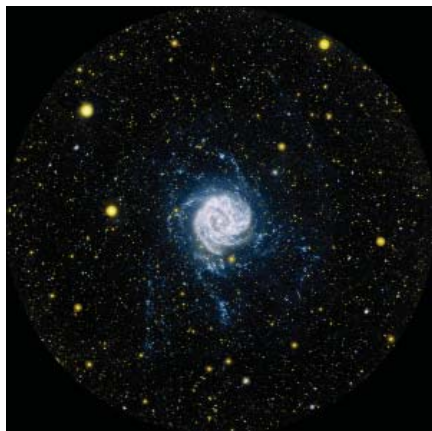


Make a Pinhole Camera



The Southern Pinwheel Galaxy, or M83, is shown in ultraviolet light in this image. NASA's Galaxy Evolution Explorer (GALEX) spacecraft took this picture of M83 at intervals between March 15 and May 20, for a total exposure time of 3 hours 42 minutes. In

fact, it is one of the "deepest," or longest-exposure, images of a nearby galaxy ever made in ultraviolet light.

Many GALEX images have exposure times of several hours. GALEX is not only "seeing" a wavelength of light that is invisible to our eyes, but it is also seeing light that is much too dim to register on even its sensitive detectors without exposing them for a very long time. So GALEX's images are pictures of light recorded over time, thus revealing information that would otherwise be unknowable.

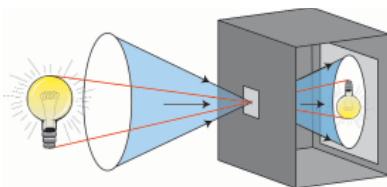
On Earth, using ordinary visible light, we can also create a single image of light recorded over time. Of course a movie or video is light recorded over time, but it is a series of instantaneous snapshots, rather than light and time both recorded on the same medium.

A pinhole camera, which is simple to make out of ordinary materials and using ordinary photographic film, can be placed anywhere and left for several minutes to record whatever photons enter it. Like GALEX, it can be placed in dim light or nearly in the dark, and, if left open long enough, will record an impression of all that goes on in its field of view.

How does a pinhole camera work?

A pinhole camera is a light-proof box. Light enters the box through a tiny pinhole on one side and strikes the opposite wall of the box, where light-sensitive paper or film (or even a CCD) records an image. The recorded image is upside down (as in all cameras) and focused because the light rays—which travel in straight lines—do not cross each other inside the box.

A pinhole camera is the opposite of "high-tech." In that way it is very unlike GALEX. However, it uses some of the same basic principles. It is fun at times to go back to the basics and make something with our own hands that we can understand and use creatively.



How to Make a Pinhole Camera

In this activity, you will make your own pinhole camera, and discover its creative possibilities.

Tools you will need

- Bottle opener
- X-acto® knife or mini-utility knife (with new blade), or small, sharp scissors
- Single hole punch (optional)
- Push pin or needle (with "perfect" point)
- Straight edge with metal edge
- Ballpoint pen (ink color other than black is best)

Materials

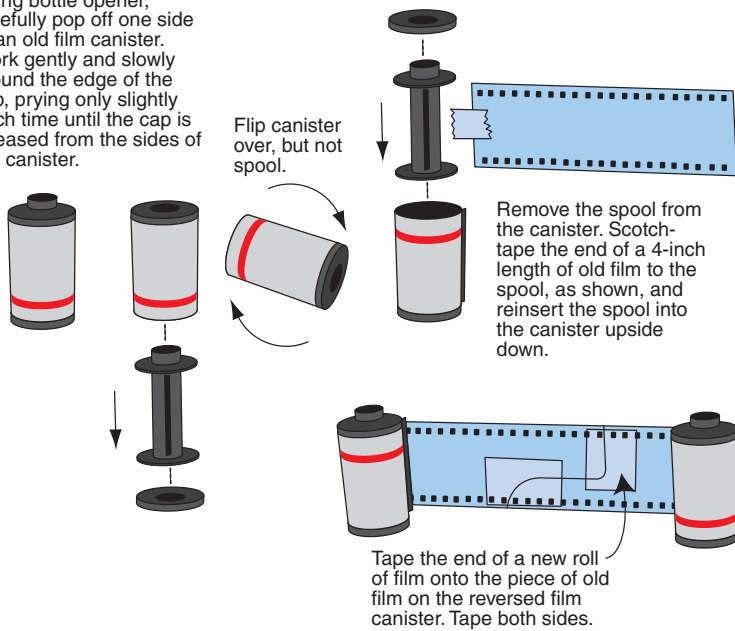
- Cardboard cereal box (single layer, flattened)
- Scotch® tape (*not* the removable kind)
- Black electrical tape
- Disposable aluminum pie tin (any size)
- 35-mm color print film, ISO 200, 24 or 36 exposures
- Empty film canister, with spool (*not* the plastic container with the snap-off cap, but the metal canister that goes inside the camera. May be available free from a "1-hour Photo" facility)
- 4-inch piece of old 35-mm film, developed (negative strip) or not
- Popsicle® stick, cut in half

Read these important instructions first!

