

BioEdSM

Think like an

Engineer

TEACHER'S GUIDE

Boomerangs

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Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine

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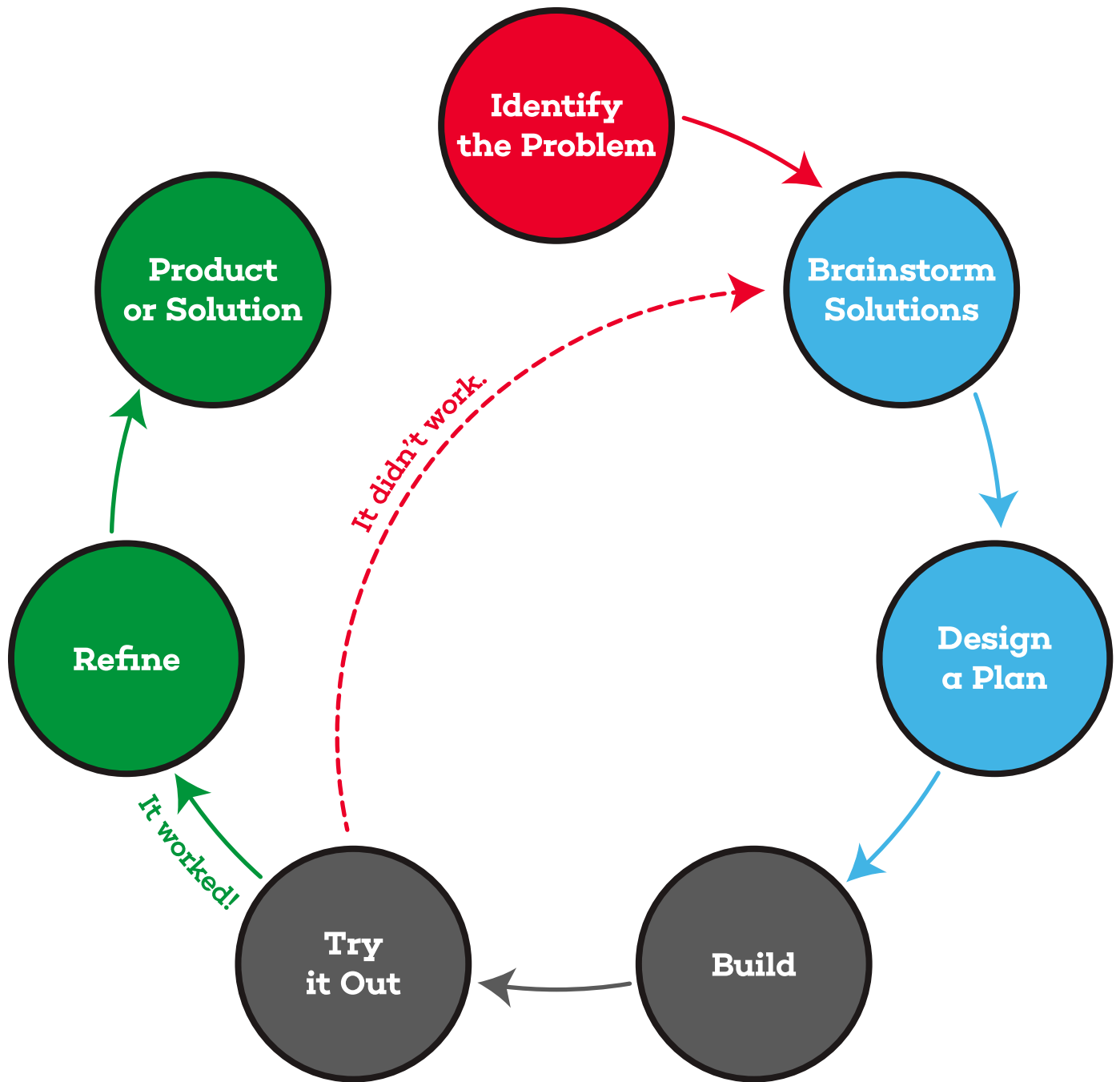
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An Engineer's Approach



2

Boomerangs Many Happy Returns

Time

1–2 sessions

Before You Start

Create one set of boomerangs for demonstration. Test-fly them to practice your launch technique and to ensure the boomerangs return.

