



Curiosity Guide #508

Paper Airplanes

Accompanies Curious Crew, Season 5, Episode 8 (#508)

Propelled Plane

Investigation #8

Description

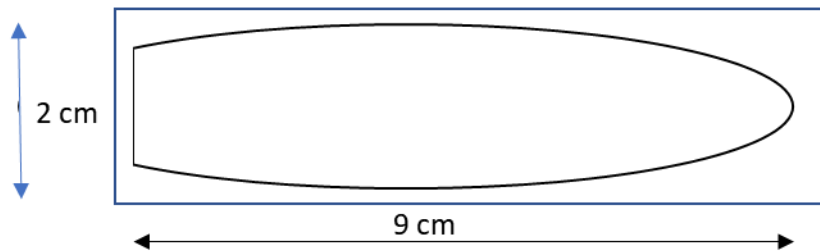
Learn how a simple rubber band can add power!

Materials

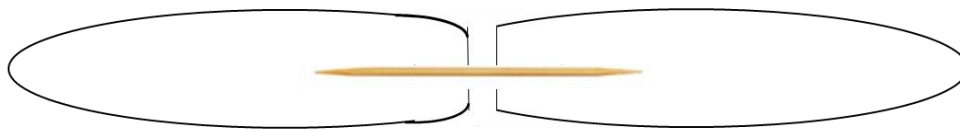
- Foam board
- Pencil
- Scissors
- Plastic cup of standard size, with no ribbing
- Hot glue
- Toothpick
- Pen
- Paper clip
- Needle nose pliers
- Paper
- Straws (5 straight)
- Ruler
- Marker
- Tape
- Hot glue
- Rubber bands
- Demonstration clip to use with written directions:
https://www.youtube.com/watch?v=FB2g_q0n8mI

Procedure 1, The propellers

- 1) Use a ruler and pencil to draw a propeller shape on a piece of foamboard. The propeller should be elliptical, with a flat edge on one narrow end. The other narrow end should be rounded. Make the propeller 9.5 centimeters long and 2 centimeters wide in the center.



- 2) Cut out the foamboard propeller. You will use this as a template to cut two propellers out of plastic.
- 3) Cut the bottom off of the plastic cup so that you have a curled flap of plastic. Save the bottom for later.
- 4) Place the propeller template on the cup, running from the top to the bottom of the cup. Trace around the template. Cut out the propeller with scissors. Repeat to make a second propeller.
- 5) Run a bead of hot glue not quite half the length of a toothpick, starting in the center of the back edge of the first propeller and running toward the tip. Place the toothpick into the glue. Let the glue set.
- 6) Repeat the steps with the second propeller but glue the second propeller to the other end of the same toothpick. Leave a gap of about three-sixteenths of an inch between the flat edges of the two propellers.



- 7) Before the glue sets, rotate the blade of the second propeller slightly around the toothpick so that the two blades are not completely in line. This action will help the propellers grab more air when moving forward.
- 8) Remove the ink tube from the pen casing and cut off a small section of the back end, about $\frac{1}{2}$ inch in length.
- 9) Using a bead of hot glue, attach the small plastic tube on the center of the toothpick and perpendicular to the propellers.
- 10) Unbend a paper clip. With the needle-nosed pliers, cut off about 3 inches. Use the pliers to make a hook on one end. The hook should be almost closed, with just enough opening to insert a rubber band snugly. The total length of the wire with hook should be about $2\frac{1}{2}$ inches. This piece will be used to attach a rubber band to the propeller.
- 11) Try out the wire hook by placing the straight end of the wire into the pen-tube section. The hook should stick out about 2 inches. In your final assembly, you may need to adjust the length of this piece for better operation, either shortening the piece a bit, or cutting a and shaping a longer hooked piece out of another paper clip. Now that you know where the hook will go, set the entire propeller system aside.

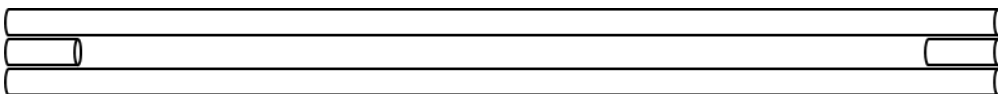
Procedure 2, The paper wings

- 1) Fold a piece of paper lengthwise. Open the paper.
- 2) Using a ruler, mark the center point of the crease.
- 3) Cut an 8-inch length of straw and use the ruler to mark the center.
- 4) Lay the straw parallel to the crease and one inch away. Make sure the two center marks are lined up, across from one another.
- 5) Tape the straw in place
- 6) Run a bead of hot glue along the top of the straw. Fold the paper in half along the crease and press down against the line of glue on the straw. The straw is now sandwiched in the folded paper.