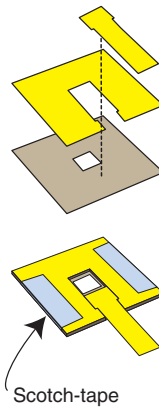
1. Photocopy pattern page at exact size. Do not reduce or enlarge the pattern. The camera is designed to exactly fit the 35-mm film canisters.
2. Scotch-tape uncut page of pattern pieces to non-printed side of cardboard. (If page does not fit on your box without pattern pieces laying on cereal box folds, cut the page apart above the "film chamber" piece, and lay that piece on the other half of the box.) Using straightedge and ballpoint pen, score all fold lines. Press hard! Red or blue pen will help you see which lines you have already scored.
3. Using X-acto knife, first cut out the holes in the camera pieces. When you cut the round holes for film spools, do not cut them too big or you will create light leaks. If you do not have an X-acto knife, you can first cut out the camera body with scissors, then use a single hole punch to start the spool holes. Insert progressively fatter pens to gently enlarge the openings to the correct size for the film spools to fit tightly. To make straight cuts, use the straightedge to guide the knife. Hold knife vertically. Don't press too hard, but go over the cuts two or three times to get through the cardboard.
4. Fold pieces on score lines and assemble as shown.

Step 1: Reversed film canister

Using bottle opener, carefully pop off one side of an old film canister. Work gently and slowly around the edge of the cap, prying only slightly each time until the cap is released from the sides of the canister.



Step 2: Shutter

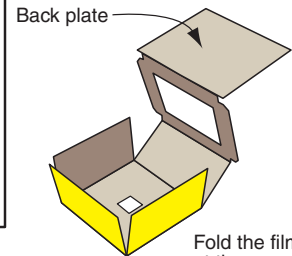


Step 3: Pinhole

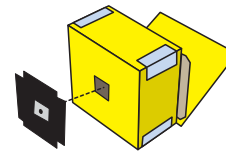


Using a circular motion, carefully push just the tip of a push-pin or needle into a small piece of thin aluminum. The pinhole should be very, very small!

Step 4: Film chamber

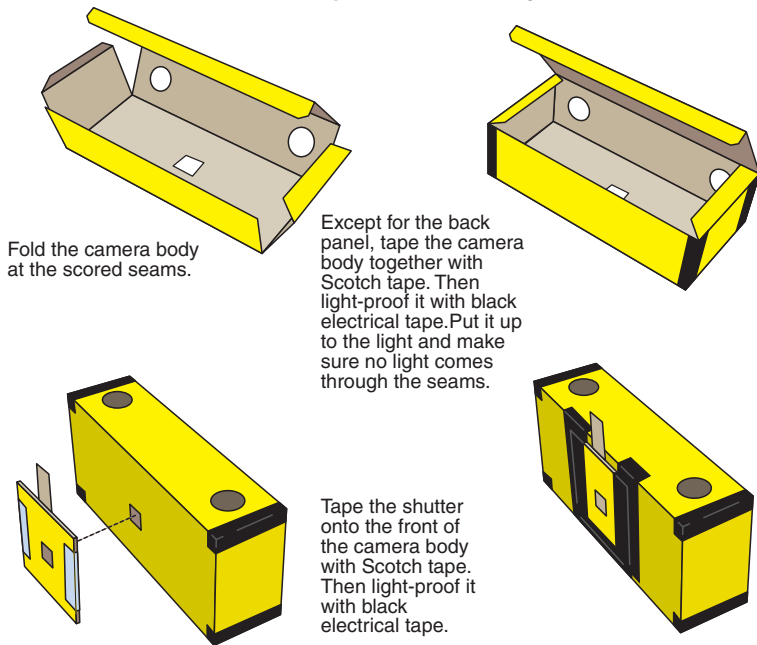


Fold the film chamber at the scored seams.

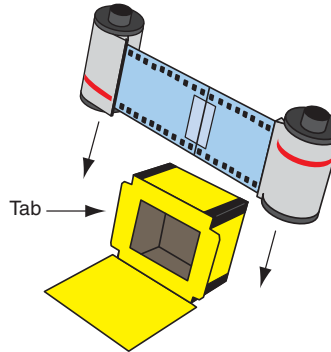
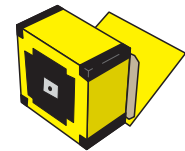


Except for the back plate, tape the film chamber together with Scotch tape, then light-proof it with black electrical tape. Put it up to the light and make sure no light comes through the seams.