Make copies of the “Four Wing Boomerang” page on card stock (one per student).

If conducting the optional activity, obtain 48 wooden paint sticks (used to mix paint) and sandpaper (40–60 grit) from a hardware store. Cut the sandpaper into 10-cm x 10-cm squares (1 per student).

You Need This Stuff

Per Student

- Pair of scissors
- Pencil with flat sides
- Sheet of 8.5-in. x 11-in. card stock
- Thick book
- Copy of “Finger Boomerangs” page
- Copy of “Four Wing Boomerang” page on card stock

Optional Activity: Paint Stick Boomerang

Teacher Materials

- Hot glue gun with glue

Per Student

- 2–4 pennies
- 1 or 2 heavy rubber bands
- 2 wooden paint sticks
- 10-cm x 10-cm square of sandpaper
- Colored markers
- Safety goggles
- Copy of “Paint Stick Boomerang” page

What It's About

Most students may envision boomerangs as wooden throwing sticks, but these fascinating flying devices can be made of many different materials, including metal, plastic and even paper. Some boomerangs are designed to return, but others do not. Both tools have been used for millennia.

The non-returning boomerang goes back to the Stone Age. Used as a throwing stick for hunting, it was shaped to travel long distances on a very straight flight path. Versions of the non-returning boomerang were used in Europe, Australia and Egypt, and among some western Native American tribes.

