow Simulator

The eclipse shadow simulator described here is the prototype version shown at the 2016 LIPS symposium. It is one of many possible designs, and improvements (a motor, for instance) are expected of anyone who makes one. This one is made to be used in the center of a very dark space, such as a planetarium, with participants arranged in groups around it about two to four meters away.

The Simulator has a light source, roughly spherical, and four eclipsing spheres on a bearing. As the user rotates the bearing, as series of eclipses happen, as quickly as desired and repeating as often as desired. Participants investigate the shadows and how they change as described below.



Materials:

For the Simulator itself:

1 clip-on lamp fixture with “conical” reflector
1 lamp socket extension with outlets
1 lamp socket extension without outlets
1 incandescent light bulb, 100–200 Watt
1 lazy-susan bearing, 6”
4 tennis balls with holes drilled in the poles
4 machine screws, round head, 3/16 width, 6” long
4 machine screws, round head, 3/16 width, 1/2” to 3/4” long
8 nuts for 3/16” screws
16 washers for 3/16” screws
4 fender washers (large washer, small hole) 1 ¼” outside diameter.
1 metal cake pan, round, 9”
1 cylindrical tube, about 6” diameter, 8 inches long, to serve as a base.

Other Materials for Participants

A variety of objects with holes, such as
colanders, spoons with holes, peg-board pieces, fly swatters
Index cards, blank, white
Nails, push pins, or other items for puncturing the index cards.
Bulletin board material, rectangles as big or bigger than index cards.

Notes on materials:

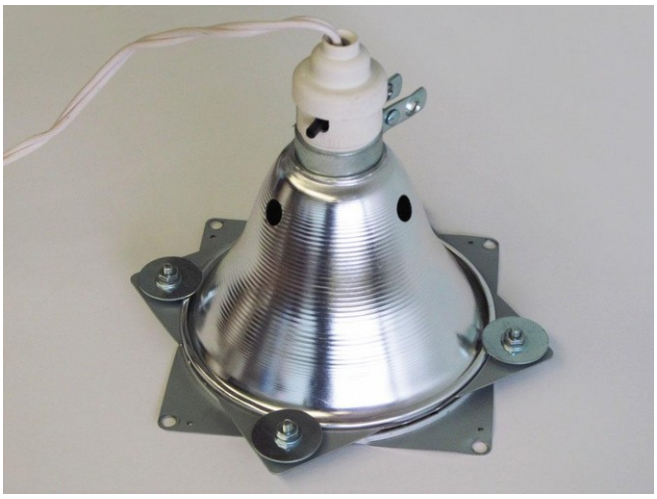
- Reflectors for clip-on lamps commonly come in two different styles, one that is more hemispherical, and one that is more conical. The conical style just happens to fit well

against a 6” lazy-susan bearing. Functionally, the only thing the reflector does in this apparatus is connect the lamp to the bearing. One could redesign the apparatus without it.

- The lamp socket extenders are simply to position the light bulb outside the reflector. The two described above do the job, but there could be other combinations that work. If you redesign it without the reflector (see above) then you might not need the extenders.
- I have used a 200 Watt bulb to demonstrate this apparatus in dark room. In the planetarium we have found that a 100 Watt bulb is sufficiently bright to make the effect work. The size of the bulb should be similar to the size of a tennis ball, or whatever your eclipsing sphere will be. I have not found a sufficiently bright LED bulb of the correct size, but if you have one it might be a preferable alternative.
- For the cylindrical base I have used a plastic pitcher when I demonstrate the apparatus outside the planetarium. The spout makes room for the cord to come out. In our planetarium we have a custom made mount that can be raised during the activity and lowered afterward.

Assembly:

Attach the lazy-susan bearing to the reflector cone. Place the large end of the cone on the side of the bearing with the holes less close to the corners. Use the short machine screws and the fender washers to hold it in place. Use 2 smaller washers as spacers between the bearing and each fender washer, and secure each fender washer with a nut.



Add four long machine screw. On the side of the bearing with the holes near to the corners, insert a long machine screw into each corner of the bearing, pointing away from the lamp, and secure them each with a washer and nut.

Add the light bulb. If you have removed the reflector from the lamp fixture, screw it back on. Screw in the lamp socket extensions, and then screw in the 200 watt light bulb. The round part of the bulb should extend beyond the lazy susan-bearing.

Add the tennis balls. Drill a 3/16 hole in opposite sides of each tennis ball. (Now have fun cleaning the gunk and the fuzz off of the drill bit.) Impale each tennis ball, one onto each of the long machine screws. Slide them to various positions so that they eclipse the light bulb to varying degrees as you spin the bearing.

Set it up. Place the lamp upright in the cylindrical base. Place the cake pan upside-down on top, supported by the ends of the four screws. This keeps light from illuminating the dome or ceiling and interfering with the darkness of the room.

Suggested Outline for Using the Eclipse Shadow Simulator:

Warn the participant that even though the light is not nearly as bright as the sun, it is unpleasant to look at. Not looking at the light will be good practice for not looking at the sun during the partial phases of the eclipse.

Distribute objects with holes (colanders, etc.) and index cards to groups of participants around the room. Have them make shadows of the objects on the index cards while you slowly rotate the lazy-susan bearing. Avoid having your own shadow fall on any of the groups. Have groups discuss how the shadow changes as the tennis balls eclipse the light bulb. Encourage them to try holding their objects at different distances from the index card.

If you like, you may recruit an adult volunteer to take a turn at slowly spinning the simulator so that you may circulate among the groups. If you motorize your apparatus, this all becomes simpler.

Have participants share out loud what they observe, and allow them to swap objects with other teams. Tell them that the changes they observe in the shadows are like the changes they will observe during the solar eclipse. Tell them that during the real eclipse the shadows will be better looking. The whole process will be slower, and it will not repeat the way it does with the simulator.

Let groups design their own shadow makers. Distribute more index cards to each team, the piece of bulletin board, and the push-pin, nail, or other hole-making device. Suggest that they start with one hole, and then with a few holes of different sizes. They can enlarge holes by wiggling the hole-making device. Then suggest that they make their own patterns of holes. Patterns can be any shapes, including spelling out words with holes. To the extent possible in your facility, do some show-and-tell among the groups.

Connect the activity to the coming eclipse. Tell participants that they have rehearsed for the eclipse. Between now and the eclipse they can find or construct more objects with holes so that they will be ready to make special shadows when the actual eclipse happens. They can take pictures of the shadows to record and share their experience of the eclipse. Invite them to post their photos to the media site for your facility.