

Exploratorium Cookbook I

A Construction Manual for Exploratorium Exhibits
Revised Edition

by Raymond Bruman and the Exploratorium Staff

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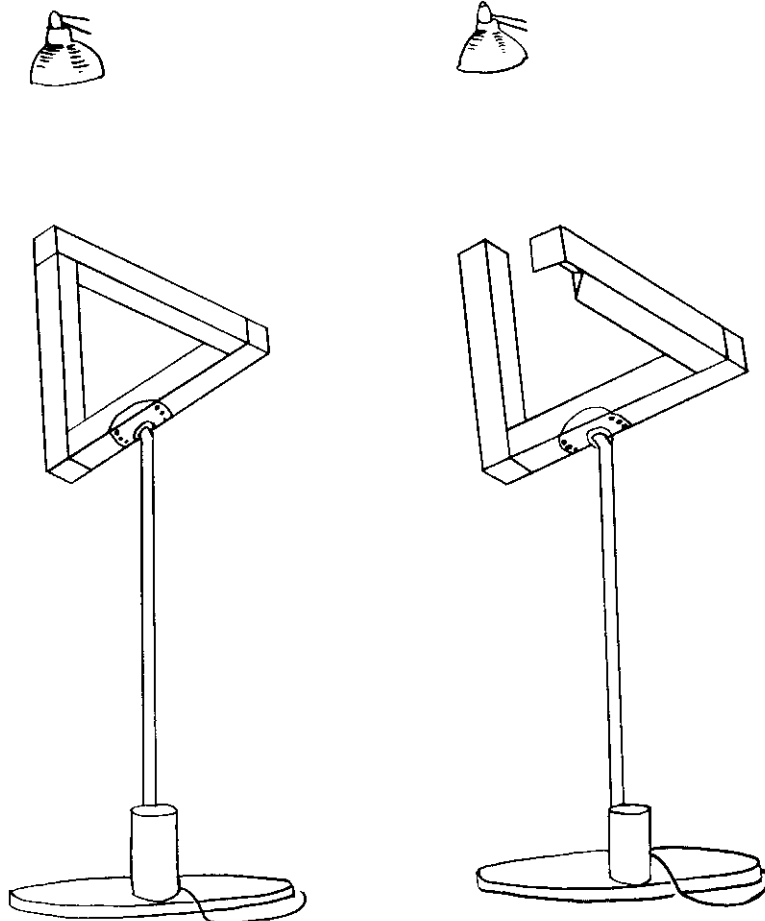
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Impossible Triangle



Description

The **Impossible Triangle** is a startling, three-dimensional visual illusion. When you look at the exhibit from a particular vantage point, it appears to be a triangle in which all three sides meet at right angles, a form that cannot physically exist. Even after you view the exhibit from other vantage points and you know that it is not really a triangle, the form will still appear to be a triangle when you view it from the special vantage point.

The **Impossible Triangle** evolved from an "impossible figure" devised by R. L. Penrose and S. Penrose. For more specific information, see their article in the *British Journal of Psychology* volume 49, number 31 (1958). R. L. Gregory, in his books *The Intelligent Eye* (New York: McGraw-Hill, 1970) and *Eye and Brain* (New York: McGraw-Hill, 1966), discusses the impossible triangle at length.

Construction

Our version is constructed of three lengths of wood measuring 4" by 4" by 29½". You can use our dimensions or adapt the structure to your needs. These instructions are for 4 by 4s (actual dimensions). Please read these instructions carefully and make sure you understand them before attempting to adapt the recipe to different dimensions. We recommend you use hardwood since it looks nicer than softwood and holds up better.

The 4 by 4s are attached to each other at right angles; you can think of them as forming three edges of an imaginary cube. (See Figure 2.) To perceive these 4 by 4s as a triangle, the visitor must view the construction looking along a line of sight that runs from one corner of this cube to the opposite corner. The 4 by 4 that is farthest from the viewer appears to fit into a notch in the 4 by 4 that is closest to the viewer. Cutting this notch is the trickiest part of constructing the exhibit.

