611-0355 (40-505) Catenary Arch

Warranty and Parts:

We replace all defective or missing parts free of charge. We accept Mastercard and visa, School P.O. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse, or normal wear and tear.

Description:

This set of hardwood blocks is precision-cut in the shape of a catenary arch. It needs no support because it is the ideal shape to hold its own weight. The forces acting on the arch cause it to take the shape of a curve naturally.

Introduction:

A catenary arch is the curve which is formed by a heavy, perfectly flexible cord, cable or chain, hanging from two fixed points not in the same vertical line, and acted on by gravity. It comes from the word *catenarius* which is Latin for *relating to a chain.*

The equation of this "chain-curve" was obtained by Leibniz, Huygens and Johann Bernoulli in 1691, who were responding to a challenge put out by Jacob Bernoulli to see if this could be done. The equation can be described as follows:

y = a cosh (x/a)

Preceding this challenge, the catenary had been under discussion in the scholarly world for some years. Huygens was the first to use the term "catenary" in a letter to Leibniz in 1690. In the same year, David Gregory wrote a treatise on the catenary. Jungius (in 1669) disproved Galileo's claim that the curve of a chain hanging under gravity would be a parabola.

In mathematical terms**,** the catenary is the locus of the focus of a parabola rolling along a straight line and is the evolute of the tractrix. It is the locus of the midpoint of the vertical line segment between the curves e^{x} and e^{-x}. Euler showed in 1744 that a catenary revolved about its asymptote generates the only minimal surface of revolution.

How To Use:

Use the full-size template on Page 2 to help you construct the arch. You do not need further support, as with a scaffold, if each block is carefully placed in order. We suggest you build up two legs simultaneously. You can cup one hand around each end while also dropping in the top two blocks. If desired, you can build the arch on a panel such as a board or cardboard and then try to raise the arch and leave it standing.

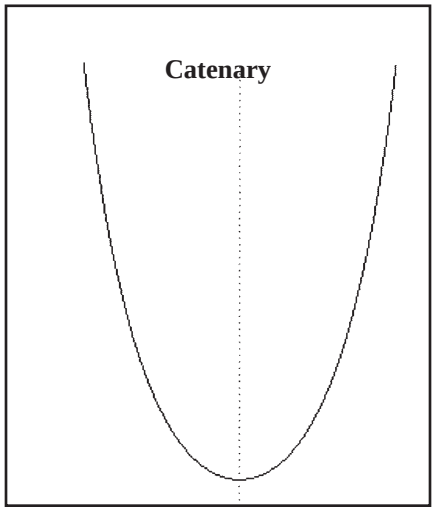
If the arch falls, it probably means the blocks were not carefully assembled according to the template. Make sure all blocks are mated to the adjoining blocks with no overlapping corners.

You might wish to number each block if you plan to have many students reassemble the arch.

Objectives:

To demonstrate the structural strength of an arch

To show the value of mathematics to engineers



Gateway Arch	**630 feet**
Eiffel Tower	**984.25 feet**
Statue of Liberty	**305 feet**
Washington Monument	**555 feet**
Empire State Building	**1,250 feet**
World Trade Center	**1.350 feet**
Sear's Tower, Chicago	**1,454 feet**

Background:

One famous architectural feature using the catenary arch is the Gateway Arch in St. Louis, part of the Jefferson National Expansion memorial. Designed by Eero Saarinen, it is faced in stainless steel. It spans 630' between the outer faces of its triangular legs at ground level and towers 630' above the Mississippi River. Its shape is that of an inverted catenary curve formed by a heavy chain hanging freely between two supports.

Each leg forms an equilateral triangle, 54' long at ground level, tapering to 17' at the top. The legs have double walls of steel 3' apart at ground level and 7 - 3/4" apart above the 400' level. Up to 300', the space between the walls is filled with reinforced concrete. After that point, steel stiffeners are used.

