

## Magic Wand

See pictures in thin air.

**When you view a slide show or a movie, where is the picture? Is it on the film, in the air, on the screen, or in the eye of the viewer? This Snack will help you investigate and understand how you see.**

### materials

- A slide projector.
- A 35 mm slide.
- A moveable screen. (A piece of white posterboard will do.)
- A pencil, wooden dowel, or meterstick.

### assembly

(15 minutes or less)

Place the moveable screen in the center of the room, about 6 feet (2 m) in front of the projector. Put the slide in the projector, turn the projector on, and focus the image on the screen. Then remove the screen.

This Snack works better if the light from the projector travels out through a door or window after it passes the point where the screen was.

### to do and notice

(5 minutes or more)

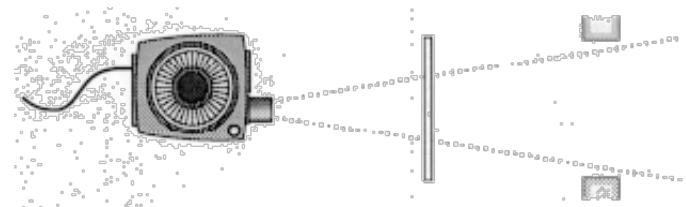
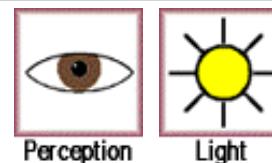
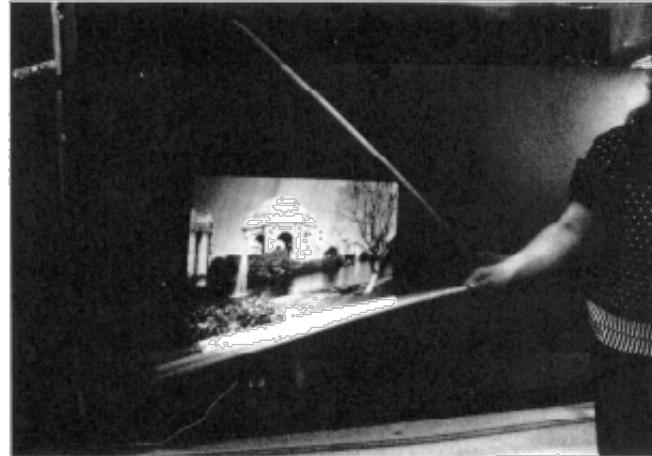
Hold the wand horizontally in the place where the screen was located. Then wave the wand rapidly up and down by flicking your wrist. Notice that the picture appears as the wand moves.

Wave the wand at an angle, or rotate it to trace out a cylinder or a cone. Notice the deformed image that you produce.

### what's going on?

The image is focused in the air. But you can't see the image unless something reflects the light to your eyes. The moving wand reflects the light just as the screen does, except that the wand reflects the image piece by piece.

When this reflected light enters your eyes, it makes an image on your retina. Your eyes retain each piece of the image for about 1/30th of a second - long enough to let you put the pieces together to make a composite picture.



Your eyes' tendency to hang on to an image for a fraction of a second is called *persistence of vision*. Persistence of vision occurs because the light detectors in your eyes, the rods and the cones, continue to fire electrical signals to your brain even after a very short pulse of light has come and gone.

The deformed images produced when you move the rod in the shape of a cylinder or cone are examples of a map projection. The flat image of the slide is projected onto a curved surface. The resulting deformations are like those that occur when the spherical surface of the earth is mapped onto a flat map.

You might wonder if you could see the image by looking directly into the slide projector from the place where the screen used to be. The light in most projectors is too bright to try this experiment. However, the answer is no. Your eye can only make images of the light that actually enters the pupil. When you put your eyes where the screen was, only light from a small part of the image enters your eye. So you cannot see the entire image.

## etcetera

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Persistence of vision is what allows you to see a television picture. One bright dot of light, produced when an electron beam collides with phosphors on the inside front of the picture tube, sweeps across the television screen. The dot sweeps across the screen one horizontal line at a time, sweeping out the entire 525 lines that fill the picture area every 1/30th of a second. Yet you do not see a flying dot; you see a complete picture.

You can do a fun 3-D version of this Snack if the slide you project is of a simple shape, such as a white circle. Hold a stiff piece of white cardboard or foamcore board where the screen would be, and then sweep the board back and forth through the image, moving the flat side toward and away from the projector. The circle will become a white cylinder hanging in space.