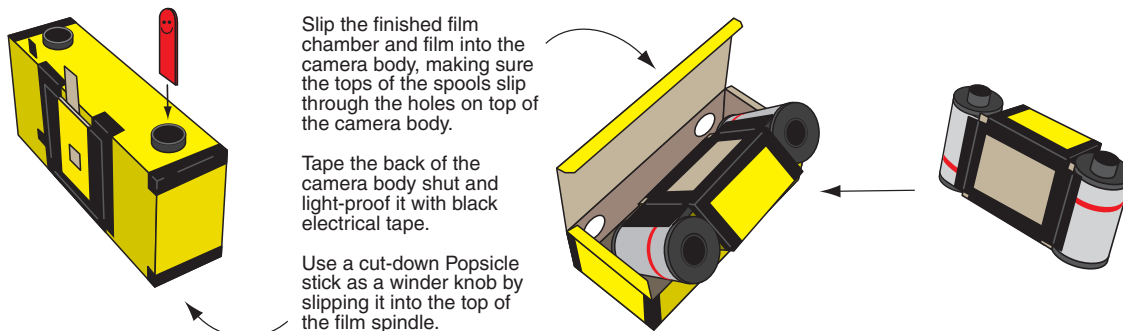
Step 5: Camera body



Tape the piece of aluminum containing the pinhole onto the front of the film chamber with black electrical tape, centering it over hole.



Step 6: Put it all together

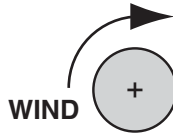


Tape this exposure guide to the back of your camera

Sunny: 1 to 2 seconds
Cloudy: 5 to 10 seconds
Indoors: 1 to 3 minutes
Night: 10 to 15 minutes
Wind film a full turn after every shot.



REWIND



WIND

Back Panel

Shutter

Shutter

Camera Body

Film Chamber

Cereal Box Pinhole Camera Plans

Print or copy at 100%. Discard all grey areas.

Taking pictures

Consult the exposure guide that you taped to the back of the camera. Because of the long (1 second to 15 minutes or more) exposure times needed, it's best to set the camera on a solid surface so it won't move during exposures. Pull the shutter tab up to expose film, and push it back down at the end of the desired exposure time. Try not to jiggle the camera when you open and close the shutter.

Don't forget to advance the film! Turn the winder stick one complete 360° turn right after every picture you take.

Photos taken with a pinhole camera are different from other photos. They are usually a little fuzzy. However, all parts of the image will be equally in focus, which may give the image a soft, ethereal quality.

Keep a record of exposure times while taking pictures for the first roll or two of film to help you learn the idiosyncrasies of your camera.

Unloading film from camera

- When you get to the end of the roll, you will feel resistance in the winder stick. Switch the stick to the new film spool and rewind the film back into its canister. Stop when you feel resistance. Your exposed film is safely back in its light-proof canister.
- Carefully remove the tape sealing the back of the camera, and remove the film chamber. Remove the tape from the back plate and film canisters and slip the tabs out of the canisters.
- Remove the tape splicing the new film to the piece of old film taped to the reversed film canister. Use the Popsicle stick to wind the end of the new film into its canister.
- Have film processed and printed by a "1-hour Photo" or similar service. Be sure to tell the technician that the film is from a homemade pinhole camera, and warn them that gaps between the exposed areas will vary. If your prints come back cut off in the wrong places or if unexposed areas of the film are printed, ask them to print them again correctly at no charge.

Types of pictures to try

- Indoors, up close to small, intricate objects, see how much detail you can record.
- Take multiple photos of the same object at varying distances (making note of the distances), and see how the field of view is affected (that is, wide angle or narrow angle view).
- Take pictures outside in sun and in shade, or on a cloudy day.
- Try capturing the night, outside, on a busy street with automobile traffic passing by. You may need exposure times of 10 minutes or more.
- Take a 10-15 minute night ride in the car on city streets. Tape the camera to the car's dashboard. You



Night drive.

will get a true recording of light and time!

- Make a portrait of yourself or someone else, in good light so your subject doesn't have to hold still too long. Try playing around with movement during the exposure—like having the subject move his or her head to appear to have two heads!
- Search for Web sites on "pinhole photography" to see photo galleries that may give you more ideas.

Discussion questions

1. How does the Galaxy Evolution Explorer take images of very faint and faraway objects?
2. Why does a pinhole camera not need a lens?
3. Why are the needed exposure times for photos using a pinhole camera usually longer than for a lens camera?
4. What would happen if the pinhole in the camera were too large?
5. What might happen if the pinhole in the camera were not round?
6. How would the focus of the photos be affected if you could make the pinhole even smaller?
7. How would the exposure time for the photos be affected if you could make the pinhole even smaller?
8. Do you think the size of the box matters when making a pinhole camera?
9. Why is the image recorded on the film inverted in a camera?
10. Do the photos from your pinhole camera express a view of the world a little different from sharp, "high-tech" photos?

This article was written by Diane Fisher and Alexander Novati. Ms. Fisher is writer of The Space Place website at spaceplace.nasa.gov. Mr. Novati is designer and illustrator of The Space Place. The article was provided through the courtesy of the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.