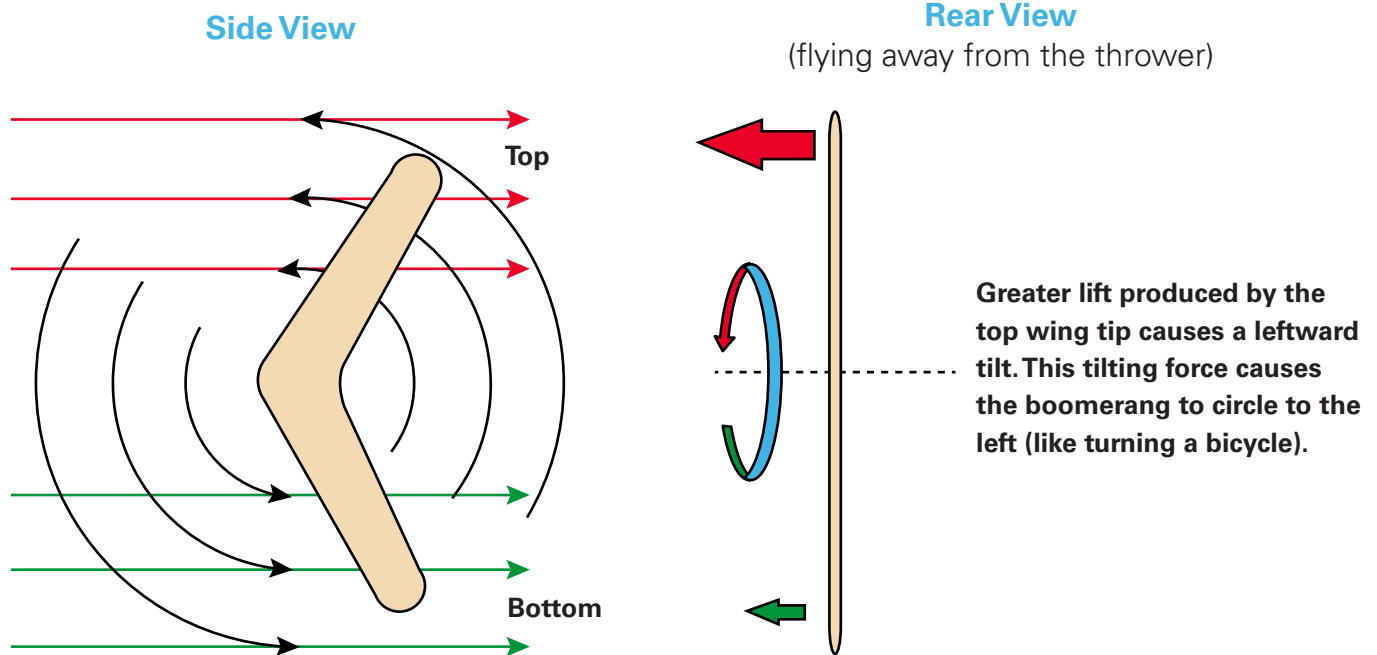


Aboriginal boomerangs in the rain forest near Cairns, Australia.

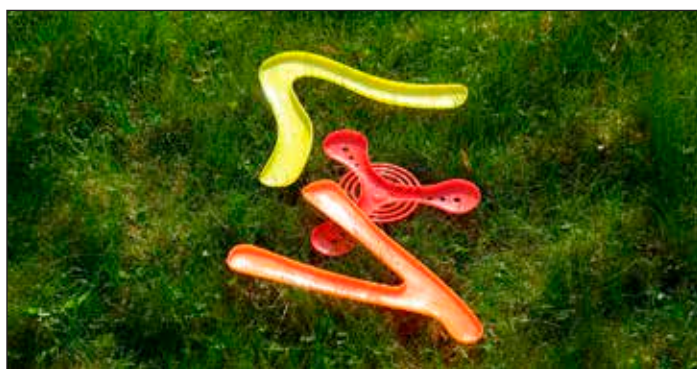
The returning boomerang was raised to a high art by the Australian Aborigines. It was used for hunting, and as a battle club, musical instrument and even fire-starter. Hunters would

Net Air Speed

The net air speed of the top wing tip (spinning into the wind) is greater than the net air speed of the bottom wing tip (spinning with the wind).



throw returning boomerangs near roosting birds, seeking to scare them into flight so they could be caught in nets. Hunters also would throw boomerangs through flocks of flying birds, hoping to clip a wing and bring down dinner.



Boomerangs today are formed using different materials and come in various shapes and sizes.

Both forms of boomerang are amazing aeronautical devices, basically rotating wings curved like an airfoil. All non-returning boomerangs are straight, but the returning variety can have many

designs. The classic returning boomerang has a lazy “L” shape, but some look like a question mark. Some returning boomerangs have three or four wings (like a cross). The different features determine how quickly a boomerang returns when thrown. Large, open designs tend to travel furthest, while tighter shapes and boomerangs with extra wings tend to follow shorter paths.

Several physical processes make a returning boomerang work: aerodynamic lift, gyroscopic precession, drag and gravity. The proper way to throw a boomerang is in a vertical plane, tossed slightly upward and with a rapid spin. The spin produces a gyroscopic effect that keeps the boomerang moving along its plane without flipping and fluttering. As the boomerang travels forward, the rapid spinning of its wing tips produces a strong lifting force. Because the boomerang is oriented vertically, the lift pushes sideways, causing the boomerang to turn and return to the thrower.

The forces influencing the flight of a boomerang are similar to the gyroscopic effect that keeps a bicycle upright and stable. To turn a bike, the

rider merely tilts to one side or the other. This puts a sideways force on the spinning wheels, causing them to turn in the direction of the rider's lean.

The leaning force on the boomerang is caused by an imbalance in the lift between the top and bottom wings as they spin forward through the air. The top wing moves against the airflow and produces a strong sideways lift. Simultaneously, the lower wing is moving in the same direction as the airflow, which produces a weaker sideways lift. The difference in lifting forces causes the boomerang to lean sideways. As with a bicycle wheel, the gyroscopic effect of the boomerang lean causes the boomerang to turn in a circle and return to the thrower.

What's the Question?

Will a boomerang always come back, no matter how it is thrown?