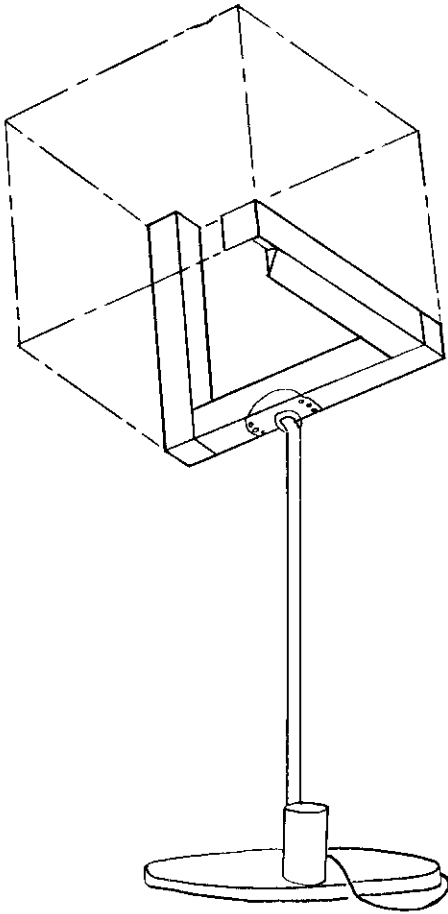


Figure 2 — Imaginary Cube

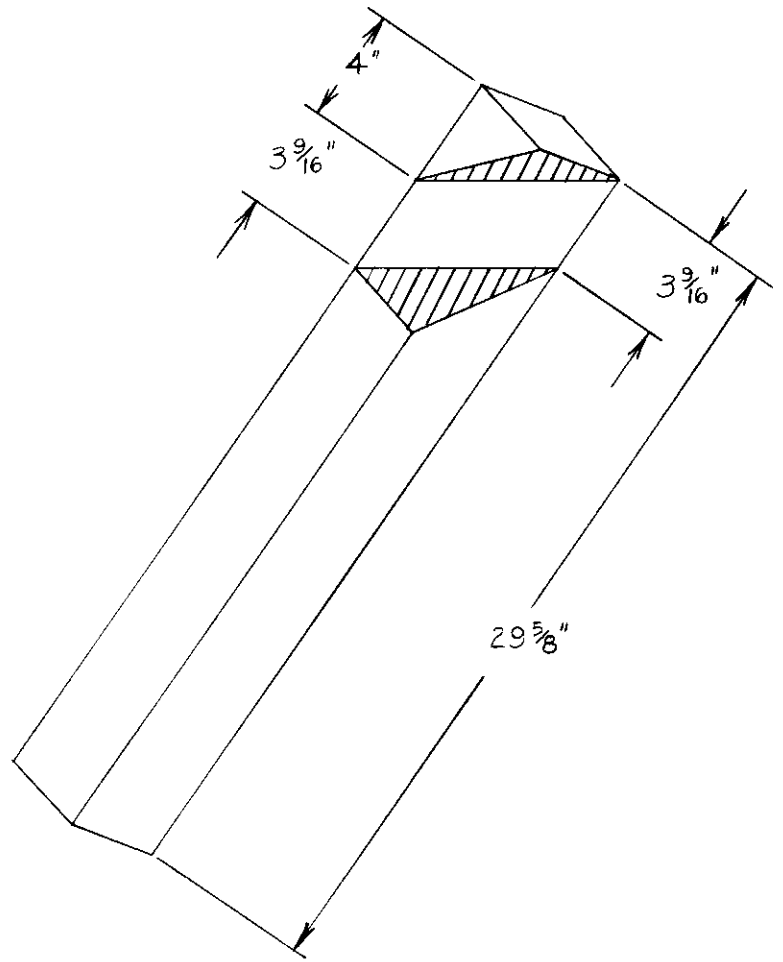


Figure 3 — Notch

Cutting the Notch

The exact geometry of the notch is complex, so you may have to read this description more than once. You may also want to practice on a piece of scrap wood before you cut the actual notch.

To get a visual picture of the notch, imagine that you are balancing the 4 by 4 on one of its long edges and looking down at the notch, as shown in Figure 3. The notch runs diagonally from one edge of the 4 by 4 across to another edge. The notch also runs at a diagonal relative to the length of the 4 by 4. The sides of the notch tilt outward so that they meet the floor of the notch at an oblique angle. The notch follows this complicated geometry because it must exactly match the end of the 4 by 4 that appears to fit into it, following the viewer's line of sight.

The most convenient way to cut the notch is to use a table saw with dado blades. You'll also need to make a jig that will hold a 4 by 4 at 45° so that the saw blade will cut across two faces.

