

NEW ROADS

MAGAZINE

DIY SCIENCE WITH CHEVY:

Quick-N-Easy Cardboard Boomerang

Inspire others to build their own boomerang by sharing photos and videos of yours with [#ChevyLove](#).

WHAT YOU'LL LEARN:

- Gyroscopic precession
 - Velocity
 - Force
 - Dihedral
- Positive attack

BUILD TIME:

Under 10 minutes

MATERIALS & SUPPLIES:

- Scissors or hobby knife
 - Ruler
 - Pencil or pen
- Relatively stiff, sturdy cardboard (pizza boxes are perfect)
- Clear packing tape

This series is designed for children ages 7–13. For outdoor use only. All activities should have adult supervision with proper safety precautions. We recommend always wearing gloves and safety glasses while conducting experiments.

BUILDING YOUR BOOMERANG:

STEP 1: CUT THE WINGS.

Cut two 14-inch by 1 ½-inch rectangles from the pizza box lid.

STEP 2: TRIM THE WINGS.

Trim the corners of each piece you cut at a 45-degree angle by marking ¼-inch from the corner along both the side and top, and then snipping off that corner.

STEP 3: BUILD THE BOOMERANG.

Use strips of packing tape to secure the two blades, one strip in front and one in back.

STEP 4: MARK THE FACE AND LEADING EDGE.

These two steps are the easiest, but vital to learning how to tune and throw your boomerang. The face of a boomerang is the side that will be closest to your head when you throw it. Right now, either side can be the face. Pick the side you like and mark it. Once you've chosen the face, you're going to mark the leading edge of each wing (this is the edge that cuts into the air when it is spinning). If you throw right handed, then the leading edge of each blade is the left edge when you view the boomerang face up from above. For left-handed throwers, the leading edges will be on the right side of each blade.

STEP 5: ADD AIRFOILS.

Holding the boomerang face up, use your thumbnail to gently crimp each blade at a point ½-inch behind the leading edge. This creates a simple airfoil—the wing shape that produces the lift and drag needed for flight. It's okay if the airfoil is hardly perceptible; aerodynamically, a little goes a long way.

STEP 6: ADD DIHEDRAL.

Few wings are flat. They either curve up or are set at an angle to the body. This is called dihedral, and it makes the flyer (be it bird or plane) more stable. A little dihedral is vital to boomerang operation. To give your boomerang's wings dihedral, hold the hub of the boomerang (where the wings cross) in one hand, and bend the wing up several inches. Don't worry about trying to get the wing to hold the curve; the very slight lift that remains after the cardboard relaxes is often just fine. (Dihedral is one of the aspects of the boomerang you'll tinker with during tuning.)

FLYING YOUR BOOMERANG:

STEP 1: PICK A LAUNCH SITE.

First, head outside and make sure you have plenty of open space around you; even a cardboard boomerang can really hurt if it smacks a bystander on the face.

STEP 2: THROW AND CATCH.

To throw a boomerang, hold it in your throwing hand, pinching one wing near the tip.

Cock your arm back so that the boomerang is vertical, with its face toward your ear. Now throw with a flick of the wrist, being sure to keep the boomerang vertical throughout your throw. The pizza box boomerang will stay vertical for about 20 feet, flying straight out and rising as it goes. Then it will begin to curve to the left (for a right-handed thrower) and lay over (lean into a more horizontal position) as it comes into its return. Finally, it'll go fully horizontal, so you can easily catch it by sandwiching it between your hands.

STEP 3: FINE-TUNING THE LAUNCH.

In very still air, you may find the boomerang returns too far in front of you, and you have to run up to catch it. If this is the case, try throwing with some added layover: Angle the boomerang a little away from your head. This puts the boomerang into its return curve sooner.

If it's a breezy day, you'll want to throw into the wind with little or no layover.

Throwing and tuning go hand in hand. Once you've finished your boomerang, give it a few tosses, and then start tuning to get better performance.



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HOW IT WORKS:

The key to the returning boomerang is *gyroscopic precession*. This is the tendency for a spinning mass to wobble when nudged, rather than just falling over (like how a top wobbles around its axis instead of just falling over).

Imagine a bicyclist riding no-handed: As she cruises down the street, she stays upright because the bike's wheels are a pair of gyroscopes, and their spinning gives them stability. If she wants to turn left, she leans left. If this were a stationary wheel, nudging the top of it (as the rider does when she leans) would just knock it over. But since it's a gyroscope, adding an additional force to the top causes the gyroscope to turn perpendicular to its axis of spin, and the bike magically follows a big leftward looping path.

Since the boomerang is spinning, it's a gyroscope; this gives it stability in flight. Although the boomerang, as a unit, has a single *velocity*, each wing has a different velocity relative to that unit: Slowly spin your boomerang on your kitchen table while sliding it forward, and you'll see that the topmost wing is always moving forward, while the bottommost is always moving backward. Since the boomerang as a whole is moving forward, that means the top wing is—in total—moving faster than the bottom.

Identical wings moving at different velocities exert different amounts of *force*, with the faster wing exerting more force. Since there is a greater force acting on the top of the spinning boomerang than the bottom, we see the same effect as the bike rider leaning left: The unequal forces make the boomerang take that circular path.

BUILDING THE BETTER BOOMERANG:

Tiny changes have a big impact on the boomerang's behavior. Tune the wings one at a time, making a single change (for example, adding a little dihedral or positive attack). Then give it a test toss, and tune some more.

DIHEDRAL.

Dihedral is the curve of the wing. A little dihedral gives the boomerang an elliptical

flight with a long hover (easier to catch). Adding lots of dihedral makes cardboard boomerangs travel a fast, tight path. To add dihedral to a boomerang's wings, hold the boomerang by the hub and gently curve the wing up.

POSITIVE ATTACK.

Positive attack is a twist along the length of the boomerang's wing. This slows the boomerang down, resulting in a flatter, rounder, lower flight path. To add positive attack, hold the boomerang by its hub with the boomerang's face up. Grab the tip of a wing and twist it counterclockwise (for right-handed throwers) or clockwise (for left-handed throwers).

ADDING WEIGHT.

Adding weight increases momentum, resulting in a longer, even more elliptical flight. The easiest way to add weight to a boomerang is by taping pennies to one or more wings. The effect will be more pronounced as you put the weight farther toward the tip. Add weight to one wing at a time. It's easiest to throw a weighted cardboard boomerang if the heaviest arm is directly opposite the one you are holding when you throw.

ADDITIONAL TIPS:

- This four-blade boomerang is easy to make, but you can use different numbers of blades. This style of boomerang works best with three or more evenly spaced blades.
- Make the hub lighter than the blades when possible (since a gyroscope functions best when most of its mass is on the outermost edges). You can narrow the blades as they approach the hub, or cut a hole in the hub. This also prevents premature layover.
- Parabolic wing tips are better than flat.
- Different thickness and weights of cardboard have different optimal lengths and widths, so experiment. In general, heavier materials mean narrower wings.