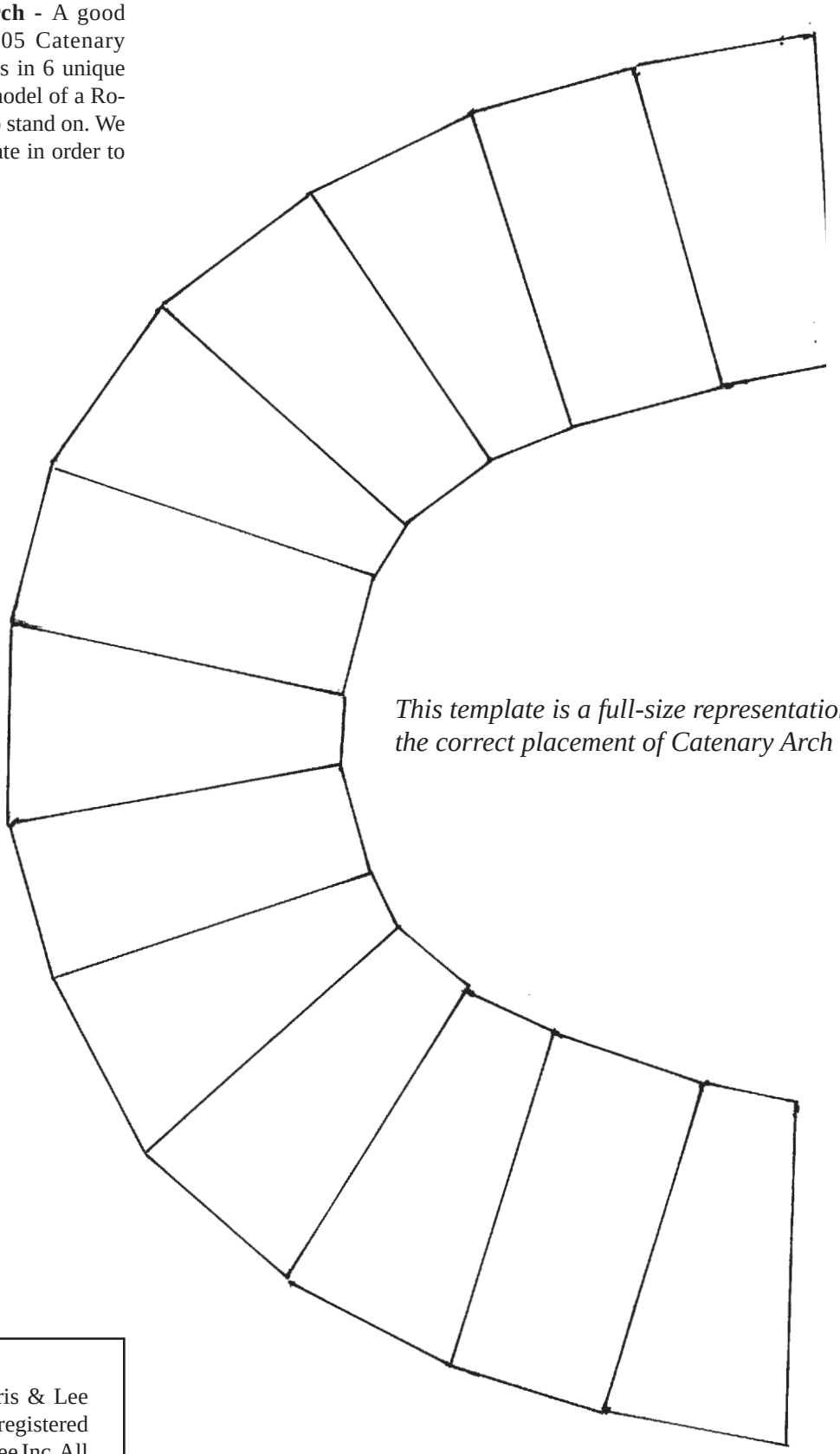
It was constructed by placing the double-walled, triangular sections one on top of another, then welding inside and out to finish the Arch legs. The triangular sections ranged in height from 12' at the base to 8' for the two keystone sections. Engineering design and construction details are invisible to the beholder. The entire surface is sparkling stainless steel on the outside and carbon steel beneath, which transmit the effects of gravity and wind to the ground. The Arch has no real structural skeleton. Its inner and outer steel layers are joined to give it the strength and permanence it needs.

Visitors enter the Arch through an underground Visitor Center and reach the observation platform at the top of the Arch by a 40 foot passenger train made up of eight five-passenger capsules in each leg. This ride operates at the rate of 340' per minute, with a round trip of 10 minutes. The observation platform, 65' by 7', has plate-glass windows providing views to east and west. For safety, there are also elevators and stairways with 1,076 steps in each leg. Elevators and stairways are for emergency use only.

Reference: The Construction of the Arch, by J.E.N. Jensen, Associate Director, National. Park Service, Washington D.C. http://www.nps.gov/jeff/arch-const.htm

Related Products:

611-0350 Roman Arch - A good companion for the 40-505 Catenary Arch! 23 hardwood blocks in 6 unique shapes builds a working model of a Roman arch strong enough to stand on. We include a full-scale template in order to build the arch.



This template is a full-size representation of the correct placement of Catenary Arch blocks.

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