



DEFINITION

The hyperbolic cosine, sometimes called the catenary, is the function whose equation is $y = \cosh(x) = \frac{e^x + e^{-x}}{2}$.

The shape of the graph of this function is similar, but not identical, to that of a parabola. To see the difference, students can use their graphing calculators to try to superimpose $y = \cosh x$ on the parabola $y = x^2 + 1$.

MATH IS ALL AROUND US

While suspension bridges often take the shape of a parabola, any bridge suspended only from its endpoints with uniform weight throughout will take the shape of a catenary, or hyperbolic cosine. The Gateway Arch in St. Louis is an inverted catenary slightly flattened at the top, and Antonio Gaudí and other architects have used inverted catenary arches in their buildings.

ACTIVITY

Take a chain (the word *catenary* is derived from the Latin word for chain), a rope, or a piece of string, and suspend both ends from the chalkboard or the wall. This can be done simply, by taping some butcher paper to the wall and affixing the string to the butcher paper, by taping the ends of the string to a whiteboard or chalkboard mounted on the wall, or by using pushpins to hang the string from the thin strip of corkboard at the top of the chalkboard.

Superimpose a set of coordinate axes on the butcher paper or chalkboard so that the vertical axis passes through the minimum point of the string. Choose a unit, and find coordinates of several points that are on the curve. Provide students the general form of the catenary, and then ask them to find the particular equation. They will have to determine what transformations they will need to apply to the general form of the equation to have it match closely with the hanging string. This activity can be particularly effective if graphing calculator screens can be projected onto the whiteboard so that the guess-and-check steps can be compared to the hanging string.