

Touch the Paper-Clip

(Another one of those look & see, but CAN'T-touch-it things!)



Materials:

- * Concave mirror (Miracle Mirror from Nada Scientific, out-of-stock!)
- * Box that the mirror came in... or a box with dimensions roughly:
 - * 10 cm x 15.5cm x 23.5 cm box or (4 in. x 6 ¼ in. x 9 ¼ in.)
 - * 15.5 cm x 23.5 cm or (6 ¼ in. x 9 ¼ in.) piece of project board
- * A small paper-clip (colorful works best)
- * Duct tape and clear tape
- * 12-inch ruler
- * Sharp cutting utensil
- * Hot-glue gun with glue sticks
- * Template for front of box (attached)

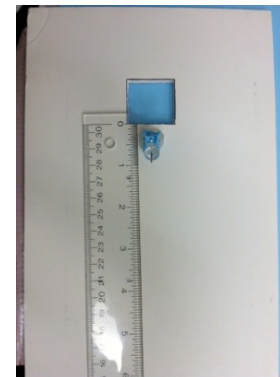
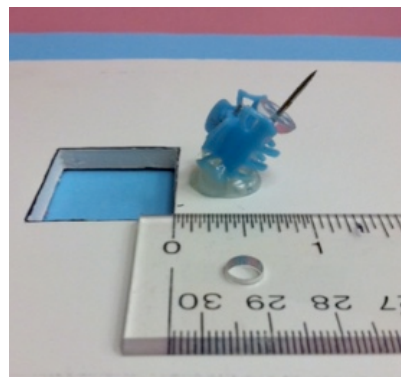
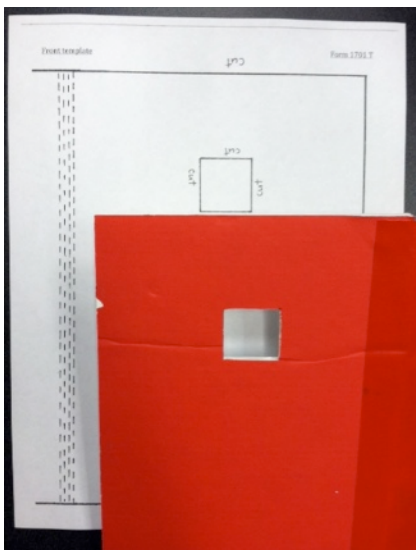
Procedure:

Securely attach (tape down) the base of the mirror to the bottom of the box. For the best results, the mirror should be all the way to the top and centered in the box. (see pic. to the left)

Cut and remove the upper portion of the box-top so that only the mirror is visible. (see pic. to the left) If this seems too difficult, just remove the whole box-top.

Using the template (Form 1701 T) provided, trace the front cover and carefully cut out ONLY the darkened heavy lines of the project board. Do NOT cut out the dashed lines on the left side of the front cover (the project board) yet!

Very carefully cut out the viewing window and loosely attach the paper-clip to the inside about 1-2 cm (less than an inch) below the viewing window. Experiment and make adjustments as you look for the location that produces the best image of the paper-clip with the project board in front of the box & mirror. (see pictures.)



Once you have found the best location for the front cover (the place that gives you the best “real” image of the paper-clip), trim the project board along the appropriate dashed line and use duct tape to attach it to one side of the box. Double-check EVERYTHING before you permanently tape down the paper-clip down.



The open box



Close the box and gently touch the paper-clip.

What Going On?

Most folks are quite* familiar with the plain/straight mirrors found in bathrooms, on walls, in some people’s purses and in dressing rooms. They appear to reverse objects in a left-right way, but NOT in an up-down way and the image appears to be on the other side of the mirror, or somehow inside the mirror. This common type of image is called a **virtual image**.

The image of the paper-clip that you see is formed by a very special and rare concave spherical mirror. Light rays spreading out from a point on the paper-clip are reflected by the concave mirror so that they actually come back together at a point in space, creating a **real image** of that point on the paper-clip. The image of the paper-clip is similar in size to the actual paper-clip, but is rightside-up, because the actual paper-clip is upside-down!

The rays continue on through this convergence point and enter your eye(s). The lens of your eye(s) brings the rays together to create an image on your *retina*. Your eye and brain can’t tell the difference between a retinal image of the reflected paper-clip and a retinal image of the actual paper-clip.

To Do and Notice:

Try to place an object behind the reflected image of the paper-clip. Not only will this seem difficult to do, but if you are successful... you will now make part of the paper-clip disappear! (or it will appear as if you have the object resting in front of the paper-clip). This would NOT happen if you tried this with the actual paper-clip. Notice that the object remains behind the paper-clip and no part of the actual paper-clip is hidden!

LIGO Connection: *LIGO uses many various optics some of which are slightly concave.*

I was introduced to the “Touch the Spring” exhibit at the Exploratorium in San Francisco, CA in 1991. The [Exploratorium’s Teacher Institute’s Snack Book](#) (ISBN 978-0-470-48186-8) provided me with the confidence, desire, detailed plans, background & great explanations to attempt this “snack”. Questions, comments and suggestions please email: tien@ligo-la.caltech.edu