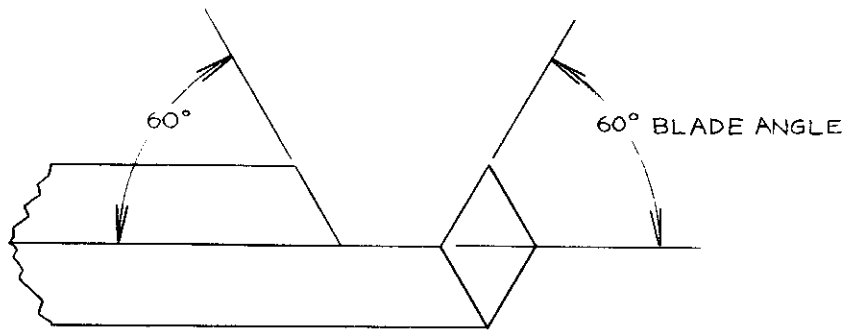
Exactly 3⁹/₁₆" from the end of the 4 by 4, make a mark

on the edge of the 4 by 4. Set the table saw's angle guide to 35¹/₄°. Position the 4 by 4 in the jig so that the marked edge faces away from you.

Using your jig, set the dado blades to cut to a depth of 2³/₁₆". (At this depth, the bottom of the notch should extend from one edge of the 4 by 4 to the other, at a diagonal.) Begin cutting your notch at the corner of the 4 by 4 and keep moving the wood over until your last cut falls just inside the mark. Be very careful not to overshoot these limits. When you are done, you should have a square-sided, U-shaped notch that runs diagonally across the wood as it sits in the jig.

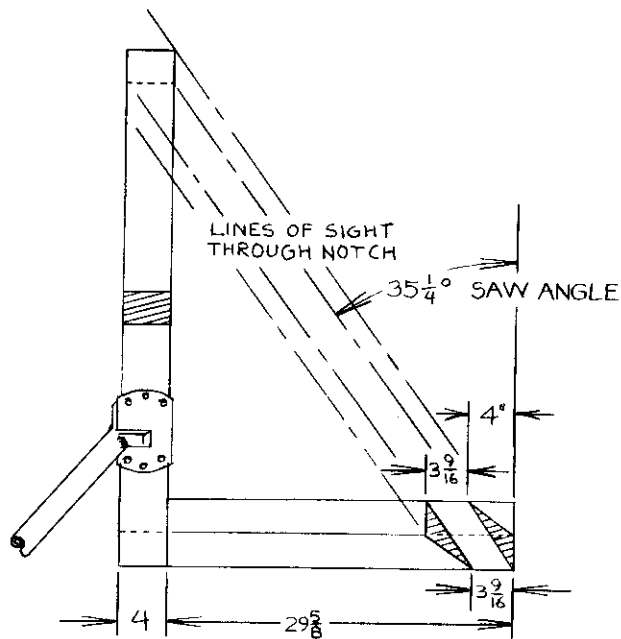
To finish the notch, you must use a regular saw blade tilted to a 60° angle and trim one wall of the notch at 60° so that the wall tilts outward. (See Figure 4.) To trim the other wall, you'll need to rotate the wood approximately 180°.

If you don't have a table saw, it is possible to use a circular saw with a tilting blade to cut the notch. To do so, you will need to construct special jigs to set the angles.

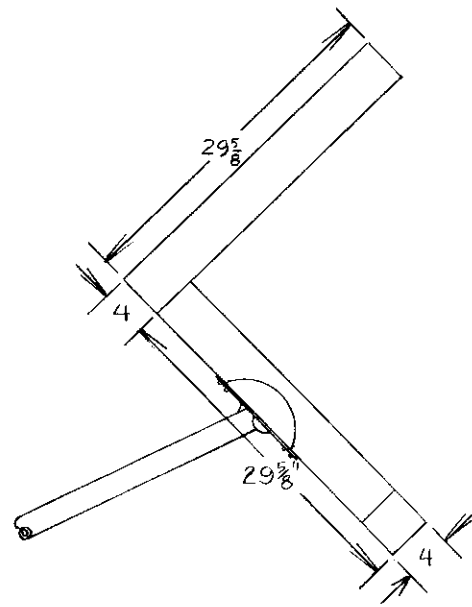


DETAIL: END OF NOTCHED ARM
(HELD IN A 45° JIG WHILE NOTCH IS CUT)

Figure 4



ORTHOGONAL VIEW, LOOKING DIRECTLY AT NOTCH
(CROSS-GRAIN CUTS SHAPED FOR CLARITY)



ORTHOGONAL VIEW, LOOKING DIRECTLY AT END OF NOTCHED ARM

Figure 5

Mounting and Lighting

The triangle stands 4' off the floor on a welded steel bracket. The bracket must hold the middle 4 by 4 at a 67° angle to the floor. The peephole, through which visitors view the triangle, is about 12 yards away. The peephole is 2" in diameter and about 4' above the floor.

