HOOP GLIDER

Inspiring the scientist in every student!

Students use engineering design principles to turn a piece of paper into an experimental wing for a new type of aircraft that may be more economical and efficient than today's airliners. Aeronautics research takes many forms, including investigating various wing shapes and layouts. As a result of this research, airplanes of the future may look very different from those of today.

As the engineer assigned to this project, you will design, build, and test the flight characteristics of a glider made from two paper hoops and a straw. Figure 1 shows an assembled hoop glider. It's easy to construct, but does it fly? Indeed it does!

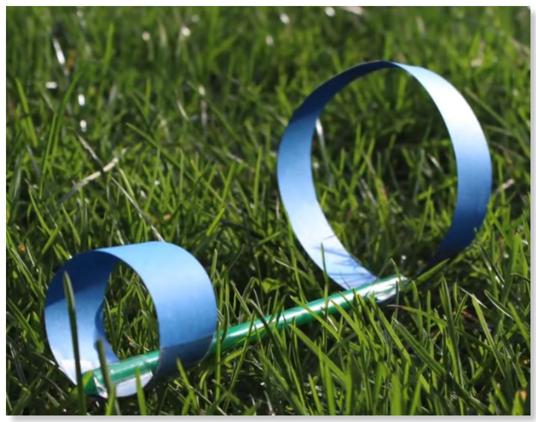


Figure 1

Once you've built a working hoop glider, your next engineering task is to brainstorm and test design changes that enable a second hoop glider to fly even farther than the first.

Build it, test it, and have fun!

INVESTIGATION CHALLENGE

- *Goal*: A hoop glider is a homemade paper aircraft that uses the four forces of flight to fly. Curved surfaces on top of the glider help generate *lift*. An aerodynamic shape reduces *drag*. *Gravity* pulls the glider toward the ground and your arm provides *thrust*. The goal of this investigation is to design and build a hoop glider that flies as far as possible.

- *Time Required:* 30 minutes to 1 hour.

- *Materials:* Construction paper or any heavy paper; a beverage straw of any size; scissors; and regular adhesive tape (e.g., Scotch brand tape).

- *Rules and Procedures*:

  Step 1: Read all instructions and discussion questions.

  Step 2: Collect your materials and *plan* how to build your first glider. As shown in Figures 1 and 2, the glider design requires two strips of paper—one large, one small— each formed into a hoop and then attached to the straw. How big should the larger paper strip be in length and width? How little should the smaller paper strip be? How far apart should the two strips be when attached to the straw? These are just some of the engineering design problems you must tackle.

  Step 3: Build your glider. Choose one paper strip and form it into a loop. Use tape to hold the ends of the loop together. Make a second paper loop in the same way. Attach the straw to the inside of one of the loops using tape. Now attach the second loop to the other end of the straw so that your glider looks like the one shown in Figure 1. Check out this [video]() if you're having trouble building your glider.

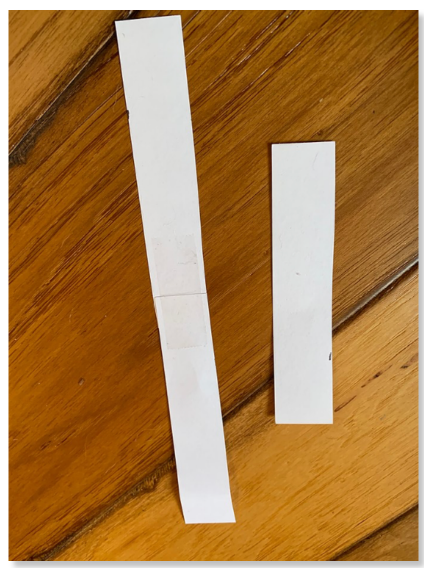


Figure 2

  Step 4: Test your design in an outdoor space with ample room to throw. Hold the hoop glider in the middle of the straw with the hoops on top and the small hoop facing forward. Throw your hoop glider just as you would throw any paper airplane. Use any object to mark the place in which the glider lands. *Measure* the distance flown and write down the result. Repeat the flight test at least nine more times, recording the distance flown each time. Analyze and interpret the data.