What To Do

1. Ask students, *Do you know what a boomerang is? What does it do? Have you ever seen one thrown, or have you thrown one yourself?* Discuss the shape of airplane wings and compare them to boomerang wings. Ask, *What does an airplane wing look like from the side?* (Refer to the wing diagram from the activity, "Ring Wing Gliders") Remind students of how airplane wings produce lift. Point out that boomerangs are rotating wings, similar to the blades of a helicopter or a ceiling fan.
2. Have students make finger boomerangs out of card stock paper. Use the patterns on the "Finger Boomerangs" sheet as a starting point. Review the instructions on how to launch these boomerangs as a class, and have students fly their own. Although the blades of these boomerangs are flat, they become airfoils when spinning, and generate lift.
3. Ask, *Are there other boomerang shapes that will return?* Have students use the rest of their card stock to design boomerangs of other shapes, cut them out, and test-fly them. Lead a class discussion of which shapes worked, which didn't, and students' speculation about the reasons for these outcomes.



Young woman in Australia learning how to throw an Aboriginal-style boomerang.

4. Tell students they have "graduated" to a larger boomerang. Have them cut out their four-wing boomerangs. Demonstrate for students how to throw this boomerang, then have them fly theirs. Ask, *Do you think there is a limit to how big you can make this kind of boomerang from card stock? If you wanted a larger boomerang, would you have to use different materials or add something to make it work?* Discuss their ideas.

Optional: Paint Stick Boomerang

1. Have students build more advanced wooden boomerangs from paint sticks. With this kind of boomerang, it is critical that students understand how to shape the wings, because paint sticks are much heavier than paper and must generate more lift to work. Refer to the "Paint Stick Boomerang" page for diagrams and instructions about which edges should be rounded or sloped. Caution students to be careful not to mix up the edges. OR, as a guide, mark or label the edges of the paint sticks to be sloped or rounded. Have students use sand paper to shape the stick edges. (If necessary, scissors can be used instead.)
2. When all the edges are shaped, have students assemble the boomerangs.
3. Distribute colored markers and let students decorate their boomerangs.
4. Fly the wooden boomerangs in a room with a

high ceiling (like a gym) or outside, preferably when the wind is not blowing. If there is a gentle breeze, prompt students to throw the boomerangs into the wind, not with it. As always, a boomerang should be thrown in the vertical plain, not horizontally (see student sheet), and with a chopping motion that spins the boomerang as it is released. The rounded side of the boomerang should face left when held vertically, and it will fly in a counter-clockwise circle.

Note: Left-handed students should hold the rounded side of the boomerang facing right, and it will curve to the right in a clockwise direction.

5. Ask students, *Would a paint stick boomerang fly differently if it weighed more? If so, how?* Use a small amount of hot glue to attach a couple of pennies to the undersides of the boomerang wings. Tell students the boomerang is kept in balance if the pennies are placed

at the same point on each wing. (Hot-glued pennies can be removed and tested in different locations without damaging the wings.)

Wrapping Up

Lead a class discussion on how boomerangs can be improved. Ask, *What can be done to make your boomerangs stay in the air longer or travel out farther? What other materials might be used to make boomerangs?*