A variety of lighting arrangements will enhance the illusion, as long as there is fairly balanced illumination on the two ends that join in the notch, and revealing shadows are avoided. The illusion is lessened, however, by lighting that is too uniform. Try to achieve the impression of a continuous object illuminated by a single light source.

Critique & Speculation

We have seen many interesting versions of this exhibit in other museums. England's Exploratorium, for example, has a version in which two impossible triangles appear to be linked when viewed from the right location.

Related Exploratorium Exhibits

MONOCULAR ILLUSIONS

Ames Chairs; Distorted Room; Far Out Corners; Multi-dimensional Shadows; Old Woman or Young Girl?; Reverse Masks; Trapezoidal Window

To do and notice

- Look through the hole in the clear disk on your left and find what seems to be a wooden triangle several yards away. Look at the wooden figure from another angle to see its true shape.
- Try to follow one face of the triangle all the way around to where it starts, and notice that you can't. Also notice that each face seems to change its orientation when it turns a corner. For example, an outside face becomes an inside face when it turns a corner.
- Have a friend or an orange-jacketed Explainer put an arm between the two open arms of the wooden figure while you watch through the hole.

What's going on

Normally, you make assumptions about the shape, size, and distance of any object you see. When you look through the hole, the two upper arms of the wooden figure appear to line up and meet at the top of the triangle. Because the arms look as if they touch, you assume they do touch. This assump-

tion is so powerful and fundamental that you can't override it; instead, you see a figure that doesn't and can't exist. If you hold your hand or a piece of paper up in front of you to cover the top corner of the triangle, you may notice that it is easier to see the true shape of the figure.

