

Cardboard Opaque Projector

Category: Physics: Light & Optics

Type: Make & Take

Rough Parts List:

1	1' Square cardboard box
5	Small pieces of cardboard or foam board
1	6" x 10-17" mirror
1	3" Diameter cardboard tube
1-2	Clip light with 23W compact florescent bulb or strong flashlight
	73mm +3.0 or 3.5 convex lens with about a 12" focal length (source: www.allectronics.com)
1	

Tools List:

Duct tape
Hot glue gun
Small wood saw
Utility knife
Protractor or 45 degree square

Video: www.youtube.com/user/OaklandCSW

Blog Link: www.oaklanddiscovery.blogspot.com

How To:



Collapse the box. Mark the center on the bottom of the box by using a straight edge to create an X from the corners.

Center the cardboard tube over the X and trace around it. This marks where the lens barrel will be.





Fold up the box leaving the top open. Tape up any seams on the sides and bottom of the box with duct tape to block out the light.

Fold the top flaps inward and hot glue them in place along the edges. Hot glue the bottom flaps of the box as well.



Cut a 5"x5" piece of cardboard. Center and trace the cardboard tube. This will be used as a collar to hold the barrel straight.

Cut out the lens barrel hole on the box using a utility knife.



Hot glue the lens barrel collar over the hole using the lens barrel to help align it.

Mounting the mirror can get a little complicated. It is important to mount the mirror inside the box at a 45 degree angle. Use a protractor or 45 degree square to help.



The mounted mirror should have one end on the bottom of the box and the other end attached opposite the lens barrel as pictured.



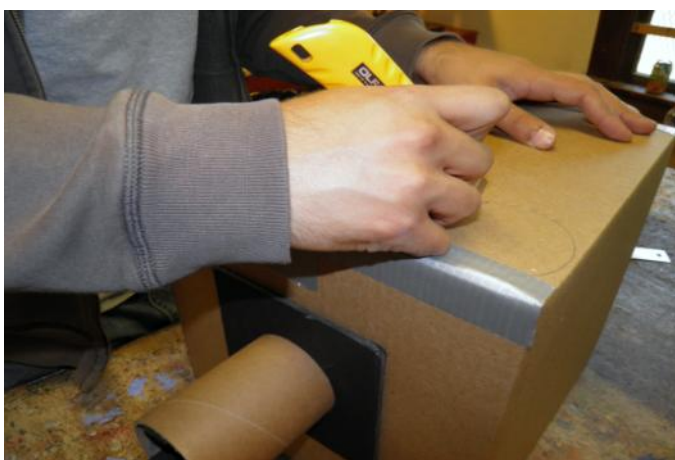
Hot glue strips of cardboard onto the box to create grooves for the mirror to fit snugly. Make sure the mirror doesn't slide around.



Hot glue 3 small pieces of cardboard 1.5" from one end of the tube. Place the lens inside the tube so it rests on the cardboard pieces.



Hot glue three more pieces of cardboard to the tube to keep the lens securely in place.



Use the cardboard tube to trace two circles onto the side of the box as shown, opposite the mirror and in the corners closest to the lens barrel.



Insert the cardboard tube into the lens barrel collar with the lens facing closest to the mirror.



Choose an image, such as this book to use in the projector. Place the image underneath the projector. The top of the projector is the side with the two holes cut out.

Place one or two light sources into the open circles to project the image onto a wall. Start by placing the projector about XXX inches from the wall. Make the room as dark as possible for better viewing.

Fine Points:

- If you are having trouble getting the angle of the mirror right, it might help to use a piece of wood to prop one end of the mirror on.
- Focus the lens by moving it up and down in the lens collar. A thick rubber band around the tube can help hold it securely in place once the focus is adjusted.
- Florescent bulbs will produce brighter and clearer images than flashlights.
- *Do not use incandescent bulbs. These get very hot and pose a fire hazard!*
- Paint the inside of the box white or cover it with aluminum foil to create a brighter image.

Concepts Involved:

- Light is reflected by the mirror.
- The angle of the mirror determines the angle that light will be reflected.
- The lens is concave and creates a bigger image by causing light rays to diverge from the source.

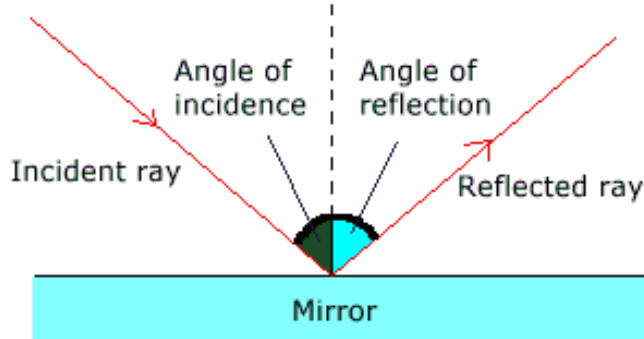
Focus Questions:

1. What would happen if the mirror wasn't angled at 45 degrees?
2. Try moving the projector farther away from the wall. Does the size of the image change? Why?
3. Why do you think painting the inside white or covering it with foil create a brighter image?

Elaboration:

Opaque projectors are the ancestor of the more modern overhead projector. The opaque projector works by creating a very bright chamber inside a dimly lit room. An image is placed underneath the projector. The image can be opaque; no transparencies are necessary because light isn't passing through the image as it would in a modern overhead projector. The light inside the projector reflects off the mirror and is directed through the lens. The lens projects the image into the room onto a surface such as a wall.

The mirror in the projector causes the light to reflect, or bounce back. The flat mirror used in this project is called a plane mirror because it reflects light rays in the same order that they approach the mirror. The angle at which the light approaches the mirror is called the angle of incidence. Since the mirror is placed at 45 degrees, the angle of incidence is 45 degrees. Light is reflected from the mirror at an angle called the angle of reflection. The angle of reflection is always equal to the angle of incidence in a mirror.



<http://www.pitlochry.pkc.sch.uk/Science%20Outcomes/chapter%2015%20-%20notes.htm>

Light travels through the lens and hits the wall. A lens is a transparent piece of glass or plastic that has a curved surface. A lens refracts, or bends, light rays as they pass through. The lens you are using has a center that bulges outward; this is known as a convex lens. Convex lenses can create images. The size of the image depends on the distances between the object and lens and between the lens and the screen.

Links to k-12 CA Content Standards:

Grades k-8 Standard Set Investigation and Experimentation:

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

Grades k-12 Mathematical Reasoning:

1.0 Students make decisions about how to approach problems:

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
- 1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:

- 1.1 Use estimation to verify the reasonableness of calculated results.
- 1.2.2 Apply strategies and results from simpler problems to more complex problems.
- 1.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
- 2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:

- 3.1 Evaluate the reasonableness of the solution in the context of the original situation.
- 3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
- 3.3 Develop generalizations of the results obtained and apply them in other circumstances.

Grade 3 Standard Set 2. Physical Sciences:

2.b Students know light is reflected from mirrors and other surfaces.

Grade 7 Standard Set 6. Physical Principles in Living Systems (Physical Sciences):

6.d Students know simple lenses are used in a magnifying glass, the eye, a camera, a telescope, and a microscope.

6.f Students know lights can be reflected, refracted, transmitted, and absorbed by matter.

6.g Students know the angle of reflection of a light beam is equal to the angle of incidence.