Extras

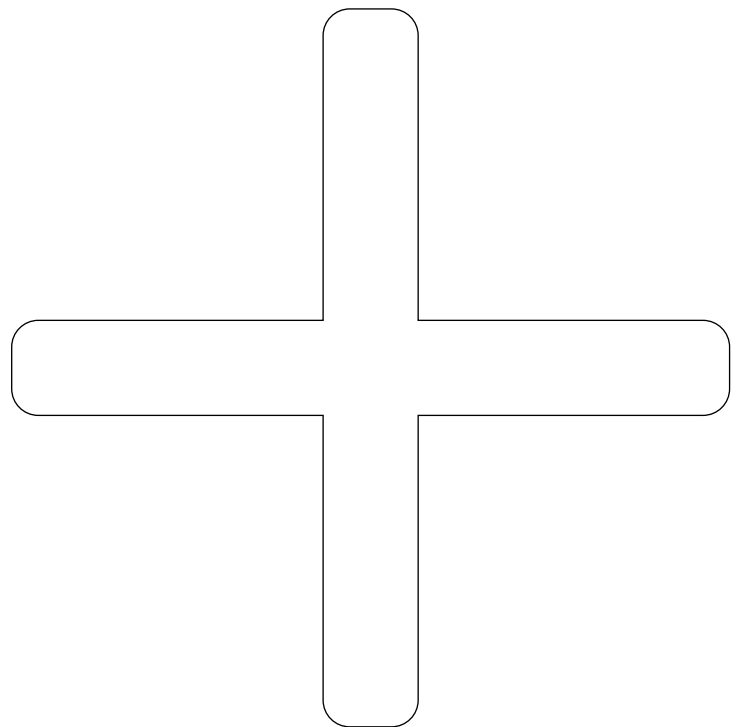
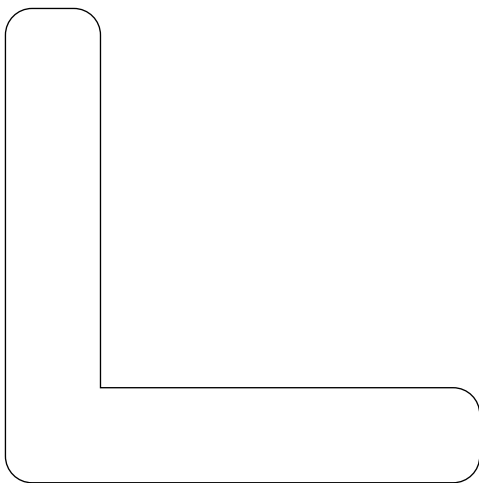
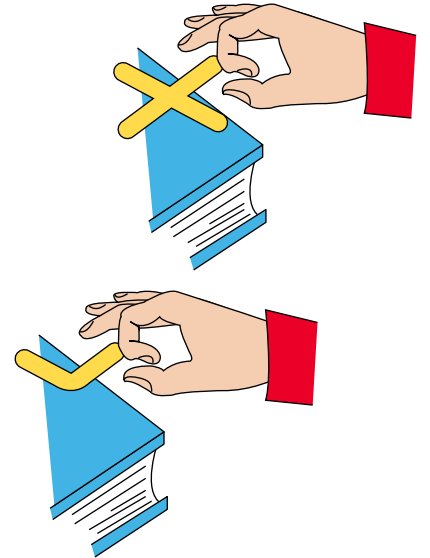
Advanced boomeranging: Teach students how to catch boomerangs. Explain that they should not try to catch a boomerang by grabbing one of its wings. Their knuckles will get banged! Instead, instruct students to wait until the boomerang is still spinning, and just about to drop the ground. They can catch a boomerang by clapping their hands together, with one under the boomerang and one above it. the wings. ■

Finger Boomerangs

You will need card stock, a pair of scissors and a pencil with flat sides. You also will need a thick book.

Use the templates below to make boomerangs, or create two designs of your own (approximately the same size as the templates).