- 7) Glue the long, open end of the folded paper shut by lifting up each corner and the middle of the long edge and placing a bead of hot glue in those spots. Press down to make sure the open side of the wings is secured in those three places.
- 8) Place the wing assembly aside.

Procedure 3, The body

- 1) Fit the end of one straw into another straw to make a straw that is double in length. To do this, flatten the end of the first straw. Slot the end of the first straw into the open end of the second straw.
- 2) Repeat with two more straws. You should end up with two extra-long straws.
- 3) Place the long straws along the long edge of the paper-wing assembly. Cut the long straws to the same length as the long side of the wings. Lay these long straws aside for a moment. If you had to cut off some straw pieces, save them.
- 4) Use the end of a paper clip to pierce a tiny hole in the center of the plastic cup lid.
- 5) Cut a rectangle out that is about $\frac{1}{4}$ -inch by 1 inch, with the hole centered in the middle of the rectangle. Set aside for a moment.
- 6) Cut two short pieces of straw, each one inch long. Use the extra pieces of straw you cut off earlier, if you have them.
- 7) Place a long straw on the table. Next to each end of the long straw, line up a short piece of straw parallel to the long straw, with ends even. Run a 1-inch bead along the side of the long straw, starting at one end. Press a short straw piece into the hot glue, lining up its end with the end of the long straw. Do the same at the other end with the second short straw.
- 8) Run a line of glue along the free side of each of the two short straws. Press the second long straw into the glue and hold until set.



- 9) Hot-glue the rectangle to the end of one of the straw shafts. The hole should be centered over the small straw spacer.

Procedure 4, Fasten the propellers to the body

- 1) Starting from the inside of the body, slide the straight end of the paper-clip hook through the spacer straw and out through the hole in the plastic rectangle you just glued on to one end of the straws.
- 2) On the propeller assembly, fill the pen tube with hot glue. Press onto the protruding straight end of the paper-clip hook.
- 3) Test to make sure the propeller rotates freely. You might need to make the paper-clip hook longer if the propeller has trouble rotating.
- 4) Link together enough rubber bands so that when slightly stretched they are the length of the long straws.
- 5) Hook one end of the rubber-band chain onto the closed hook. Feed the other end through the straw spacer and hold in place with a piece of cut-off paper clip.
- 6) Bend the clip down toward the shaft of the straw so the rubber band can't slip off.

Procedure 5, Attach the wings

- 7) Make a smaller paper wing for the back of the plane. Fold a piece of paper in half lengthwise. Keeping the fold intact, cut the paper to 5 inches in length and $3 \frac{1}{4}$ inches in width.
- 8) Hot glue the small wing centered on the end of the straw assembly.
- 9) Temporarily tape the front wings on the straw assembly, starting about four inches behind the propeller.
- 10) Find the center of gravity by balancing the straw assembly on one or two fingers. The center of gravity should be slightly in front of the center of the main wing.
- 11) Adjust the wing as necessary, and then hot glue in place. Make sure the internal straw is on the leading edge and that the wing is centered.

12) Crease the outside edges of the back wing so that there is a $1 \frac{1}{2}$ inch crease pointing up on each side.

Procedure 6, Test your plane

13) Wind up the propeller and give the plane a gentle push.

14) Could you get your plane to fly?

15) Adjust the flaps. How does that effect the flight pattern?

My Results

Explanation

The wound-up rubber band produces elastic potential energy. When the rubber band is released, the propeller starts to spin and adds to the thrust of the push forward you give the plane when you launch it. The curve of the propeller blade causes the air particles to move faster off the front of the blade than the air hitting behind the blade. This difference causes the air particles to force the craft forward continuously. The paper wings catch enough air under them to provide lift so that the plane is not pulled down too quickly.

Responding to adjustments of the flaps on the rear wing, the plane may loop, bank, or nose dive. This is because of the air drag that the flaps cause, deflecting the plane's path one way or another.

Explore further. Adding rubber-band power to your aircraft can increase its flight time, like adding rubber bands did with our helicopter and propelled plane. Some well-designed paper planes without rubber-band power can also travel quite far. In fact, a man named Tony Fletch from Wisconsin had the first record in 1986, when he was able to fly his dart paper plane 193 feet. That's even longer than the first flight by the Wright Brothers! The current record is held by Joe Ayoob with a distance of 226 feet 10 inches. Wow- maybe YOU can go for the next record!

Think about this. It sure is amazing that one piece of paper can be so much fun. Even though paper is wonderfully lightweight, its fibers don't let the air particles pass through. So, after you've created your paper plane masterpiece and have launched it forward, the plane will start to fall because of gravity. But those carefully-folded wings you made deflect those air particles and give the plane its lift. Trimming the plane to find the balance between gravity and lift on one hand, and thrust and drag on the other, is what makes paper airplane science so much fun. Remember, stay curious and keep experimenting!

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