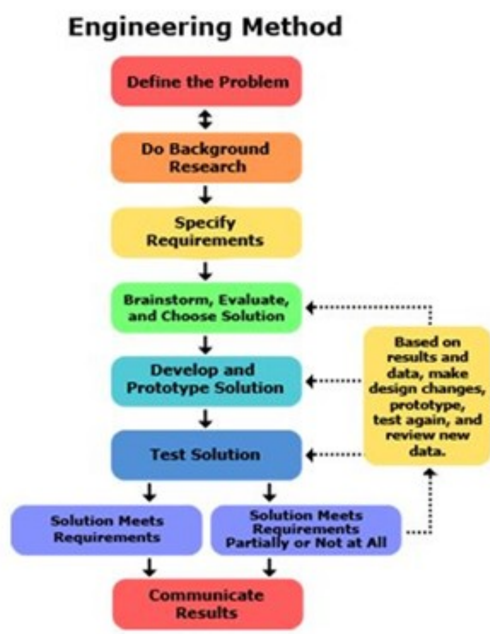
Step 5: Design Improvements. Build a second glider using smaller or larger hoops than the first. Which glider, the first or second, will travel the farthest? *Test your claim* by throwing the second hoop glider at least ten times, marking the place where the glider lands, measuring the distance flown, and recording the results.

- *Questions for Discussion*:
  1. How far did the first hoop glider travel?
  2. How much farther did the second hoop glider travel? Was your claim correct or incorrect?
  3. What might explain these results?
  4. What do you think would happen if you changed: straw length? number of loops? glider weight?
  5. What would happen if your design used one very large loop in the back and one very small loop in front?
  6. What would happen if your design used two straws placed next to one another? Or one straw at the bottom of the two loops and a second straw at the top?
  7. Engineers' early ideas rarely work out perfectly. How does testing help improve your design?
- *Something Else to Consider*: When throwing the glider, it's very important to give it the same push forward each time. When a human throws an object, there are variations in the force (thrust) used and these can affect flight distances. What could you do to control the release so that each throwing force is the same? Design and draw a simple mechanism that "throws" the glider with exactly the same force each time.

TEACHER'S CORNER[1]

NGSS 3–5: Engineering Design Process ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

NGSS 3-5: Engineering Design Process ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.



NGSS 3-5: Engineering Design Process ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

NGSS 3-5 ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

NGSS 3-5: ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Airplanes of the future may indeed look very different from those of today. The National Aeronautical and Space Administration (NASA) is developing flight technologies for a new generation of safe, environmentally compatible, and

[1] Sources: *Hoop Gliders: An Exploration into the Principles of Flight*, Sierra Watershed Education Partnership; and *The Ring Wing Glider,* part of the National Aeronautical and Space Administration's Jet Propulsion Laboratory *Engineering in the Classroom* tool for educators. The NGSS listed here are those identified in *The Ring Wing Glider*

highly productive aircraft. One such idea is NASA's Limited Dual-Mode One-Person Commuter Concept Vehicle, which features a hoop-like ring-wing lifting body concept.

By the way, the only living things capable of powered flight (think "thrust" from flapping wings) are insects, birds, and bats. Flying fish have been known to glide for hundreds of meters thanks to enlarged fins that act like wings.

Watch this [video]() on how to create hoop gliders and the science behind how they work.

KEY CONCEPTS: FOUR FORCES OF FLIGHT

- *Weight:* a force that is directed toward the center of the earth.
- *Lift:* the upward force created when a wing (or hoop) is moving through the air. The wing (or hoop)'s curved surface causes the air to go faster over the top surface creating a region of low pressure underneath, and thus lift. When an airplane (or hoop glider) flies, the wing (or hoop) is designed to provide enough lift to overcome the aircraft's weight.
- *Drag:* The resistance force of the air pulling against the motion of the aircraft or hoop glider. Drag is the force opposed to the flight direction. The aerodynamic shape of aircrafts help reduce drag.
- *Thrust:* Thrust is the propulsion force that moves the aircraft or hoop glider through the air. Airplanes use jet engines to create thrust. In this hoop glider investigation, your arm created the thrust.

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