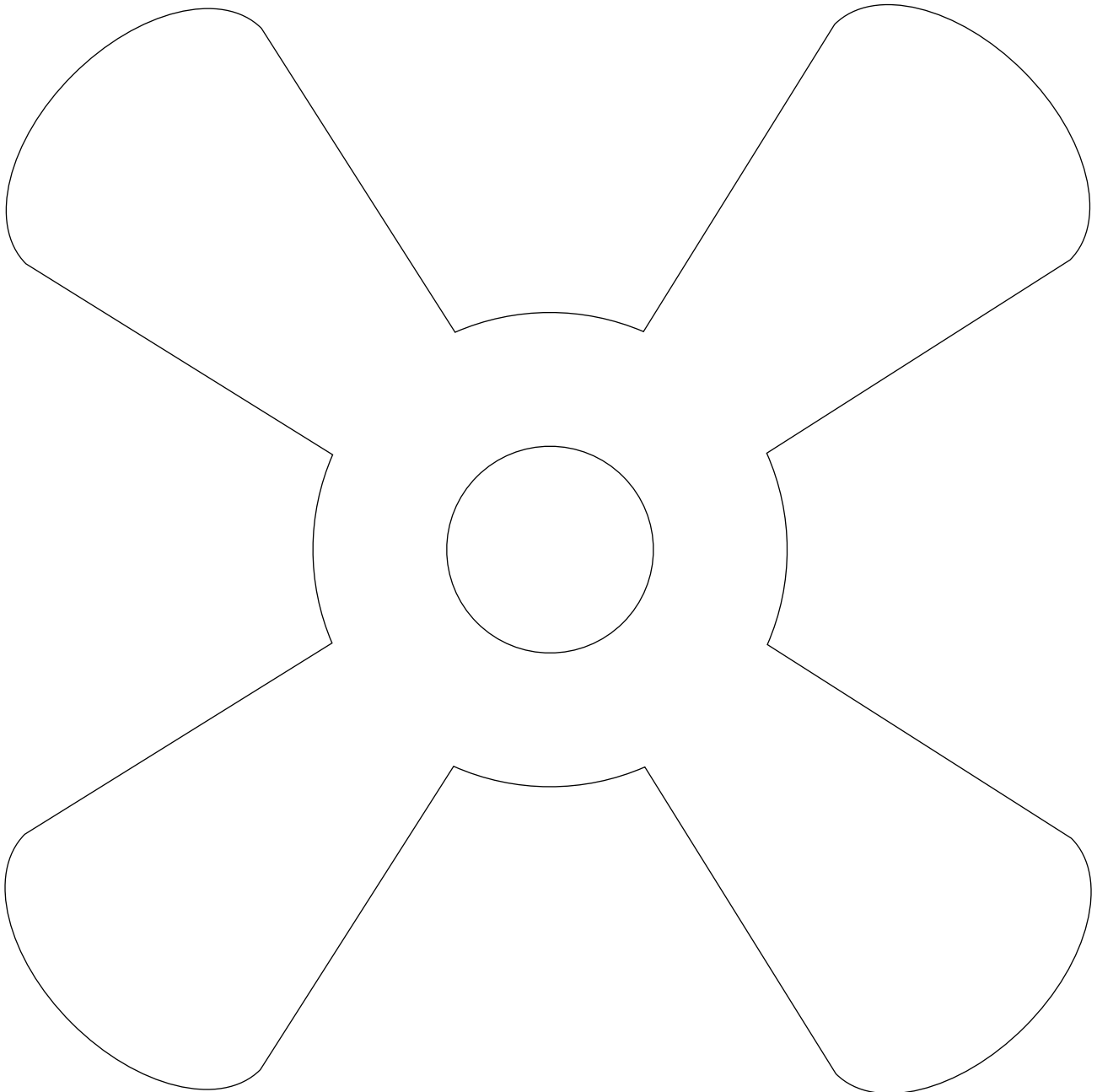
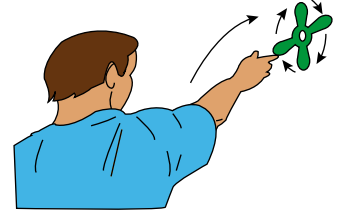
1. Cut out the templates below and trace each shape onto card stock. Cut out the boomerangs from the card stock.
2. Place the pencil underneath one end of the book to lift it slightly. Lay the boomerang on the raised edge of the book.
3. Use your index finger and flick one wing of the boomerang so that it spins rapidly as it flies off the book. The boomerang should gain some lift and then return to you.
4. Does it matter if you flick the boomerang so that it rotates clockwise or counterclockwise? Try it and find out.



Four Wing Boomerang

You will need a prepared sheet of card stock with the image below printed on it, and a pair of scissors.