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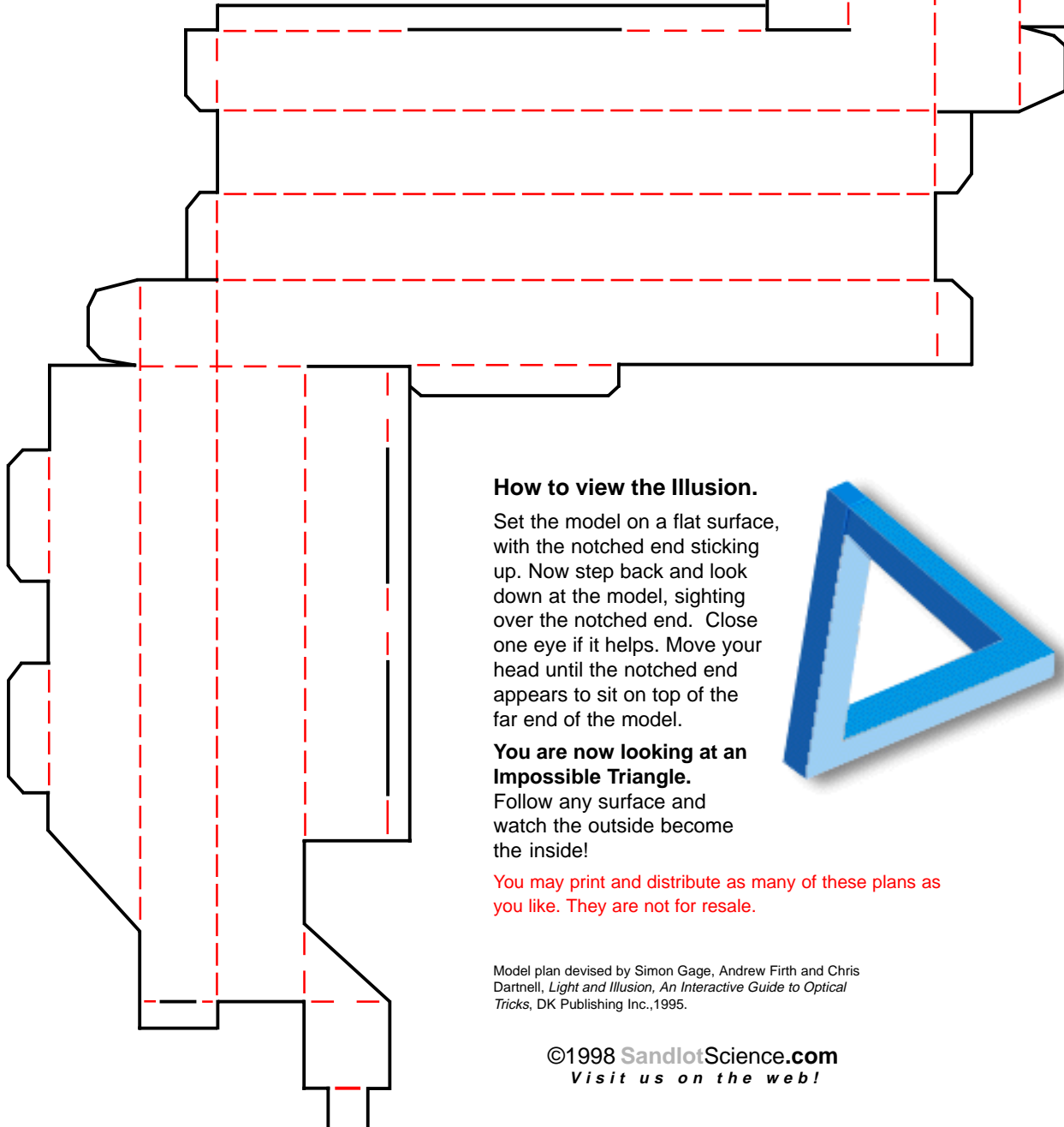
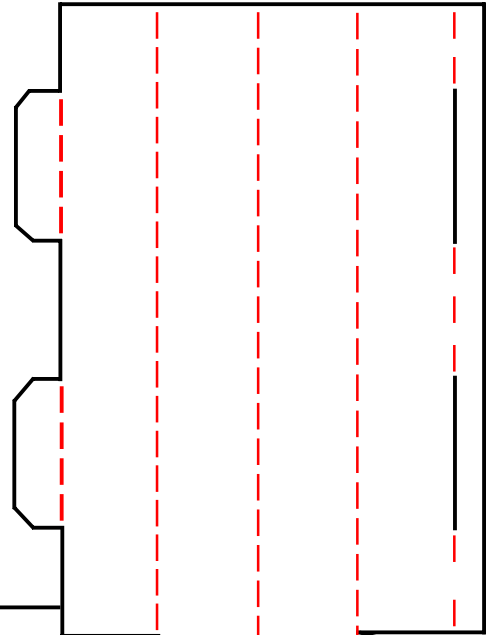
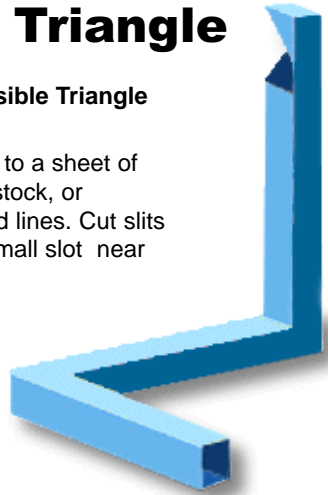
The Impossible Triangle

This 3-D model becomes an Impossible Triangle when viewed from the right place.

Begin assembly by attaching the plan to a sheet of light cardboard, such as heavy laser stock, or construction paper. Cut out along solid lines. Cut slits opposite each tab as indicated. Cut small slot near the notched end as indicated.

Score and fold along dotted lines. With the plan face-up, make all folds bend away from you.

Carefully fold the model into shape. Tubes are formed by folding narrow flaps, then inserting tabs into slots. To close ends of tubes, fold side flaps and insert lid flaps.



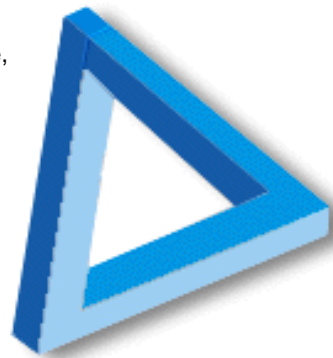
How to view the Illusion.

Set the model on a flat surface, with the notched end sticking up. Now step back and look down at the model, sighting over the notched end. Close one eye if it helps. Move your head until the notched end appears to sit on top of the far end of the model.

You are now looking at an Impossible Triangle.

Follow any surface and watch the outside become the inside!

You may print and distribute as many of these plans as you like. They are not for resale.



Model plan devised by Simon Gage, Andrew Firth and Chris Dartnell, *Light and Illusion, An Interactive Guide to Optical Tricks*, DK Publishing Inc., 1995.