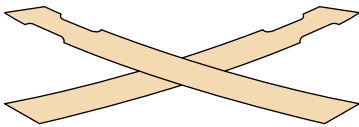

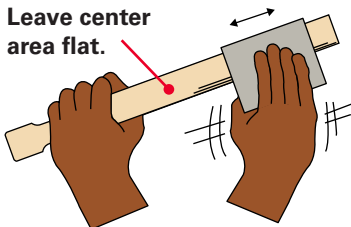
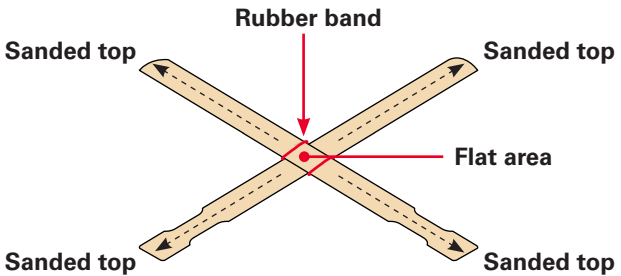
1. Cut the boomerang out of the sheet of card stock. Then cut out the center hole.
2. Hold the boomerang vertically by one wing. Spin the boomerang rapidly as you throw it straight forward. Your throw should resemble a chopping motion.
3. What happens when you throw the boomerang horizontally? Try it.



Paint Stick Boomerang

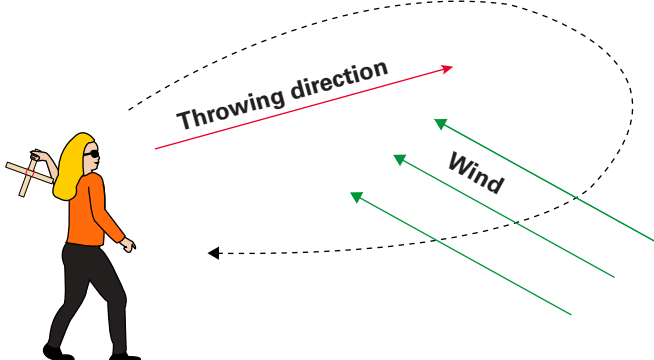
You will need two wooden paint sticks, sandpaper and one or two rubber bands.

How to Build a Paint Stick Boomerang

1. Examine your paint sticks. They probably will be slightly curved lengthwise because of warping. Use the side that is curved upward (like a smile) as the “top” of your sticks. This is the side you will shape with sandpaper. 
2. Before sanding, think of shaping the sticks into the form of airplane wings. 
3. Hold the first stick in one hand and use the sandpaper to smooth and shape just the edges on the “top” of your stick into a slope. Do not sand the bottom of the stick, nor its center area. Repeat with the other paint stick. 
4. After the sticks have been shaped, place one on top of the other in a cross pattern. The sanded sides of both sticks go in the “up” position. 

Hold the blades together with a rubber band. Slip the rubber band over one end of the top stick. Pull it under the cross stick and then slip the rubber band over the other end of the top stick. You may have to double the rubber band to make it tight enough to hold the two sticks together. The boomerang is ready for flight.

How to Throw the Boomerang

1. Stand in an open area. Grasp the boomerang at the end of one stick. Your thumb should lay across the top, “sloped” side of the boomerang. Raise the boomerang up, as though you’re about to throw a football. Aim slightly upward and throw the boomerang with a firm chopping motion, causing it to rotate rapidly as you release it. If you’re right-handed, the boomerang will circle to the left. If you’re left-handed, it will circle to the right. Be careful not to throw the boomerang if other people are nearby. 

2. A properly thrown boomerang will return to you and continue spinning as it drops to the ground. Catch it by trapping the boomerang between your hands. Don’t try to catch it by one of the blades. This can injure your fingers.

Tips

If the wind is blowing, face the wind and then turn about 45 degrees, or 1/8 of a circle, to the right or left (whichever hand you will using to throw). Throw the boomerang at that angle to the wind. If the wind is gusting or shifting, be prepared to chase the boomerang.

The boomerang will fly very differently if you throw it horizontally, like a Frisbee®. Try it and see what happens.